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Office of Civilian Radioactive Waste Management
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Dear Ms. Dixon:

Enclosed are the State of Nevada Comments on the Draft Environmental Impact Statement for a Geologic Repository for Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.

The State's comments are comprised of several elements. We provide a brief introductory section (Part 1), followed by sections containing general comments (Part 2) and specific comments (Part 3). Three appendices, which elaborate on comments contained in Parts 1 and 2 are attached. These appendices are to be treated as full, original comments. In addition, there are a series of attachments that contain information supporting comments made elsewhere in the comment document.

1 As you will see from the comments, Nevada finds the Draft EIS to be legally, procedurally, and substantively deficient. We do not believe that the Draft can be salvaged as a defensible NEPA decision document. Given the pervasive deficiencies, we see no alternative for DOE but to withdraw the current Draft EIS and initiate a new scoping process in preparation for the development of a new programmatic environmental impact statement (PEIS). Subsequent environmental analyses would then need to be tiered to the PEIS in order to provide adequate assessments of impacts for the proposed repository and its facilities, the proposed rail spur, the proposed heavy-haul and intermodal facilities, the Nevada transportation system, and the national transportation system.

Had DOE undertaken a serious and adequate approach to NEPA compliance for the Yucca Mountain program, including the comparison of the proposed action with a reasonable and realistic no-action alternative, Nevada contends that the assessment would have supported only one course of action - abandonment of the flawed, costly, and dangerous Yucca Mountain repository.

Should you have questions regarding the enclosed comments, please do not hesitate to contact me.

Sincerely,

Robert R. Loux
Executive Director

RRL/cs
Enclosure
cc Governor Guinn
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Nevada Congressional Delegation
U.S. Nuclear Regulatory Commission
U.S. Environmental Protection Agency
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STATE OF NEVADA COMMENTS ON THE U.S. DEPARTMENT OF ENERGY'S DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

Volume 1

Prepared by
The Nevada Agency for Nuclear Projects
Office of the Governor

Carson City, Nevada
February 28, 2000

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In addition we wish to thank the following consultants for their important contributions to these comments: Transportation advisor Robert J. Halstead, hydrology consultant Linda Lehman, Dr. James Flynn and his colleagues at Decision Science Research Institute, geology advisor Steven Frishman, environmental scientist Dr. Charles Malone, Dr. Marvin Resnikoff and his colleagues at Radioactive Waste Management Associates, engineering consultant Richard Moore, transportation modeling consultant James Williams, and terrorism expert Dr. James David Ballard.

The Agency for Nuclear Projects is also grateful for informal advise provided by Clark County Nuclear Waste Division staff Russell diBartolo and Fred Dilger and by social scientists Dr. Alvin Muskkatel and Dr. K. David Pijawka.

"President Clinton merely wants science to finish before politics send the waste here."
A DOE representative at the public hearing in
Crescent Valley, Nevada (December 9, 1999)

"The significant problems we face cannot be solved at the same level of thinking we were at which we created them."
Albert Einstein

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PART 1
INTRODUCTION

The Past as Prologue

In 1985, then-Governor Richard Bryan, commenting on the draft Environmental Assessment (EA) for the Proposed High-Level Radioactive Waste Site at Yucca Mountain, noted that "... the information and analyses contained in the draft EA itself fails, in most instances, to support conclusions drawn and findings made by DOE in evaluating [the Yucca Mountain site]. Time and again, conclusions are made that simply cannot be supported by information in the draft or in referenced materials that were compiled by DOE's own contractors. On numerous occasions, conclusions and findings in one section of the document can be seen to contradict information presented elsewhere. The problem is compounded when these unsubstantiated conclusions and findings are used as the basis for comparing and ranking sites later in ... the draft."

Governor Bryan went on to point out that "any objective, scientifically-minded observer reviewing the draft EA ... can come to but one conclusion based on the information contained in the document; namely, that there is simply not enough data available to allow any conclusion to be reached" about the suitability of the site or about potential impacts of the Yucca Mountain program. Almost fifteen years and approximately $7 billion later, this same criticism can legitimately be made with respect to DOE's Draft Environmental Impact Statement (EIS) for the Yucca Mountain program.

2 It is both enlightening and disturbing to compare the major deficiencies cited by the State of Nevada in its review of the draft EA with findings made concerning the Draft EIS. In addition to the inadequate and incomplete information that characterizes each document, these two attempts at complying with National Environmental Policy Act (NEPA) requirements also share many other commonalities. Both documents inappropriately constrict the area of influence for impact assessment and ignore impacts to the State as a whole; both are entirely deficient in the assessment of transportation impacts and ignore the effects of the program on states and communities nationwide; both fail to adequately evaluate cumulative impacts, especially the contributions of Nevada Test Site activities and contamination to both short and long-term impacts of the Yucca Mountain program; both contain cursory and inadequate socioeconomic impact assessments and completely ignore large potential economic impacts to Nevada's principal economic sector, tourism and gaming; both dismiss consideration of Native American impacts and issues with platitudes and paternalistic pronouncements; and both present assessments about repository performance and potential environmental contamination through the use of unsubstantiated assumptions, limited and inadequate data, and grossly optimistic interpretations.

3 The fundamental and irreparable shortcomings of the Draft EIS are all the more disturbing because DOE should have known better. Thousands of pages of comments were provided on the draft and final EA. Nevada alone submitted over 300 pages of detailed, focused, and extremely helpful comments on the draft EA. Thousands more comments were made by hundreds of people and organizations during the scoping process for the draft EIS in 1995. For the most part, prior comments and criticisms that would have assured an adequate EIS were disregarded. DOE simply moved stubbornly forward in a manner designed to produce a minimalist environmental impact statement ratifying DOE's predetermined and politically driven conclusion that the Yucca Mountain program will result in no significant impacts anywhere, at any time.

4... ***A Legally and Substantively Deficient Document***

The comments contained in the following Parts of this document present, in both general and specific terms, compelling evidence that DOE's Draft EIS is both legally and substantively deficient in numerous ways. In addition, the State of Nevada contends that the procedures used by DOE to notify those people potentially affected by the Proposed Action and to solicit public input as required by NEPA are likewise deficient and in violation of NEPA statutory provisions and implementing regulations.

The State of Nevada asserts that the Draft EIS fails to appropriately reflect the unique nature and scope of the Yucca Mountain program. It does not adequately assess impacts associated with the repository and related activities, and it is not in compliance with either the letter or spirit of NEPA. The State formally reiterates its assertion that a Programmatic Environmental Impact Statement (PEIS) for the high-level radioactive waste (HLW) program should have been, and still should be, prepared. The unique, first-of-a-kind nature, complexity, and unprecedented time scale of the federal HLW program require the preparation of a PEIS, with project-specific EISs for related program elements tiered to the PEIS. The HLW program is simply too massive in scope and overwhelming in complexity for DOE to attempt to use a single EIS as the vehicle for assessing impacts and making programmatic decisions. By preparing a narrowly focused, non-programmatic EIS such as the Draft released for comment (and then indicating that it will be the basis for some program decisions and not for others), DOE is circumventing the intent of the National Environmental Policy Act.

5 ... ***A Flawed Public Involvement Process***

The State further contends that the public comment process for the Draft EIS, especially with respect to potentially impacted states and communities outside Nevada, clearly violates the spirit and letter of NEPA. Notices announcing the comment period and public hearings did not adequately describe the Proposed Action and its implications for people along transportation routes. Nevada believes DOE intentionally withheld crucial information, both in the Draft EIS

5 cont. and in notices and communications about hearings and comments, indicative of the true national scope of the high-level waste program.

The irony of the situation is that DOE has, in fact, done the analyses needed to reveal specific highway and rail routes that would be used for waste shipments. However, that information was buried in data used to run computer models and was not made explicit in the Draft EIS. The document contains no maps or other information showing which cities and communities along transportation corridors will be affected by this massive and unprecedented high-level radioactive waste shipping campaign. Under substantial pressure from certain members of Congress and other interested parties, DOE belatedly posted maps of routes ostensibly used in the Draft EIS transportation analyses on its web site the last week of January, almost six months after the release of the draft document for public comment and after eighteen (18) of the twenty-one (21) public hearings had already been completed. No information on numbers of shipments or mode of transport was included with the DOE maps. Nor were the public notices for the remaining public hearings changed to make people in cities where the final hearings were held aware of the transportation implications of the Proposed Action.

Nevada believes that DOE has violated the National Environmental Policy Act by concealing crucial information used for analyses in the Draft EIS. Absent this information, persons affected by the transportation impacts of the Proposed Action have no way of determining the substantive and legal sufficiency of DOE's analysis. Such concealment of information can only diminish public confidence in DOE's ability to safely transport these highly radioactive materials. One can only conclude that such an oversight is intentional and designed to suppress public interest in the project and participation in these public hearings.

6 ... ***The Absurdity of the No-Action Alternative***

Apart from the inadequacies of information and analyses and the many procedural deficiencies of the Draft EIS, the use of an unreasonable, even absurd, No-Action Alternative as the basis for comparison of impacts with the Proposed Action further contributes to the overall insufficiency of the Draft EIS. NEPA requires that federal agencies, in preparing environmental impact statements supporting major federal decisions and projects, consider alternatives to the action being proposed, especially the alternative of taking no action. In the Draft EIS, DOE has chosen two No-Action Alternative scenarios that are unrealistic, unreasonable, and legally deficient.

The Draft EIS postulates a situation where, in place of a repository at Yucca Mountain, spent nuclear fuel and high-level radioactive wastes are assumed to be stored on-site at reactor and generator locations for a period of 10,000 years. In the first No-Action Alternative scenario, DOE assumes that active institutional control is maintained for the entire time, while under the second scenario, institutional control ceases after the first 100 years.

6 cont. Both scenarios are wholly inappropriate, even absurd. The Council on Environmental Quality interprets "no action" as "the federal agency not acting at all" (i.e., not constructing and operating a repository at Yucca Mountain). In the absence of a repository, it is unacceptable to assume that spent fuel and HLW would simply be left at reactor sites forever. The most plausible No-Action Alternative scenario is one where there would be some period (50 to 100 years) of at-reactor storage (most likely in dry storage configurations), combined with the application of waste reduction technologies, and followed by some form of revised (and, hopefully, dramatically improved) process to site and construct storage and/or disposal facilities.

DOE's No-Action alternative cannot be defended on the basis of reasonably foreseeable courses of action in the absence of a decision to move ahead with the development of a repository. Instead, what DOE appears to have done is select scenarios designed to generate the greatest public alarm and political pressure in favor of its Proposed Action. In so doing, DOE has violated the clear intent of NEPA that a realistic and reasonable No-Action Alternative be evaluated and compared to the Proposed Action.

Conclusion: Need for a New Draft PEIS and Public Comment Period

4 cont. After an extensive review of the Draft EIS and associated reference materials, the State of Nevada finds the document so inadequate and deficient as to require its withdrawal and the immediate announcement by DOE of the intent to prepare a new ***programmatic*** EIS sufficient to evaluate program-wide impacts and support program-level decisions that are reasonable and defensible. PEIS development process should begin with a new scoping process designed to actively and meaningfully obtain public input on the content and nature of the data and analyses necessary to define alternatives at the program level and to identify and assess potential impacts to the physical and human environment.

The impacts associated with the proposed high-level radioactive waste repository at Yucca Mountain, thousands of miles distant from the majority of U.S. nuclear power reactors, will affect the State of Nevada as well as at least 42 other states, hundreds of cities, and thousands of communities located along highways and rail lines that would be used for waste transportation. The program that the PEIS must address is unprecedented for a federal project in its scope, time frame, and the geographical area it encompasses. It is also unique in that the EIS must assess not only the more traditional effects of a large and complex project - impacts to the environment, to public health and safety, to area populations, and to state and local economies - but the EIS must also address those impacts that derive from the highly controversial nature of this activity and the fact that the program involves the handling, movement, storage, and disposal of extremely hazardous nuclear materials. It is the nuclear nature of this undertaking that makes it different from more traditional federal projects and requires an EIS that fully examines a broader range of impacts (including those related to risk, risk perception, and stigma) in Nevada

4 cont. as well as in states and communities through which spent nuclear fuel and HLW must pass en route to a Yucca Mountain repository.

The existing Draft EIS fails to undertake this type and level of analysis. DOE must reconsider its entire approach to NEPA compliance and commit itself to a producing a comprehensive and adequate programmatic environmental impact statement. Schedule pressures and perceived political imperatives should not be permitted to obstruct the implementation of a truly adequate NEPA process and decision documents that must provide justification and guidance for a ten thousand year program.

PART TWO
GENERAL COMMENTS

Deficiencies with Respect to National Environmental Policy Act Requirements

7 ... The Draft EIS treats the proposed Yucca Mountain repository as just another federal program, with no attention paid to the one-of-a-kind, controversial, extremely long duration, and extraordinarily complex program that is characterized by irreducible uncertainties in almost every aspect of its design and implementation. The overly general, almost off-the-shelf impact assessment contained in the document is entirely inadequate and inappropriate for a program of the type and complexity presented by the Proposed Action. Nevada continues to believe, as stated in the State's Scoping Comments on DOE's 1995 Notice of Intent, that DOE should have prepared a programmatic EIS for the repository project and then tiered separate EISs to it for the Yucca Mountain repository facilities, the rail spur corridor selection, the selection of Nevada and national highway and rail routes, and the intermodal transfer facility. Such an approach would more accurately reflect the complex and interconnected nature of the various elements of the program and allowed DOE to better assess and address environmental impacts program wide. It would also have enabled DOE to deal more directly and effectively with the wide range of uncertainty presented by each aspect of the program.

Council on Environmental Quality (CEQ) regulations require federal agencies to assess the effects of major federal actions on the human and natural environment. Where such actions involve a broad program that contains groups of concerted actions clearly and systematically connected, federal agencies are required to follow National Environmental Policy Act (NEPA) "tiering" requirements.

Tiering refers to NEPA analysis presented through preparation of Programmatic Environmental Impact Statements - otherwise known as PEIS documents. The PEIS allows federal agencies to address broad program or policy decisions that are subsequently followed by narrower EIS statements that address site-specific decisions.

Over the past fifteen years, DOE has used the PEIS process extensively. The process has been employed to examine many issues such as the disposition of surplus plutonium, managing the nuclear weapons stockpile, and selecting regional disposal sites for DOE low-level and mixed low-level waste.

Tiering is used to make a broad program decision that will later be supported by specific EIS analyses of lesser scope. In other words, tiering is appropriate when it helps the lead agency (in this case, DOE) to focus on the issues that are ripe for decision and exclude from consideration issues that are not yet ripe for decision.

7

7 cont. In the case of the Yucca Mountain Draft EIS, DOE has corrupted the tiering process, as defined under CEQ regulations Sec.1502.20 and 1508.28, in that the Draft EIS does not purport to be a programmatic document, yet it, nevertheless, attempts to serve as the basis for both programmatic and project-specific decisions. The Draft EIS "programmatically" identifies alternative transportation modes and routes within Nevada, while seeking to support "comparative decisions" on one or more of these alternatives as part of the EIS decision process. It also expressly states that a site-specific assessment of Nevada transportation modes and routes will follow, once the mode and route comparative siting decisions are made. This is precisely the role tiering is intended to have through the PEIS process. Yet the Yucca Mountain EIS is not a Programmatic EIS document.

The Draft EIS also fails to identify the cross-country rail and truck routes used in DOE's own transportation impact analysis. So, where programmatic decisions at the national level are clearly warranted, DOE has chosen to avoid the identification of transportation modes and routes.

Overall, this means that communities outside Nevada share the same fate as communities inside Nevada; that is, no one is availed of any reliable information about who will be affected by the transportation of nuclear waste across the country to a repository in Nevada. Accordingly, while the EIS attempts to serve as the basis for both programmatic and project-specific decisions, it unequivocally fails on both accounts.

8 The NEPA analysis in the document is segmented, which can only lead to fragmented decision making. In the State's view, DOE has corrupted the NEPA process by leaving some of the most significant issues and impacts un-assessed. DOE has either refused to assess or purposely postponed key decisions concerning national and local transportation modes and routing alternatives. These actions have conveniently avoided compliance with NEPA tiering
9 requirements. DOE has also avoided mandatory requirements that specify involvement of other federal agencies in the NEPA process. Again, this is unacceptable, given the clear jurisdictional control these other agencies have over proposed actions defined in the Draft EIS.

10 CEQ regulation 1502.9 require draft Environmental Impact Statements to fulfill and satisfy the requirements established for final statements in section 102(2)(C) of the National Environmental Policy Act. This means that if a draft statement is deemed inadequate as to preclude meaningful analysis, the agency must prepare and circulate a revised Draft EIS. Given inadequacies of the Yucca Mountain Draft EIS (e.g., it is neither a project-specific document nor a programmatic document), we contend that DOE is now obligated to prepare and circulate a revised Draft EIS for the repository program.

Conflict with Provisions of the Nuclear Waste Policy Act of 1982, as Amended

11 The Draft EIS that DOE has released for public comment does not reflect the fundamental concept of geologic isolation as required by the Nuclear Waste Policy Act of 1982. This Act calls for the isolation of spent fuel and high-level radioactive waste through the mechanism of deep geologic disposal. Instead, the "evolving" facility design described in the Draft EIS relies almost exclusively on engineered barriers to compensate for the inadequacies of the site and to make the facility work. The Draft EIS implicitly acknowledges that Yucca Mountain, as a geologic formation, is incapable of isolating highly radioactive and long-lived wastes from the environment.

The nearly complete reliance of the Yucca Mountain project on the waste package (and other possible engineered barrier contributors) is also a contradiction of the geologic disposal concept as described in DOE's 1980 Final Environmental Impact Statement (EIS) Management of Commercially Generated Radioactive Waste. The 1980 EIS states, "Geologic barriers are expected to provide isolation of the waste for at least 10,000 years after the waste is emplaced in a repository and probably will provide isolation for millennia thereafter. Engineered barriers are those designed to assure total containment of the waste within the disposal package during the initial period during which most of the intermediate-lived fission products decay. This time period might be as long as 1,000 years..." The Yucca Mountain Draft EIS describes a project that does not conform to the intent or the requirements of the Nuclear Waste Policy Act. This project, as it is currently described, targets future generations to be contaminated by nuclear waste, instead of protecting them.

12 The Draft EIS should acknowledge and describe the two factors that have served to eliminate a whole suite of potential repository designs and have driven the current general design concept. The two factors are: 1) the discovery of rapid infiltration and flow of water in fractures in the unsaturated zone (contrary to the original conceptual model of very slow matrix flow downward through Yucca Mountain); and 2) the incorporation of large, horizontally emplaced waste packages in drifts, driven by the now-defunct development of the Multi-Purpose Container concept (replacing the concept of thin-walled stainless steel, vertically emplaced waste packages). These factors together reflect the finding that a Yucca Mountain repository system must rely on a robust engineered barrier system because the natural barriers of the site are not capable of providing significant waste isolation alone. The key design requirement that is central to Yucca Mountain repository performance is a waste package that has a projected long life relative to the regulatory compliance period.

Inadequate and Misleading Notices of Public Hearings

13 ... Although the U.S. Department of Energy (DOE) has conducted public hearings on its Draft Environmental Impact Statement (EIS) for a High-Level Radioactive Waste Repository at

13 cont. Yucca Mountain, Nevada in various cities around the country, DOE has gone to considerable lengths to conceal information about nuclear waste transportation routes, shipment numbers, and risks to specific states and communities located on or near transportation corridors to a Nevada repository.

The notices for these public hearings, for example, refer only to a Draft EIS for a radioactive waste repository in Nevada. They do NOT indicate that people in hundreds of cities and communities across the country stand to be impacted in major ways by thousands of radioactive waste shipments as a direct result of the Yucca Mountain project. DOE has made no effort to inform citizens of potentially impacted communities of the spent nuclear fuel and high-level radioactive waste transportation aspects of the Proposed Action and the potential for such transportation to result in impacts to specific communities along shipping routes.

14 ... Furthermore, the Draft EIS itself contains no analyses of possible spent fuel and HLW transportation impacts on states, cities, and communities along potential shipping routes, despite the fact that, in responding to public comments on the 1985 draft Environmental Assessment (EA) for the Yucca Mountain site, DOE committed to just such an assessment as part of the Yucca Mountain EIS:

> "The DOE believes that the general methods and national average data used [in the EA] are adequate for this stage of the repository-siting process [i.e., the pre-site characterization stage]. Route-specific analyses and an evaluation of the impacts on host States ***and States along transportation corridors will be included in the environmental impact statement***" (emphasis added).[1]

The irony of the situation is that DOE has, in fact, done the analyses needed to reveal specific highway and rail routes that would be used for waste shipments and to conduct required impact assessments along those routes. That information, however, is buried in data used to run computer models and is never made explicit in the Draft EIS. The Draft EIS contains no maps or other information showing which cities and communities along transportation corridors will be affected by this massive and unprecedented radioactive waste shipping campaign. One can only conclude that such an oversight is intentional and designed to suppress public interest in the project and participation in these public hearings.

Nevada believes that DOE has violated the National Environmental Policy Act by concealing crucial information used to support conclusions in the Draft EIS. Absent this information, persons affected by the transportation impacts of the Proposed Action have no way of determining the substantive and legal sufficiency of DOE's analysis. Such concealment of

[1] "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Appendix C, Comment-Response Document, p. C.2-37 (May, 1986).

14 cont. information can only diminish public confidence in DOE's ability to safely transport these highly radioactive materials.

Unreasonable No-Action Alternative

15 The National Environmental Policy Act requires that federal agencies, in preparing environmental impact statements supporting major federal decisions and projects, consider alternatives to the action being proposed, including the alternative of taking no action. In the Draft EIS for the proposed Yucca Mountain high-level nuclear waste repository, DOE has chosen two No-Action Alternative scenarios that are unrealistic, unreasonable, and legally deficient.

The Draft EIS postulates a situation where, in place of a repository at Yucca Mountain, spent nuclear fuel and high-level radioactive wastes are assumed to be stored on-site at reactor and generator locations for a period of 10,000 years. In the first No-Action Alternative scenario, DOE assumes that active institutional control is maintained for the entire time, while under the second scenario, institutional control ceases after the first 100 years.

Both scenarios are wholly inappropriate, even absurd. The Council on Environmental Quality interprets the No-Action Alternative as "the federal agency not acting at all" (i.e., not constructing and operating a repository at Yucca Mountain). In the absence of a repository, it is unacceptable to assume that spent fuel and HLW would simply be left at reactor sites forever. The most plausible No-Action Alternative scenario is one where there would be some period (50 to 100 years) of at-reactor storage (most likely in dry storage configurations), combined with the application of waste reduction technologies, and followed by some form of revised (and, hopefully, dramatically improved) process to site and construct storage and/or disposal facilities.

DOE's No-Action Alternative scenarios cannot be defended on the basis of reasonably foreseeable courses of action in the absence of a decision to move ahead with the development of a repository. Instead, what DOE appears to have done is select scenarios designed to generate the greatest public alarm and political pressure in favor of its Proposed Action. In so doing, DOE has violated the clear intent of NEPA that a realistic and reasonable No-Action Alternative be evaluated and compared to the Proposed Action.

The No-Action Alternative is prescribed in the Nuclear Waste Policy Act. Under Section 113 (c)(3), if the Yucca Mountain site is unsuitable, the Secretary of Energy is to inform Congress, make recommendations for future action, and wait for further direction, which assuredly would not be leaving irradiated nuclear fuel on site with little or no control for 10,000 years.

Inaccurate Project Description

16 The Draft EIS fails to reliably define a proposed repository design and holds open a range of design options that, in various combinations, would require extensive additional environmental impact analysis. This condition exists in the Draft EIS despite the fact that the Final EIS, mandated by the NWPA to be included in the Secretary's Site Recommendation Report, must also include "a description of the proposed repository, including preliminary engineering specifications for the facility" (Sec. 114(a)).

The Draft EIS does not describe the proposed repository project in a manner that allows an analysis of its impacts. Asserting that the design for the facility is still "evolving," DOE describes a number of design alternatives and options in the Draft EIS with the expectation that whatever design is finally selected, its impacts will have been bounded by the analysis of the alternatives and options. The range of possible impacts is wide, and they all lead to releases of radionuclides from the repository that will contaminate a groundwater source currently used for drinking water and agricultural purposes. What cannot be known from this Draft EIS is how much radiation is released, how fast it is released, and how soon it is released. In simple terms, because of the inadequate project description, this Draft EIS does not tell us what the future risks of the proposed repository are to people and the environment.

Incomplete Site Characterization Data

17 Performance confirmation activities are nothing more than continuing site characterization activities. The name was changed so that DOE could meet its self-imposed schedule. What it really means is that DOE has not completed site characterization in sufficient detail to conduct an adequate environmental impact assessment or make an adequate site recommendation to the Secretary. The site, according to this Draft EIS, will not be determined suitable or unsuitable until closure. This is contrary to the intent of the NWPA and means that the Draft EIS is and final EIS will be based on flawed and seriously incomplete data.

18 For the low thermal load repository, the Draft EIS would include Area 5, in order to provide sufficient underground emplacement area. Area 5 has not been the object of site characterization and, therefore, should not be included in the Draft EIS or repository planning until it has been characterized. The Secretary's site recommendation is to be made at the completion of site characterization according to the NWPA. In the case of the low thermal load alternative design, site characterization has not been completed in a portion of the area included in the Proposed Action. If the low thermal load alternative is to be considered a reasonable alternative, which it must if it is included in the Draft EIS, this Draft EIS should be deferred until after characterization of Area 5 is satisfactorily completed.

Reliance on Incomplete and Obsolete Performance Assessment Information

19 Performance assessment results used in this Draft EIS are based on a Total System Performance Assessment (TSPA) code and supporting analyses that were developed prior to those currently being used in DOE's site suitability evaluation for site recommendation. The Draft EIS must include a description of the current TSPA and include its results and analyses, rather than relying on an acknowledged incomplete and obsolete TSPA. In order to meet the need for a complete and accurate evaluation of the long-term impacts of the Proposed Action, DOE should issue a new Draft EIS for public review and comment that includes information and analyses consistent with the Site Recommendation Report.

443 The output of the TSPA model for the Draft EIS is highly dependent on seepage rates into the drifts. However, the results of critical studies on the movement and chemistry of water after the thermal pulse are not yet available. It should be stated clearly in this Draft EIS that the repository performance projections are tentative, at best, and are subject to large adjustments, pending further information on crucial aspects of heat effects on the assumed characteristics of the natural barrier system and its interaction with the engineered barrier system. This uncertainty alone is sufficient to declare the projected performance of the repository in this Draft EIS premature and lacking in credibility.

444 It should be made clear that the waste package degradation models described in the Draft EIS are essentially unsupported by reliable long-term data and are based largely on extrapolation and assumptions of expected behavior. In addition, the waste package design analyzed in this Draft EIS is not the design currently under consideration. Therefore, the TSPA products in this Draft EIS are invalid.

Inadequate Assessment of Cumulative Impacts

20... The Draft EIS fails to adequately assess cumulative impacts from past, current, and future activities at the Nevada Test Site (NTS). Estimates of the NTS contribution to off-site radiation exposures and projections of future cumulative exposures are based on woefully inadequate and incomplete data. Known and suspected contaminated sites in the proposed withdrawal area are not acknowledged, and their remediation status is not described.

DOE's own estimates place the combined source term for all tests conducted at the NTS at 300 million curies. The geographic scope of existing groundwater contamination in the region may exceed 300 square miles and extend to depths ranging from 500 to 5,000 feet. Yet the Draft EIS concludes that the maximum potential dose from the underground testing inventory is calculated to be 0.2 millirem per year and that the cumulative annual dose from both NTS and Yucca Mountain sources would 0.42 millirem per year.

20 cont. In fact, DOE does not have the data required to calculate a base case scenario for determining groundwater travel time in the region, let alone to make an estimate of radionuclide movement in the groundwater. Estimates of hydraulic conductivity contained in the Draft EIS (e.g., movement of contaminants through the groundwater) rely on only one data set obtained from a single well for a period of fifty years. This limited data is then extrapolated over a 10,000 year period to produce the estimated 0.2 millirem per year dose figure (as the contribution to cumulative groundwater impacts caused by nuclear testing). As a result, it is not possible, with any reasonable level of confidence, to estimate the amount of radionuclides released through the groundwater to the biosphere in the region of influence beneath the NTS and offsite locations. Both the State of Nevada and DOE's own independent peer review group[2] have documented these facts as part of ongoing technical and regulatory reviews of DOE's Underground Test Area program for the NTS.

Developing believable and reasonable estimates of the potential cumulative impacts to groundwater from existing contamination beneath the NTS and future contamination from a proposed repository at Yucca Mountain is mandatory for assessing the degree to which the Proposed Action would affect public health and safety. The Draft EIS fails to make this fundamental assessment and is, therefore, deficient. The Draft EIS fails to meet the basic requirement of NEPA as defined by the Council of Environmental Quality implementing regulations, Sec. 1500.1(b).

The Draft EIS also fails to adequately assess impacts from contaminated sites known to be located within the proposed repository withdrawal area. For example, it is known that there are high-level waste residues from the nuclear rocket program buried at an unknown location in Area 25 of NTS. The Draft EIS must contain affirmative information regarding the location of this material and assure that, if it is in the proposed withdrawal area, it will be recovered and managed according to applicable laws, regulations, and orders. In addition, there are reportedly at least 20 other known contaminated sites within the portion of the NTS that is included in the proposed withdrawal area. These areas must be fully rehabilitated under the jurisdiction of NTS so they are not passed on to OCRWM, where they would remain a continuing hazard. The impacts associated with required clean-up activities should have been addressed in the Draft EIS.

Maximally Exposed Individual

21 ... The maximally exposed individual for this Draft EIS should be a subsistence farmer located at the boundary of the repository operations area. This would be equivalent to a maximally exposed individual adjacent to an operating nuclear reactor. There is no rationale

[2] "External Peer Review Group Report on Frenchman Flat Data Analysis and Modeling Task, Underground Test Area Project," (ITLV/13052-077A0), prepared for U.S. Department of Energy, Nevada Operations Office under contract No. DE-ACO8-97NV13052 (September, 1999).

21 cont. provided to locate the maximally exposed individual 20 km from the operating repository surface facility.

22 ***Uncertainty***

As presented in this Draft EIS, the uncertainties from all sources, both in repository performance and system design, and thus environmental impacts are of such range and magnitude that a decision to select the preferred alternative can not be supported by this document. The definition and analyses of uncertainties should recognize that the program is a major national effort, unique and unprecedented as an engineering project, with extremely long time horizons, an uncertain political and financial base from which to work, and a long list of important physical site characteristics that are extremely difficult to define and measure.

23 ***Compliance with Existing Regulations***

This Draft EIS is written to comply with regulations that currently do not exist, i.e., the NRC's proposed revised licensing regulations (10 CFR 63) and DOE's proposed revisions to the guidelines for recommending repository sites (10 CFR 963). These proposed regulations greatly reduce the requirements that DOE must meet in order to determine that the Yucca Mountain site is suitable and to apply for a NRC license. Neither of these proposed regulations has been approved as of the date of the Draft EIS or these comments. The Draft EIS should have been written to comply with the regulations that are currently in place, i.e., 10 CFR 60 and 10 CFR 960.

24 ... ***Reliance on Incomplete and Inadequate Modeling of Groundwater***

The Draft Environmental Impact Statement (Draft EIS) for the Yucca Mountain high-level waste project includes an evaluation of environmental consequences (in terms of dose) of alternative repository design concepts and alternatives. The conclusion drawn from the results of these evaluations is that compliance is achieved.

There is, however, strong evidence that casts doubt on the validity of the conclusions and these compliance assessments in light of NWPA and NEPA requirements. This evidence is related to the choice of groundwater pathways selected for the analyses.

At Yucca Mountain, the primary human exposure pathway is through ingestion of groundwater. In conducting a performance assessment for Yucca Mountain, an accurate view of the groundwater flow field is essential. The velocity of the groundwater is one of the most sensitive parameters in the transport equation and, therefore, strongly influences dose calculations. The direction of the groundwater pathway is important as it dictates the hydrologic and geochemical character of the rock encountered along the pathway. Direction, along with

24 ... velocity, strongly influence sorption and other important variables such as dilution and effective porosity in the saturated zone.

There has been considerable debate over the actual flow paths that would be followed by radionuclides released from the repository. Modeling results performed by the State of Nevada (Lehman and Brown, 1994, Lehman and Brown, 1995) indicate major differences may exist in flow path direction, velocity, and sorptive capability compared to that used in the latest assessments by DOE, including the Draft EIS, if all available data sets are utilized.

By failing to evaluate credible alternative models or opposing views of the saturated zone, DOE is not in compliance with NEPA. Being out of compliance with NEPA means automatic noncompliance with the NWPA. DOE is specifically out of compliance with NEPA Section 1502 for not summarizing, discussing or using important data sets; failure to evaluate credible opposing viewpoints; and not proposing testing to reduce uncertainty in the choice between alternative conceptual flow paths.

The Nuclear Waste Policy Act requires that an EIS, consistent with the National Environmental Policy Act, be prepared and accompany a recommendation for site approval. The amended NWPA (1987) still requires consistency with NEPA, but does not require the DOE to consider:

441...

1. The need for the repository
2. Alternative sites to Yucca Mountain, or
3. Non-geological alternatives

NWPA Section 114(f) specifically states that all other provisions of NEPA apply. NEPA Section 1502.22 relates to incomplete or unavailable information. NEPA regulations require that, if information is available that would aid in evaluating uncertain effects, it must be obtained and analyzed unless it is too expensive to do so. If costs are prohibitive, then it must be disclosed as incomplete or unavailable information. Specifically, regulations require that if information cannot be obtained, the EIS must include :

1. A statement that such information is incomplete or unavailable.

2. A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment.

3. A summary of existing credible scientific evidence that is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment.

441 cont.

4. The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain Draft EIS is not in compliance with numbers 2, 3, or 4 above. While DOE has stated that information used in determining the groundwater flow model is incomplete or unavailable, the existing credible scientific evidence relevant to evaluating reasonably foreseeable significant adverse impacts has not been summarized nor has it all been utilized in developing flowpaths.

To be in compliance with NEPA, DOE is required to consider effects of credible alternative models in the Draft EIS. While the Draft EIS recognizes differing viewpoints regarding groundwater flow and references the State of Nevada-funded studies of Lehman and Brown, 1995, there has been no evaluation of the impacts. (See Attachment U to these comments for an expanded discussion of this topic.)

25 ...

Lack of an Integrated Approach to Environmental Impact Assessment (EIA)

NEPA establishes national environmental policy and is meant to coordinate responses to environmental issues by bringing together other environmental legislation and policy for all environmental media regarding an individual major action. The YMP Draft EIS falls short in regard to joint regional land use planning with other agencies, citizens, and private stakeholders. Additionally, there has been no effort on DOE's part to integrate NEPA documentation for the Yucca Mountain project with other ongoing and anticipated federal activities.

The task of addressing the overall environment in an integrated sense is not achieved in the Draft EIS because environmental components are addressed in a piecemeal and incomplete fashion. For example, only biota and soils were addressed in the Draft EIS, the former only at the population and community levels. Ecosystems were avoided as was their role in the regional landscape. Consequently, impact analysis was not performed in the context of regional plans to assess the carrying capacity of the region's resources and the cumulative effects that could occur.

The range of uncertain adverse impacts on the Yucca Mountain region that are meaningful in the context of future generations is missing from the Draft EIS. This applies in particular to the interactions between climate change and future releases of radionuclides into the regional environment. NEPA infers also that a goal of national environmental policy is to work toward sustainable resources and economies through ecosystem management. Such an approach has been taken by DOE at the Nevada Test Site, but the Yucca Mountain project has steadfastly refused to adopt a comparable approach. Consequently, policy-relevant EIA and decision making in the context of holistic environmental and human dimensions was impossible for the Yucca Mountain project. This failure is at the root of one of the Draft EIS's fundamental insufficiencies.

25 cont. The precedential nature of the Proposed Action in terms of contamination far into the future will endanger the environment and render future natural resources unusable. A comprehensive and integrated holistic approach to EIA that considers humans within the natural environment should be applied to the Yucca Mountain natural region. A particular loser in the NEPA process for the Yucca Mountain project has been long-term quality of the human environment regarding future generations. The Draft EIS condones sacrificing the Yucca Mountain region for the future. For additional comments in this regard, see Appendix III of these comments.

Inadequate Consultation on Historic Preservation Issues

The State Historic Preservation Office has reviewed the Draft EIS for Yucca Mountain. The National Historic Preservation Act charges the Department of Energy (DOE) to consider the effects of this undertaking on historic properties eligible for inclusion in the National Register of
26 Historic Places. DOE has already identified archaeological sites potentially eligible for inclusion in the National Register. Additionally, the Consolidated Group of Tribes and Organizations has also indicated an interest in properties *around* Yucca Mountain, but it is difficult to discern from the Draft EIS whether or not these properties are located within the area of potential effect.

As outlined in 36 CFR 800, Advisory Council regulations, DOE must consult with the State Historic Preservation Office (SHPO) to identify consulting parties that include the Advisory Council, local governments, tribes, and any other party interested in historic properties that occur within the area of potential effect. Second, DOE must consult with the SHPO to define the area
27 of potential effect. Although a programmatic agreement (PA) between the Council and DOE specified how consultation was to proceed during site characterization activities, this document is over ten years old and does not address transportation systems or intermodal transfer stations. We request that it be replaced by a new PA that reflects amendments to the National Historic Preservation Act in 1992 and the revised 36 CFR Part 800 regulations that went into effect in June 1999. The Nevada State Historic Preservation Office requests DOE consult with this agency to craft a new agreement document.

In conclusion, the Draft EIS does not disclose sufficient information to determine effects to properties that might be found eligible for inclusion in the National Register of Historic Places. DOE is urged to enter into consultation with the State Historic Preservation Office as soon as possible to establish a process for meeting its obligations under the National Historic Preservation Act. DOE would have to make commitments in an executed agreement prior to the issuance of a Final EIS.

Incomplete and Inadequate Assessment of Impacts to Native Americans

28 The treatment of Native American issues and impacts in the Draft EIS is entirely inadequate. The Draft EIS ignores potential impacts to Native communities from the transportation of spent fuel and HLW, both in Nevada and nationally. For Native American interests in Nevada, it presents a sanitized section on "Native American Views of the Affected Environment," but fails to reflect the strong and ubiquitous opposition to the Yucca Mountain project on the part of Native peoples in Nevada and California.

29 Nationally, there is absolutely no attempt to identify Native lands and communities located along radioactive waste shipping routes. The Draft EIS should have identified Native American lands that are traversed by or are located in proximity to highway and rail routes. Numerous Indian lands/communities outside Nevada will be impacted by spent fuel and HLW shipments including: Gila Bend, Navajo, San Xavier, and Salt River in Arizona; Umatilla and Cow Creek in Oregon; Miccosukee in Florida; Fort Hall in Idaho; Winnebago in Nebraska; Cattaraugus in New York; Quapau, Ottawa, Modoc, Sac Fox in Oklahoma; and others. The failure to identify Native lands and communities along transportation routes and to assess impacts of the Proposed Action on those entities is another indication of the inadequate and superficial treatment of transportation impacts in the Draft EIS.

30 The Draft EIS also fails to reveal in its discussion of the affected environment that Native American tribes in the immediate vicinity of the Yucca Mountain project area and along potential transportation routes are, for the most part, economically disadvantaged. Reservations and communities in Nye, Lincoln, and Inyo counties are rural and isolated, and either lack a land base or have land bases too small to support their populations by ranching or other locally common means. A large number of people are unemployed, underemployed, and/or living below the poverty level. Any negative statewide economic impacts associated with or caused by the repository or repository-related nuclear waste transportation will have a disproportionate impact on such communities because of these depressed baseline conditions.

31 ... The 1986 Environmental Assessment for Yucca Mountain stipulated that, "[i]f the Yucca Mountain site is approved for site characterization, [Native American impacts] will receive appropriately detailed treatment in research to be performed during the Environmental Impact Statement process."[3] The EA also made special note of the "potential for impacts on Native American cultures from [SNF and HLW] transportation activities" and stated that "[t]his aspect will receive appropriately detailed treatment ... if Yucca Mountain is approved for site

[3] U.S. Department of Energy. Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada, May, 1986, pp C.4-30.

31 cont. characterization."[4] This Draft EIS contains no such "detailed treatment" of Native American impacts.

32 The State of Nevada's research has shown that Native American tribes in the area around Yucca Mountain and along transportation routes have unique governments. As independent federally recognized entities, tribal governments have a role equivalent to states in most federal undertakings. They also have a special status according to various environmental and cultural protection acts and in the Nuclear Waste Policy Act of 1982. To date, none of the tribes in the study area has been granted "affected Indian Tribe" status under the NWPA, although several have applied. The repository project has also spilled over into the campaign by the Western Shoshone National Council, a political entity made up of representatives from many Western Shoshone tribes, to reclaim lands under the Treaty of Ruby Valley of 1863. This has brought the Western Shoshone and other tribal governmental entities into conflict with DOE, as well as other federal and state agencies. Because of the unique governmental position of tribes, their interests are not likely to be well protected or even properly represented in deliberations over the repository. They may also come into conflict with neighboring local governments over differences in positions regarding the repository, thus increasing their isolation from intergovernmental interaction. None of these issues are addressed in the Draft EIS.

33 ... ***Legally and Substantively Deficient Analysis of Socioeconomic Impacts***

The Draft EIS fails to adequately describe the socioeconomic environment at risk of significant impacts from the Proposed Action. The Draft fails to describe the environment with respect to Nevada's major economic sector and discuss why the State's tourism-based economy is especially vulnerable to impacts associated with the proposed Yucca Mountain facility and related transportation of spent fuel and HLW. As noted in specific comments relative to Sections 4 and 5 of the Draft EIS, the State of Nevada, affected local governments in the State, the Nevada University System, and DOE's own contractors have identified potential areas related to tourism, economic development, business in-migration, and related areas potentially vulnerable to the extraordinarily negative and stigmatizing characteristic of high-level nuclear waste facilities and activities. The Draft EIS is deficient in not including these areas in its definition of the socioeconomic environment and comprehensively addressing potential impacts in subsequent sections of the document.

A considerable body of research has been complied by the State of Nevada between 1986 and 1998 and was available to DOE for use in preparing the Draft EIS. The State's comments on DOE's 1995 Notice of Intent to prepare an environmental impact statement for the Yucca Mountain program set forth a comprehensive description of the available research, data, and

[4] Ibid, pp C.7-42.

33 cont. findings. The Draft EIS completely ignores this work and completely fails to address the most significant and far reaching area of likely socioeconomic impacts, the tourism/gaming sector.

A complete and in-depth treatment of the State's impact studies and their findings can be found in the three major summary reports on the Nevada socioeconomic studies published in 1989, 1993, and 1995, respectively.[5] In addition, two major books dealing with the policy implications of the findings of Nevada's socioeconomic research have been published by the State of Nevada's study team.[6] The State's Technical Review Committee has also issued two reports of its findings with respect to the studies, and a summary of the Nevada research was published in the ***Proceedings*** of the National Academy of Sciences.[7]

The Draft EIS inappropriately restricts the socioeconomic "region of influence" to three Nevada counties (Clark, Nye, and Lincoln). The region of influence must also include counties and areas affected by rail spur development and operation; intermodal facility siting, construction, and operations; heavy-haul truck transportation; and highway transport of spent fuel and HLW waste. In addition, the State of Nevada as a whole will be affected by repository activities in terms of impacts on the State's major industries; impacts to the State revenue base; and impacts to State agencies that have responsibilities for repository activities (highway regulation/maintenance, law enforcement, emergency management/response, etc.).

Since the Proposed Action encompasses a national radiological waste shipping campaign of unprecedented proportions, duration, geographic scope, and potential impacts, the socioeconomic environment region of influence should also include cities and communities located along all of the specific transportation routes nationwide. Attempting to constrict the region of influence for the Proposed Action is inappropriate and renders the Draft EIS deficient in its scope and approach to impact identification and assessment.

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[5] Ref. (1) "An Interim Report on the State of Nevada Socioeconomic Studies," (June, 1989); (2)"State of Nevada Socioeconomic Studies of Yucca Mountain 1986 - 1992: An Annotated Guide and Research Summary," (June 1993); and (3) "State of Nevada Socioeconomic Studies Biannual Report: 1993 - 1995," (June, 1995).

[6] Ref. One Hundred Centuries of Solitude, by James Flynn, et al., Westview Press, Boulder, Colorado (1995); and The Dilemma of Siting a High-Level Nuclear Waste Repository, by D. Easterling and H. Kunreuther, Kluwer Academic Publishers (1995).

[7] Ref. "Interim Statement of the Technical Review Committee on the Yucca Mountain Socioeconomic Project," by G. F. White, et al. (January, 1990); "Nuclear Waste's Human Dimension," by K. Erikson, et al., in Forum for Applied Research and Public Policy, Fall, 1994; and "Socioeconomic Studies of High-Level Nuclear Waste Disposal," in Proceedings of the National Academy of Sciences, Vol. 91, pp. 10786 - 10789, November, 1994.

33 cont.

The analyses of socioeconomic impacts is limited only to the areas of employment, population, economic measures (personal income, gross regional product, and government expenditures), housing, and public services. There is no attempt to evaluate the effects of the Proposed Action on the State's major economic sector - the tourism industry - or to examine impacts of the project on property values, economic development, State and local government revenues, State agencies, intergovernmental issues, and other important areas.

Perhaps the most important deficiency in the Draft EIS treatment of socioeconomic impacts is its failure to analyze in any way the impacts of the Proposed Action on Nevada's most significant economic sector. The Draft EIS contains no explanation of why such an analysis was not undertaken, and it ignores extensive comments and information on this matter provided by the State of Nevada and affected local governments in response to the 1995 scoping process Notice of Intent. The failure to address this crucial area of likely and significant impact is, of itself, grounds for finding the Draft EIS legally and substantively deficient.

The State of Nevada formally initiated a comprehensive study of the socioeconomic impacts of a proposed high-level nuclear waste repository at Yucca Mountain in 1986 after the Nevada site had been chosen as a potential waste disposal site. Between 1987 and 1995, the State's study has produced over 250 reports and work products, plus numerous publications in scientific and academic literature.[8] Summaries of research reports produced under the State's studies are attached as Appendix I of these comments.

The State's research has demonstrated that a major potential source of impacts from the Proposed Action stems from intense negative perceptions and avoidance behaviors by the public in response to a high-level radioactive waste repository, which, combined with the vulnerability of the Nevada economy to changes in its public image, could produce large negative impacts. These are not "psychological" impacts. These are real, measurable economic effects that derive directly from the Proposed Action and are substantiated by a considerable body of scientific research and evidence.

The great public and media interest in the radioactive waste program makes it almost certain that any association with these negative perceptions will adversely affect Nevada's attempts to attract tourists, conventions, in-migrants, and new business investments. This would be especially damaging in the event of a nuclear waste accident associated with Las Vegas, which is one of the world's major tourist destinations and a dominant contributor to Nevada's economy.

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[8] A detailed summary of the State of Nevada research can be found in the publication, "State of Nevada Socioeconomic Studies of Yucca Mountain 1986 - 1992: An Annotated Guide and Research Summary," NWPO-SE-056-93 (June, 1993). See also "State of Nevada Socioeconomic Studies Biannual Report, 1993-1995," by James Flynn, et. al. (July, 1995).

33 cont. The conclusion of the Nevada researchers and the State's Technical Review Committee is that stigma impacts could be very negative and very large.

The existing research on stigma effects and potential impacts provides a viable theoretical and methodological base that DOE should have used to undertake a detailed assessment of these types of impacts on Nevada's economy, public revenues, public services, and community quality of life. These assessments should have taken into account the increasingly competitive gaming and tourist marketplaces and the important role that any negative perceptions and stigma could have in affecting an economy uniquely reliant on tourism revenues. It is very possible that, through the social amplification of risk process, even relatively minor events or accidents could have serious economic consequences. Such impacts would dwarf any projected benefits to be derived from project employment and spending.

While Nevada may be especially vulnerable to stigma impacts, given its economic base, the Draft EIS should also have addressed stigma effects for program facilities and transportation routes wherever they might be located in the nationwide system that the Proposed Action postulates.

The analyses of so-called "standard" socioeconomic impacts contained in the Draft EIS are also inadequate and incomplete. The analyses ignore impacts to State and local government revenues, public services such as those related to emergency management and response, intergovernmental systems and relationships, and the unique tax and revenue redistribution systems that characterize Nevada's fiscal environment.

A comprehensive and integrated discussion of the need for an adequate assessment of economic impacts of the Proposed Action is contained in Appendix I of these comments.

A summary of State of Nevada research findings covering each major area of socioeconomic impact assessment is contained in Appendix II of these comment.

The fact that DOE has chosen not to analyze impacts of the Yucca Mountain project on Nevada's principal economic sector and on other areas of the Nevada socioeconomic environment vulnerable to stigma effects of the Proposed Action (i.e., property values, economic development/business location decisions, in-migration, etc.) is disturbing, given DOE's past assessments of the relevance of such impacts to the repository program. As early as 1986, DOE's final EA for the Yucca Mountain site acknowledged the potential for impacts to Nevada's tourism-dependent economy and the need for additional research. In an uncharacteristically insightful pronouncement that actually presages the State of Nevada's later research on the subject, the final EA states:

33 cont.

"... the potential for adverse public perception of a repository and its associated waste transportation could adversely affect the tourism industry. The importance of public perception lies in the attractiveness of the image of Las Vegas to potential visitors. Concerns have been expressed that this image could be affected by the visibility of the repository and waste shipments and by safety concerns regarding the high-level radioactive waste-disposal system, particularly when accompanied by extensive media attention. Preliminary research to date concerning the potential effect of a repository on tourism is inconclusive; ***therefore further studies will be conducted***" (emphasis added).[9]

Additional commitments to address tourism and so-called risk perception impacts are contained throughout the final EA.[10] No subsequent work on this crucial impact assessment area was ever carried out by the DOE Yucca Mountain Project.

The Nuclear Waste Policy Amendments Act of 1987 directed DOE to report to Congress on potential socioeconomic impacts that could occur as a result of locating a repository at the Yucca Mountain site. DOE was directed to report on fourteen (14) specific areas of potential impacts covering the gamut from education to public health to public lands, emergency response, transportation, and the like. Specifically singled out by Congress was the directive (number 13) that DOE report on potential impacts to "tourism and economic development, including the potential loss of revenue and future economic growth."[11]

The "Section 175 Report" was released in December 1988. While the treatment of tourism and economic development impacts in the document was cursory, at best, the report did conclude that a repository at Yucca Mountain could have negative effects on these important economic areas. With respect to economic development, the report found that, "[b]ecause the repository may be defined by some as a hazardous activity, some limitations on the prospects for economic development in Nevada may result."[12]

In evaluating the potential for impacts on tourism and economic development later in the report, DOE concluded, "Possible changes in economic development patterns, generally, and in

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[9] "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," (May, 1986), p. 5-110.

[10] Ibid., p. 5-111, p. 6-87, p. C.7-6.

[11] Public Law 97-425 [42 U.S.C. 10174(a)]

[12] "Section 175 Report: Secretary of Energy's Report to Congress Pursuant to Section 175 of the Nuclear Waste Policy Act, As Amended," by the U.S. Department of Energy Office of Civilian Radioactive Waste Management, December, 1988 (DOE/RW-0205), page 46.

33 cont. the tourism industry specifically, in southern Nevada may result from the repository program."[13] By implication (and intent of Congress), such impacts were to be identified and quantified in subsequent impact assessments.

Following the publication of the Section 175 Report, a policy directive was issued by DOE headquarters to OCRWM Associate Directors and Office Directors stipulating that "... perception-based impacts [i.e., stigma impacts] are of potential concern to affected governments, interested parties and the public and should be appropriately addressed by OCRWM."[14] The memorandum was in response to an earlier memo that sought to limit research in this area. The new directive superceded the prior guidance and specifically noted that "[the previous memorandum] is not viewed as limiting OCRWM-supported research in this area [i.e., stigma and perception impacts on tourism and economic development]."

The June 1992 memorandum was followed in July 1992 with a "Socioeconomic Policy Management Directive" from OCRWM. This directive was intended to serve as "... the program-level policy document that will guide the conduct of all OCRWM socioeconomic activities. Project-level socioeconomic plans for all OCRWM components will be prepared in accordance with the guidance provided in this document, and will serve as the primary source of information about each project's socioeconomic activities." (page 1)

To guide the OCRWM socioeconomic program, the Policy Directive set forth a list of specific objectives "designed to help OCRWM realize its mission." Two of these objectives are especially relevant to the Draft EIS:

- Address "standard" impacts arising primarily from program-related employment and population growth as well as expenditures for materials, equipment, and services.
- Address developments, as necessary, in the area of "special" impact assessment arising primarily from the various components of the high-level radioactive waste program."(page 2)[15]

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[13] Ibid, page 64.

[14] Memorandum from Jerome Saltzman, Director, OCRWM Office of External Relations, dated June 3, 1992.

[15] The terms "standard"impacts and "special" impacts are terms of art in socioeconomic assessment. The former refers to the impacts of the range of specific economic indicators used routinely in such assessments. The later refers specifically to those impacts that occur as a direct result of the nuclear or hazardous nature of the project and are synonymous with "stigma" impacts.

33 cont. The Draft Yucca Mountain EIS addresses only "standard" impacts associated with the Proposed Action (and that only partially). It completely ignores the "special" impact assessment directive.

In addition to DOE's policy pronouncements regarding the need to assess "special" impacts, there is evidence that DOE considered the State of Nevada's extensive work in identifying potential stigma impacts associated with the high-level radioactive waste program to be credible and appropriate. In 1993, DOE commissioned Argonne National Laboratory to evaluate research on risk perception and stigma impacts carried out by the State of Nevada. Since much of the State's work involved survey research, Argonne contracted with the National Opinion Research Center (NORC) at the University of Chicago to undertake a technical evaluation of the methodologies used in the State's "special" impact assessment activities. The NORC report is instructive as to the high quality and appropriateness of the Nevada stigma research. The report concluded:

> "... the [State of Nevada] surveys could provide valuable data about risk perceptions and potential behavioral responses. NORC identified a few minor problems with a number of questions and calculated response rates but claimed these problems would probably not have any major biasing effects."[16]

The report went on to praise the creativity and robustness of the survey research, noting that the State surveys "exhibit some considerable creativity in approaching a difficult measurement problem." The report expressed "confidence that the conclusions [of the State's stigma research] are not highly dependent on the measurement technique, that is they are robust across measurement methods," noting that "... such robustness is a very important attribute in assessing the validity of the surveys."

DOE has, in fact, sponsored its own "stigma" research that is not included in the socioeconomic analyses contained in the Draft EIS. An excellent example of this research is the work done by the University of New Mexico under contract with DOE. Of particular interest is a study by Drs. Gawande and Jenkins-Smith on the effects of stigma on property values along routes in South Carolina that were used to transport spent nuclear fuel from foreign research reactors. The Gawande and Jenkins-Smith findings are extraordinarily important and relevant to the potential for stigma effects stemming from the Yucca Mountain project and related nuclear waste transportation. Specifically, the researchers found that the hazardous, nuclear nature of these shipments and people's responses to them directly caused property values in urban Charleston to be "lowered in a substantive manner":

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[16] "Technical Evaluation of Available State of Nevada Survey Instruments," by Argonne National Laboratory, Environmental Assessment and Information Sciences Division, February, 1993 (ANL/EAIS/TM-93), page 1.

33 cont. "... we are convinced by the results for Charleston County [South Carolina] that real price effects can occur when shipments like those involved in the [foreign spent nuclear fuel] FSNF return program take place. Despite systematic and extensive search for alternative explanations, the onset of the shipments appears to be the best explanation for the drop in housing values close to the route. Moreover, the results are consistent with research regarding the effects of other disamenities (e.g., polluted water, air and Superfund sites), with the self-reports of perceived risk of spent nuclear fuel shipments obtained in public opinion surveys, and with surveys of expected effects of nuclear waste shipments on housing values (Flynn et al, 1997)."[17]

It is clear from the historical record that DOE, as early as 1988, recognized the potential for "special" or stigma effects of the Yucca Mountain program to result in significant impacts to Nevada. DOE took steps to evaluate the extensive body of research on this matter produced by the State of Nevada and found that work to be sound. Finally, DOE undertook its own research on stigma impacts associated with the transportation of spent nuclear fuel and obtained confirmation that such impacts can and do occur and are potentially significant.

The fact that no assessment of "special" impacts to Nevada's uniquely vulnerable tourism-dependent economy was conducted in the Draft EIS, despite DOE's prior knowledge of the potential for and legitimacy of such impacts, renders the socioeconomic impacts assessment in the Draft EIS both legally and substantively deficient.

34 ... ***Inappropriate Transportation Scenarios***

The transportation scenarios analyzed in the Draft EIS are inappropriate and non-reflective of reasonable transportation scenarios for the project. The all truck and all rail scenarios do not reflect a reasonable and readily identifiable expectation of how waste shipments would occur.

Information is readily available to DOE to estimate, with a high degree of certainty, which reactor/generator sites would ship spent fuel or HLW by rail, which would ship by truck, and which would ship by some form of barge-rail combination. The State of Nevada conducted such an evaluation in 1996 using available information.[18] The results of that study are contained in Attachment V to these comments.

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[17] "Nuclear Waste Transportation and Residential Property Values: Estimating the Effects of Transient Perceived Risks," by Kishore Gawande and Hank Jenkins-Smith, University of New Mexico, June 1999 (page 28).

[18] "The Transportation of Spent Nuclear Fuel and High-Level Waste: A Systematic Basis for Planning and Management at National, Regional, and Community Levels," by Planning Information Corporation (September, 1996).

34 cont. The State of Nevada also believes that the use of bounding scenarios for evaluating potential transportation impacts is inappropriate when information clearly exists that would have allowed a more accurate and realistic assessment. DOE appears to have chosen not to undertake a site-specific, point-to-point evaluation in order to keep the transportation analysis (and its results) general in nature and less likely to provoke the public response and involvement that would accompany a more detailed and realistic transportation impact assessment.

35 The use of the all train scenario is especially problematic because, given the lack of rail access to Yucca Mountain, there is no justification for it. The Draft EIS, as discussed elsewhere in these comments, does not demonstrate that rail or intermodal (rail to heavy-haul truck) access to Yucca Mountain is feasible. Therefore, assuming that all spent fuel and HLW can be shipped to the site via rail is inappropriate.

36 The transportation scenarios used as the basis for assessing transportation impacts in the Draft EIS are legally and substantively deficient. The evaluation of transportation risks and impact must be redone using realistic and reasonable transportation scenarios.

37 ***Failure to Disclose Transportation Routes***

The Draft EIS fails to identify the specific transportation routes for spent fuel and HLW shipments from specific reactor and generator locations to Yucca Mountain, despite the fact that these routes were identified as part of the analyses contained in the transportation appendix. DOE, in effect, has chosen to hide the routes and simply report the results of the analyses in a generic fashion. The half-hearted and inadequate attempt to publish a set of route maps three week before the end of an extended comment period (and after 18 of 21 public hearings had already been conducted without any notice to the public about likely routes and potentially impacted communities) in no way mitigates this extraordinary and fundamental deficiency in the Draft EIS. The maps themselves fail to contain information about shipment numbers, modal mix, and specific communities impacted.

One can only conclude that the failure to disclose specific nuclear waste shipping routes in the Draft EIS is intentional and designed to serve a political objective of suppressing public interest in the project and participation in the public hearings, especially those in states other than Nevada. Nevada believes that DOE has violated the National Environmental Policy Act by concealing crucial information used in the Draft EIS. Absent this information, persons affected by the transportation impacts of the Proposed Action have no way of determining the substantive and legal sufficiency of DOE's analysis. Such concealment of information can only diminish public confidence in DOE's ability to safely transport these highly radioactive materials and, of itself, renders the Draft EIS fundamentally deficient.

Inadequate Analysis of Rail Corridors in Nevada

38 The analysis of potential rail corridors in Nevada is inadequate, incomplete, and arbitrary. Different corridors are evaluated at different levels of detail; specific alignments are not identified precisely enough to adequately assess impacts; and no preferred alternative is identified. That decision is left to some "future" decision point, but DOE states that the information in the Draft EIS "could" be used to make the decision at that time.

The analysis of potential rail corridors and the identification of a preferred alternative is essential to assessment of transportation risks and impacts associated with the Proposed Action in the Draft EIS. There is no justification for deferring such analyses to an unspecified future time and unspecified "environmental reviews." The Draft EIS should have contained detailed and specific evaluations of each potential corridor, with the same level of information and analysis for each. The Draft EIS should then have compared the available alternatives and identified the one that minimizes risk and maximizes safety. Absent such an evaluation, the Draft EIS is deficient.

39 *Inadequate Analysis of Highway Routes in Nevada*

The evaluation of alternative highway routes is inadequate, incomplete, and relies on numerous questionable assumptions. The most likely alternative highway route (the NDOT 'B' route from I-80 to US 93 to US 6 to US 95) is not analyzed at all; the primary route (I-15 to US 95) assumes infrastructure that is not in existence (the yet-to-be-built Las Vegas beltway section); and the Draft EIS ignores the route that would be used under existing U.S. Department of Transportation regulations (I-15 connecting directly with US 95 in Las Vegas).

The Draft EIS should have evaluated all potential highway routes in Nevada for waste shipments to Yucca Mountain, with the same level of information and analysis for each. The Draft EIS should have contained a detailed comparison among the available alternatives, and a preferred alternative should have been identified. Deferring such analyses and decisions to some unspecified future time is inappropriate and renders the assessment of transportation risks and impacts in the Draft EIS inadequate and deficient.

40 ... *Inadequate Treatment of Heavy-Haul Truck Transport in Nevada*

The Draft EIS fails to demonstrate the feasibility of the unprecedented large-scale, long duration heavy-haul transport of SNF and HLW on public highways. It misrepresents the operational complexity of such shipments; grossly underestimates the amount and cost of infrastructure improvement required along Nevada highways; and contains an incomplete and inadequate analysis of potential heavy-haul truck (HHT) routes.

40 cont. Nevada believes that the use of heavy-haul trucks for thousands of shipments of spent nuclear fuel from any of the proposed intermodal transfer facility sites to Yucca Mountain is infeasible and dangerous. The costs associated with highway construction and improvements would be prohibitive, if the necessary infrastructure modifications could be made at all. The disruption to traffic flows and the accident risks posed by these massive, slow-moving, multiple unit vehicles and their escorts would pose unacceptable and unmitigable problems for Nevada's highways. In addition, the frequency of heavy-haul trips required to deliver waste and return the empty vehicle to the intermodal facility would place an unprecedented and unacceptable burden on Nevada's highway transportation infrastructure.

The Draft EIS should have evaluated heavy-haul transport in Nevada against the other alternatives for delivering spent fuel and HLW to Yucca Mountain, and DOE should have determined that such shipments are costly and impractical at best, dangerous and irresponsible at worst. Simply examining the heavy-haul option as a stand-alone alternative, as the Draft EIS does, is inadequate.

41 ***Inadequate and Inaccurate Analysis of Spent Fuel Radiological Characteristics***

The Draft EIS misrepresents the radiological characteristics of the spent fuel that would be transported, using reference fuel that is older, less radioactive, and less thermally hot. The EIS considers a "typical" Pressurized Water Reactor (PWR) assembly as one that has cooled for 25.9 years (page H-17). The State believes this an inaccurate assumption. However, even if one accepts this average age of 25.9 years, it is quite likely that fuels cooled both less than and more than 25 years would be transported to the proposed repository. Therefore, the accident consequences would be greater than estimated by DOE simply because radionuclides decay exponentially.

Contrary to DOE's view that oldest fuel will be shipped first, it is more likely, due to cost and operational considerations, that older fuel would first be shipped to the proposed Private Fuels Storage facility in Utah, and newer fuel would be shipped first to the proposed repository, followed at a later time by very old spent fuel. The average age of fuel shipped might be 25.9 years, but in terms of accident impacts, it is inappropriate to use the average age of fuel, since it is not a linear, but exponential, decay. Using only the "average" fuel characteristics results in a gross underestimate of impacts of potential releases from shipping containers.

42 ... ***Faulty Assessment of Routine Radiation Exposures Due to Transportation***

The Draft EIS grossly underestimates the routine radiation exposures along highways and rail lines. The generic analyses contained in the Draft EIS do not account for the potentially long stop-times, slow speeds, unique highway characteristics, and the interface between highway infrastructure and community characteristics along potential Nevada heavy-haul routes.

42 cont. Repeated transit of spent fuel and HLW shipments (thousands of trucks over a sustained period of almost four decades) would result in routine exposures greater than estimated in the Draft EIS, especially in areas like Las Vegas (I-15, Spaghetti Bowl, Beltway), Caliente, Tonopah, Goldfield, Beatty, and Pahrump, depending on the location of the intermodal transfer facility.

43 ***Inadequate Treatment of Accidents and Terrorism/Sabotage Impacts***

The Draft underestimates the consequences of severe accidents and terrorism/sabotage incidents, especially with respect to heavy-haul transportation. The Draft EIS fails to appropriately recognize human initiated events as risk factors associated with the loading, transportation, and unloading of radioactive waste shipments. The Draft reflects an overriding "denial" philosophy that is evidenced in the lack of critical or even anecdotal discussion of sabotage and terrorism within Section 6 and Appendix J of the Draft EIS.

The Draft EIS must acknowledge the existence of credible and realistic risks from sabotage and terrorism. The symbolic value of repository shipments as targets and the regularity, frequency, and duration of shipments substantially increase the risks of human initiated events.

Spent fuel loading, transfer, and unloading activities should have been recognized as vulnerable to sabotage and terrorism attacks. These risks should have been addressed in the Draft EIS together with the implications of new regulations needed to limit the effects of human initiated events on the overall repository shipment program.

The complete point-to-point shipment process needs to be re-analyzed using updated assumptions about terrorist/sabotage technology and more realistic expectations of the potential for sabotage and terrorism attacks. The State of Nevada has begun this process by publishing several relevant documents on target types and risks associated with potential adversaries. Recognition of these concerns and an adequate analysis of the risks associated with potential terrorism/sabotage must be incorporated within the final EIS.

PART THREE
SPECIFIC COMMENTS

SECTION 1. PURPOSE AND NEED FOR AGENCY ACTION

44 Page 1-1; Section 1 - Purpose and Need for Agency Action

The original intent of the NWPA was the permanent disposal of nuclear waste. DOE has ignored this intent and, instead, has focused on delaying releases from the repository so that future generations must shoulder the burden of and be affected by the resulting contamination. The Yucca Mountain project, as depicted in this Draft EIS, does nothing but target future generations for radionuclide contamination.

45 The Draft EIS states that "DOE has ultimate management responsibility for other highly radioactive materials. Examples of such materials include Greater-Than Class-C and Special-Performance-Assessment-Required wastes. The Department might need to dispose of these materials in a monitored geologic repository to protect public health and safety. However, disposal of Greater-Than Class-C and Special-Performance-Assessment-Required wastes at the proposed Yucca Mountain Repository could require additional legislative action or a determination by the U.S. Nuclear Regulatory Commission to classify them as high-level radioactive waste."

The State of Nevada contends that DOE has not developed a "path forward" for the disposition of commercial Greater-Than Class-C (GTCC) waste and/or DOE owned Special-Performance-Assessment-Required wastes. DOE must acknowledge that the Waste Management Programmatic Environmental Impact Statement (DOE/EIS-0200-F) did not address bounding alternatives for the disposition of these waste types. Because of the long-lived radiation hazards associated with these waste types, the Draft EIS should have acknowledged that these wastes must be confined from the biosphere for the indefinite future. In other words, shallow land burial is not an option for final disposition of these wastes. Rather than provide a largely speculative discussion about what might be needed to resolve the "path forward" disposal options, the Final EIS must acknowledge that DOE has yet to postulate a preferred disposal option for these wastes.

46 ... Page 1-3; Section 1.1 - Potential Actions and Decisions Regarding the Proposed Repository

The text states that the Draft EIS analyzes potential impacts of transporting SNF and HLW to Yucca Mountain from 77 sites across the United States. However, nowhere in the Draft EIS is there a description of the routes that were analyzed or maps that show specific highways and rail lines. This omission is a major deficiency in the document -

46 cont. one that, by itself, provides legal basis for the Draft EIS to be withdrawn and reissued for public comment with transportation routes clearly identified and route specific analyses articulated and evaluated. It is impossible for the public located along potential routes to participate in the NEPA process when critical information regarding the nature and location of potential impacts is hidden or withheld.

47 The text states that "the EIS provides the information necessary to make decisions regarding basic approaches [to waste transportation] (for example, mostly rail or mostly truck shipments), as well as the choice among alternative transportation corridors." The content of the Draft EIS does not substantiate this statement. In fact, given the overtly generic manner in which information is analyzed and presented, it will be necessary for DOE, at a minimum, to prepare a separate EIS that addresses impacts associated with transportation modes and route alternatives.

Nevada also contends that, contrary to the assertion in Section 1.1, future decisions such as the selection of specific rail alignments or specific locations of an intermodal transfer facility will require more than just additional field surveys, consultations, engineering and environmental analyses, and NEPA reviews. The information contained in the Draft EIS is not even sufficient to support the selection of a specific corridor for construction of a rail spur to Yucca Mountain. Such a decision must be supported by a separate EIS that adequately evaluates alternatives, including information about specific rail alignments. Nevada further contends that selection of a location for an intermodal transfer facility must also be supported by a separate EIS, not just supplementation of the inadequate and incomplete generic analyses contained in this Draft EIS.

48 ... Apparently, DOE has chosen to limit the National Environmental Policy Act decision process for the Draft EIS by postponing specific decisions on transportation modes and routes and disposition of waste volumes greater than 70,000 metric tons. Given this situation, the Draft EIS must provide additional detail about how the NEPA process will be followed to make forthcoming "repository related" decisions. Specifically, the discussion in the Draft EIS on page 1-21 (Environmental Impact Analysis Process) must be expanded to include how NEPA tiering requirements (40 CFR 1808.28) will be addressed for assessing connected actions and decisions.

DOE has not demonstrated the technical, economic, or environmentally acceptable feasibility of transporting spent nuclear fuel and high-level radioactive waste to the proposed site. Absent this demonstration, DOE violates the National Environmental Policy Act by deferring the transportation related decisions. Specifically, if the proposed repository is approved based upon this EIS, DOE will begin to make a substantial commitment of resources to the proposed repository, even though the method of transportation to the site has not been determined. This could result in forcing a

48 cont. transportation related decision that results in unacceptable, adverse impacts. This is the scenario that the NEPA process is designed to avoid.

49 This section must also include a discussion about the need for and/or option to use NEPA supplemental environmental impacts statements to address forthcoming repository related decisions (as per 10 CFR 102.314). State officials contend that DOE will receive substantial public comment on the Draft EIS about the lack of NEPA analysis to support the selection of transportation modes and routes. DOE must advise readers that supplemental EIS documents will be prepared if DOE determines that the purpose of NEPA will be furthered by doing so (40 CFR 1502.9(c)(2). This section should also note that DOE is required to prepare a supplemental EIS if there are substantial changes in the Proposed Action that are relevant to environmental concerns, or if there are significant new circumstances or information about environmental concerns that would affect the Proposed Action or its impacts (40 CFR 1502.9 (c)).

50 Page 1-7; Section 1.2.3 - High-Level Radioactive Waste

The Draft EIS indicates that liquid HLW will be vitrified, poured into canisters, and allowed to solidify prior to transport to Yucca Mountain for final disposal. The Draft EIS gives the impression that this vitrification process is readily available and easily applied to the waste forms currently existing at DOE facilities. The Draft EIS fails to address the substantial problems that have plagued DOE's waste vitrification program and the implications of potential failure to make vitrification possible and/or practical at various DOE generator locations. Operational failure of the vitrification process will have significant implications for worker health and safety, transportation risks, surface facility operations at Yucca Mountain, and long term repository performance.

51 Page 1-8; Section 1.2.5 - Other Waste Types with High Radionuclide Content

The Draft EIS fails to articulate an adequate legal rationale supporting the inclusion of wastes other than spent nuclear fuel and high-level radioactive waste as defined in the Nuclear Waste Policy act of 1982, as amended. Particularly, there does not appear to be any legal justification for the inclusion of "Special-Performance-Assessment-Required" waste referred to in Section 1.2.5.

52 ... Page 1-9; Section 1.3.2 - Nuclear Waste Policy Act

The discussion of the Nuclear Waste Policy Act contained in this section presents a distorted and revisionist picture of the process that led to the 1987 amendments. The discussion fails to address the serious problems with DOE's implementation of the original Act, congressional investigations that found DOE deficient in its handling of the

52 cont. program, the level of controversy surrounding the program, the highly charged political environment that led to the 1987 amendments, and the purely political criteria that were used to single out Yucca Mountain as the only site to be studied. This information provides essential context for evaluating and understanding impacts associated with the program as it exists today.

53 Page 1-13; Section 1.3.2.4 - Environmental Protection and Approval Standards for the Yucca Mountain Site

While the Yucca Mountain Draft EIS is not intended as a site suitability document, it must nevertheless address the site's ability to meet established health, safety, and environmental standards. The performance of the site in relation to such standards is, itself, a measure of impact on the physical and human environment. The final EIS must evaluate Yucca Mountain against the proposed Environmental Protection Agency radiation protection standards and must demonstrate that the Yucca Mountain site can meet the 15 millirem annual release standard and the 4 millirem groundwater protection standard. Failure to meet these EPA standards would constitute a significant project impact and would lead to the disqualification of Yucca Mountain as a candidate site.

54 Page 1-16; Figure 1-6 - Land Withdrawal Area Used for Analytical Purposes

The expanded map is not correct. The locations of the Lathrop Wells Road, its intersection with Highway 95, and Amargosa Valley are incorrect. The Lathrop Wells road exits the southern boundary of Area 25 of the Nevada Test Site and proceeds south to Highway 95, just west of the intersection with State Road 373 at Amargosa Valley.

55 ... Page 1-17; Section 1.4.2 - Proposed Disposal Approach

The third sentence of the first full paragraph indicates that "(t)he waste packages would be moved underground by rail." This is also described elsewhere in the document (Section 2.1.2.2.1 Subsurface Facility Design and Construction, Page 2-27 through 2-31). However, nowhere does the Draft EIS indicate what level of inspection will be performed on the rail/trolley system, as well as other infrastructure in place at the site. Inasmuch as a transportation or emplacement related accident at the site could have catastrophic and long-term impacts to Nevada, quality control, inspection by qualified outside expertise, and a comprehensive maintenance and inspection program for the transportation activities and infrastructure within the site are critical to program safety. The Draft EIS fails to address this important component of long-term site safety.

DOE can contract for such services from the private sector, utilize existing contractors, hire DOE expertise in these areas, or provide resources so that other State or federal

55 cont. agencies conduct inspections. Additional resources for affected federal or state agencies would need to be quantified and funded accordingly.

56 Page 1-20; Section 1.4.3.3 - Site Recommendation

The terms used in Sec. 114(a) of the Nuclear Waste Policy Act should be used in describing the requirements for recommending the site:

Bullet 2 - "waste form" not "material forms"; and "form" not "forms";

Bullet 5 - "waste form" not "material form"; and "analysis seem to be sufficient" not "are sufficient"

57... Page 1-21; Section 1.4.3.4 - No-Action Alternative

This section states "DOE recognizes that neither scenario would be likely if there were a decision not to develop a repository at Yucca Mountain; however, they are part of the EIS analysis to provide a baseline for comparison to the Proposed Action."

The two scenarios are so irresponsible as to make them impossible. The nature of the hazard of spent nuclear fuel is such that it would never be permitted remain at reactor sites without active institutional controls. There is no basis to assume that active institutional controls could be implemented for 10,000 years. This is pure speculation, substantiated by the statement in Section 2.2, No-Action Alternative (page 2-59): "Under any future course that would include continued storage, both commercial and DOE sites would have an obligation to continue managing spent nuclear fuel and high-level radioactive waste in a manner that protected public health and safety and the environment."

The fact that neither of the No-Action Alternative scenarios would be permitted or implemented dictates that these are not reasonable alternatives. NEPA regulations require that alternatives to the Proposed Action be reasonable (Sec. 1502.14). Therefore, the Draft EIS No-Action Alternative is not in compliance with NEPA regulations, and the Draft EIS is insufficient in this selection of No-Action Alternative scenarios.

The Draft EIS, on page 2-1 states, "DOE does not intend to represent the No-Action Alternative as a viable long-term solution but rather to use it as a baseline against which the Proposed Action can be compared." Comparing the impacts of unreasonable alternatives to impacts of the Proposed Action is meaningless and serves no purpose in the analysis of impacts of the Proposed Action.

57 cont.

While the NWPA exempts DOE from the need to evaluate alternatives to the Yucca Mountain site and to geologic disposal, it does not exempt DOE from evaluating a reasonable No-Action Alternative that represents the situation without a Yucca Mountain repository. The No-Action Alternative selected for analysis by DOE postulate scenarios where spent fuel and HLW are left on-site at generator locations for 10,000 years. Such scenarios are entirely unrealistic. The Draft EIS must be rewritten using a No-Action Alternative that realistically depicts the future in the event DOE is required to abandon the Yucca Mountain project. The NWPA, as amended, specifically directs DOE to report back to Congress for instructions on how to proceed in such an event. It is entirely unrealistic - even absurd - to believe that Congress would direct DOE to store waste at generator sites for 10,000 years. The No-Action scenarios contained in the Draft EIS appear to have been chosen for their political value to alarm the nation and to pressure Congress and the Administration to stay the course with Yucca Mountain in spite of the many serious flaws within the current program.

58 Page 1-21; Section 1.5 - Environmental Impact Analysis Process

This gives an overly broad view of NEPA that focuses on procedure and avoids the intent, purpose, substance, and spirit of the Act. There is no indication of the guidance followed in the course of conducting Environmental Impact Assessment or for preparing the Draft EIS. New guidelines and techniques for improving the NEPA process (e.g., Salk and others, 1998; Caldwell, 1998; Clark and Canter, 1997; Ortolano, 1997; Gilpin, 1997; Weisner, 1995; Bartlett and Malone, 1993) appear not to have been used in this case. Moreover, significant substantive issues raised prior to the release of this Draft EIS and contained in Attachments A, B, C, D, E, F, G, and H have not been addressed.

59 ... Page 1-21; Section 1.5.1 - Notice of Intent and Scoping Meetings

The State of Nevada reiterates its objection to the manner in which the scoping process for the Draft EIS was handled, both in Nevada and elsewhere. In comments on the proposed scope of the Yucca Mountain EIS in 1995, the State found that the notices of the scoping meetings did not adequately describe the Proposed Action and its implications for people along transportation routes. DOE failed to indicate the true national scope of the high-level waste program and deliberately chose not to make people aware of the potential transportation routes through their communities - and the consequent risks from spent nuclear fuel (SNF) and HLW shipments - as part of the notices for scoping meetings. Failure to adequately inform potentially affected citizens of possible consequences of the Proposed Action for their communities created a situation where public participation in the EIS scoping process was suppressed, as evidenced by the poor turnout at most of the EIS scoping meetings. In effect, DOE disenfranchised people throughout the country who stand to be substantially affected by the proposed

59 cont. repository program and who were not afforded adequate opportunity to participate in the initiation of the NEPA process.

In addition to DOE's failure to adequately notice the scoping Draft EIS hearings, the information contained in the original Notice of Intent (NOI) and DOE's informational presentations at the beginning of each scoping meeting misrepresented and, in certain instances, distorted the Yucca Mountain program and its possible impacts. For example, no information was provided on the possible unfavorable conditions present at the Yucca Mountain site. The implementation alternatives contained in the NOI failed to include any discussion of the relationship between thermal load, the space required for waste emplacement, and the capacity constraints at the Yucca Mountain site. Inadequate information was provided on the relationship between regional (i.e., Nevada-specific) and national transportation impacts and analyses, and misleading information was provided regarding transportation regulations, waste volumes required to be transported, and the possible modes and routes for SNF and HLW transportation.

The inadequate meeting announcements and the incomplete information presented led to a recommendation by the State that DOE extend the scoping period and initiate new scoping meetings. DOE rejected the State's recommendation and proceeded with development of the Draft EIS.

The fact that the repository project description "evolved" significantly from the time of the scoping meetings in1995 to the issuance of the Draft EIS in August 1999 created a situation wherein the "project" that was presented in scoping materials and hearings is now unrecognizable in the Draft EIS. The conceptual design for the repository in 1995 relied primarily on the geologic environment for waste isolation, while the "evolved" design of this Draft EIS places primary waste containment emphasis on engineered barriers, with little or no credit taken for the isolation capabilities of the Yucca Mountain geology. In addition, the three thermal load scenarios specified in the 1995 scoping materials and carried forward into the Draft EIS no longer reflect the thermal conditions postulated for the current preferred repository design.

For all these reasons, the original scoping process and scoping meetings should be considered inadequate as well as irrelevant to the current state of the proposed repository program. DOE should be required to re-scope the project and reissue the Draft EIS using the information obtained from the new public scoping process, as required under NEPA.

60 ... Page 1-23; Section 1.5.1.1 - Additional Inventory Studies

The Nuclear Waste Policy Act limits the amount of spent nuclear fuel that can be disposed in a Yucca Mountain repository. In addition, the Act does not authorize

60 cont. disposal of Greater-Than-Class-C or Special-Performance-Assessment-Required waste in a Yucca Mountain repository.

61 Page 1-24; Section 1.5.3 - Relationship to Other Environmental Documents

This section includes the 1996 Final EIS for the Nevada Test Site (NTS) but does not mention the important DOE-NTS Resources Management Plan that should have been used as the model for the Yucca Mountain environmental assessment. This issue, essentially involving the use of ecosystem management, is further discussed in Attachments F, G, H, I, J, K, and L.

62 ... Page 1-26; Section 1.5.3 - Relationship to Other Environmental Documents

Table 1-1 - Draft EIS, Idaho High-Level Waste and Facilities Disposition

The 1995 Idaho/DOE Settlement Agreement (USDC) schedules conversion of all sodium-bearing HLW liquid waste in the INTEC Tank Farm into calcine by 2012 and mandates removal of all calcined HLW by 2035. DOE now estimates that treatment will be completed and waste will be "ready for removal" from the Idaho National Environmental and Engineering Laboratory (INEEL) by 2035, but does not guarantee the waste will actually be removed by that date.

The State of Idaho maintains that sodium bearing tank waste is HLW and cites the DOE Order 435.1 definition of high-level waste as "liquid produced directly in reprocessing." Using this definition, the State identifies both sodium bearing and non-sodium bearing waste as HLW. The State of Idaho also includes in its HLW definition liquids from the second and third extraction cycles that were routed to an evaporator before being sent to the Tank Farm and states that "as such, these liquids contain radioactive fission products in sufficient concentrations to warrant permanent isolation in a geologic repository." (DOE says only the liquid from the first reprocessing cycle is HLW.) Idaho contends that DOE should manage the sodium-bearing waste as HLW unless and until a "Waste Incidental to Reprocessing" determination is made in which the referenced HLW waste would be classified and managed as either TRU or low-level waste.

If Idaho's definition of HLW holds up, volume estimates for HLW from INEEL to Yucca Mountain could change substantially and would put pressure on DOE's 4,667 MTHM volume commitment for HLW in Yucca Mountain.

Idaho has also formally recommended that DOE allow disposal of HLW containing hazardous waste constituents at Yucca Mountain. If INEEL prevails, other sites would

62 cont. also be in line to ship such wastes to Yucca Mountain, and volume and waste type estimates, as well as the regulatory oversight scenario, would be significantly altered.

Idaho is also challenging DOE's method for calculating Metric Ton Heavy Metal for HLW because it does not accurately reflect actual concentrations of radionuclides and relative risk, i.e., DOE's standard says one canister of HLW = 0.5 MTHM. Idaho says this calculation does not recognize the fact that much of DOE's waste is less radioactive than "typical" waste used in the comparison. Idaho says DOE has overestimated the HLW MTHMs, exceeding the amount allowed in the repository. Idaho further contends that, if other methods of calculating MTHM were used, DOE could stay well within the capacity set for Yucca Mountain and allow INEEL to send larger quantities of its waste to Nevada.

Because waste volumes and types are so central to understanding the entire range of impacts associated with a Yucca Mountain repository, the Draft EIS should have fully evaluated these issues.

63 *Final Waste Management PEIS for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (Waste Management PEIS) (DOE 1997b)*

This document characterizes and identifies the volumes of HLW at DOE facilities nationwide and uses or updates previous Spent Nuclear Fuel information. The PEIS evaluates only the storage of immobilized HLW canisters. Treatment and disposal of HLW were not analyzed. However, the final disposition of these immobilized canisters is on-site storage "until shipment to a geologic repository for disposal." If this waste is to be disposed at a Yucca Mountain repository, the Draft EIS should evaluate both the treatment and disposal of this waste at Yucca Mountain.

SECTION 2. PROPOSED ACTION AND NO-ACTION ALTERNATIVE

64 Page 2-2; Section 2.1 - Proposed Action

There is no justification provided for the proposal to permanently withdraw 230 square miles (150,000 acres) of land for the repository. A rationale for this large a withdrawal area should be provided, especially in light of the fact that the proposed underground repository and surface facility cover an area of less than 6 square miles.

65 ... Page 2-6; Section 2.1.1 - Overview of Implementing Alternatives and Scenarios

It appears that DOE has chosen to segment the Proposed Action into various transportation and repository development activities. Such activities are further

65 cont. subdivided into a national and a Nevada-specific transportation program. The transportation program includes the off-site manufacture of shipping casks and disposal containers, construction of a potential rail line to Yucca Mountain, and development of heavy-haul truck capabilities using one or more intermodal (rail to truck) waste transfer facilities. For repository development, DOE has divided activities into surface and sub-surface repository construction. Such segmentation is incompatible with the requirements of a comprehensive assessment of impacts and, in the absence of a Programmatic EIS and tiered EISs for related program components, may be in violation of NEPA.

Because of the multitude of uncertainties associated with these activities, along with the evolving nature of the program, the Draft EIS depends on an analytical environmental impact process that "bounds" impacts likely to result from the Proposed Action. This bounding analysis supposedly incorporates assumptions so conservative that they overstate the risks and thereby fully address the multitude of program impacts and uncertainties. While this approach is typically used for Programmatic EIS documents, this Draft EIS is not a Programmatic EIS.

There are also outstanding and potentially significant non-programmatic issues that are part of the Proposed Action that must be specifically evaluated in the Draft EIS. These issues should not be misrepresented as programmatic alternatives evaluated through a "bounding analysis." For example, Navy spent fuel in storage at the Idaho National Environmental Engineering Laboratory will be shipped by rail to a geologic repository. Consequently, either rail access to Yucca Mountain will be developed or an intermodal waste transfer facility and heavy-haul trucks will be required to move Navy spent fuel to a Yucca Mountain repository. Since the Draft EIS is not a programmatic document and fails to evaluate the impacts of moving Navy fuel to Yucca Mountain, supplemental NEPA documents must be prepared to assess such impacts. To do otherwise misrepresents the NEPA process.

66 Since titanium drip shields are required for all repository design scenarios discussed in the Draft EIS, DOE must also address resource impacts and costs associated with the acquisition and manufacture of the drip shields.

67 ... The Draft EIS explicitly acknowledges that DOE does not have a final or even current design for a repository at Yucca Mountain. There is, therefore, no realistic basis for evaluating the impacts of the Proposed Action on people and the environment. The Draft EIS states "DOE recognizes that the plans for a repository would continue to evolve during the development of the final repository design and as a result of U.S. Nuclear Regulatory Commission licensing review of the repository. In addition, decisions on how spent nuclear fuel and high-level radioactive waste would be packaged ... would be part of the transportation planning process."

67 cont. This statement reflects the legal and substantive insufficiency of the Draft EIS. Future decisions regarding the facility design, transportation system configuration, and repository operations - decisions that are not part of the analysis contained in the Draft EIS - can drastically alter the type and significance of impacts that are generated. The Draft EIS should have included a detailed and specific repository design that can be identified and evaluated as integral to the Proposed Action. Likewise, other aspects of the Proposed Action that can generate significant impacts, such as the transportation system, must be identified and described at a level of detail that permits adequate impact identification and assessment. Attempting to compensate using unclear, undefined, and overly generic descriptions of the Proposed Action seriously interfere with the ability of the public and other reviewers to evaluate the adequacy of the analyses contained in the Draft EIS.

68 Page 2-9; Section 2.1.1.3 - National Transportation Scenarios

The Draft EIS fails to identify the national highway, rail, and barge shipping routes that would be used to transport SNF and HLW from generator sites to Yucca Mountain. Absent such clearly identified routes, it is impossible to adequately assess impacts to communities and the environment along transportation corridors. The failure to specify routes and to conduct route-specific impact assessments not only prevents citizens living in cities and communities along those routes from participating effectively in the NEPA process, but it also precludes a differential comparison of risks and impacts among alternative routes and combinations of modes and routes. This is a major shortcoming of the Draft EIS and is, itself, grounds for determining that the Draft EIS is substantively and legally deficient.

69 ... Page 2-9; Section 2.1.1.4 - Nevada Transportation Scenarios and Rail and Intermodal Implementing Alternatives

The Draft EIS is deficient in its analysis of SNF and HLW transportation scenarios within Nevada. The Draft EIS fails to evaluate and compare all of the available highway alternatives in Nevada, including at least one routing alternative identified by the Nevada Department of Transportation (NDOT) that involves shipping waste from the northeast via I-80, U.S. 93, U.S. 6, and U.S. 96 (the NDOT 'B' route). NDOT considered this route to be a principal alternative to the shipment of waste through the Las Vegas Valley. DOE ignores this alternative in the Draft EIS by indicating that it has not been formally designated as a preferred alternative by the State of Nevada. The absence of formal designation at this time - years before a repository has been approved, much less constructed - should not constitute a reason for failing to evaluate one of the most likely alternative highways routes to a Yucca Mountain facility.

69 cont.

In almost every aspect of the Proposed Action, DOE makes assumptions about future conditions and future actions and proceeds to incorporate those assumptions into its analyses. This is true of the repository design, facility performance, the operations of the repository and support facilities, the source of energy and water for the project, and many other areas of the Draft EIS. The failure to evaluate the NDOT 'B' route in the Draft EIS on the grounds that it requires an assumption of a future designation by the State demonstrates the fundamental inconsistency and self-serving nature of the analyses contained throughout the Draft EIS.

70 Likewise, the Draft EIS fails to evaluate each of the rail spur and intermodal facility alternatives at the same level of analysis and with the same level of information. It also postpones the selection of a preferred rail spur, intermodal facility location, the identification of specific rail spur alignments, and the analysis of specific operational aspects and impacts of the rail/intermodal system to some future, undefined time. Nevada contends that there is sufficient information available now for DOE have to compared rail spur alternatives, identified a preferred alternative, identified a specific and clearly defined rail alignment within the preferred corridor, identified whether an intermodal transfer facility is needed, and, if needed, selected a preferred site for such a facility. Failing to undertake these analyses and present findings in the Draft EIS makes it impossible for potentially impacted citizens and communities to effectively participate in the NEPA process.

71 Although DOE maintains that the "mostly legal weight truck" and "mostly rail" scenarios adequately bound the analysis for the national transportation scenarios, this is not true for the Nevada Transportation Scenarios. Under the "mostly legal weight truck" scenario, DOE must still deal with more than 300 rail shipments of high-level waste and Naval fuel **(references)**. The Nevada Transportation Scenario fails to describe how DOE will deal with these shipments without either constructing a rail line or operating an intermodal transfer site and heavy-haul trucks.

72 ... Page 2-10; Section 2.1.1.5 - Continuing Investigation of Design Options

The text states " ... this EIS describes and evaluates the current preliminary design concept for the repository and current plans for repository construction, operation monitoring, and closure." This statement is inaccurate. The design contained in the Draft EIS is no longer the current repository design being used by DOE for planning purposes, site recommendation, and licensing. In fact, there are major differences between the design used in the Draft EIS and the one DOE is now using as its reference design. Given the extraordinary long duration of the project, the difficulties in adequately bounding uncertainties even under the most favorable conditions, and the characteristics of the materials to be handled, stored, and disposed of at the facility, the use of an outdated and

72 cont. obsolete project design as the basis for impact analyses in the Draft EIS is unacceptable. DOE must decide on the facility design it intends to use and then conduct the required impact and performance assessments based on that design. To do otherwise renders the NEPA analysis inadequate.

This section concludes that, even though a broad range of repository design features and alternatives are still under consideration, "the analytical scenarios and implementing alternatives evaluated in the EIS provide a representative range of potential environmental impacts the Proposed Action could cause." This conclusion is drawn from an analysis of options for design features and design alternatives in Appendix E, from which DOE determined that "impacts from the design options would be relatively minor in relation to the potential impacts evaluated in this EIS."

NEPA Regulations,1502.18(b), state that an appendix shall "[n]ormally consist of material that substantiates any analysis fundamental to the impact statement." DOE's conclusion is not substantiated by the analysis in Appendix E because it is clear that some design alternatives and options in combination, or alone, will have significantly greater and different environmental impacts than the alternative thermal load designs evaluated in the Draft EIS. It is made clear in the Draft EIS that all the design feature options and alternatives are available for future DOE decisions.

The Draft EIS fails to reliably define a proposed repository design and holds open a range of design options that would require extensive additional environmental impact analysis. This condition exists in the Draft EIS, despite the fact that the Final EIS, mandated by the NWPA to be included in the Secretary's Site Recommendation Report, must also include "a description of the proposed repository, including preliminary engineering specifications for the facility." (Sec. 114(a)).

From the many options available, it is not possible for a reviewer to identify a description of the proposed repository and thus evaluate the nature and extent of its potential impacts on the environment.

73 ...

Page 2-11; Section 2.1.2 - Repository Facilities and Operations

The statement is made that "... spent nuclear fuel and high-level radioactive waste would be handled remotely with workers shielded from exposure to radiation using design and operations practices in use at licensed nuclear facilities ***to the maximum extent practicable***" (emphasis added). Since the Yucca Mountain facility is required to be licensed by the NRC and all facility operations would be carried out under NRC regulations, it is inaccurate to assume that practicability would dictate which regulations would be followed and which would not be. The statement that practices used in other

73 cont.

licensed facilities would be implemented at Yucca Mountain only to the extent practicable is indicative of the assumption throughout the document and the entire DOE program that regulations and requirements can be changed, modified, or suspended to meet the dictates of the project.

74

Page 2-11; Section 2.1.2 - Repository Facilities and Operations

The 870 acre repository operations area described here does not reconcile with the description of disturbed land and repository subsurface area found in Table 8-4 and on page 8-8. This difference should be clarified.

75

Page 2-13; Section 2.1.2 - Repository Facilities and Operations

The intent to end emplacement in 2033 coincides with the last year of current reactor operating licenses. Will the last spent fuel generated by the last operating reactor be shipped to the repository immediately after reactor shut-down? Can this be done with the planned transportation casks? Does this require any special considerations for operations in the Waste Handling Building at the repository surface facility? Also, calcined waste from INEEL won't be ready for shipment off-site until 2035. If this waste is to be emplaced in a repository at Yucca Mountain, the Draft EIS should be revised to reflect the possible change in the date for the end of emplacement at Yucca Mountain.

It should be noted that the NWPA requires the waste to be retrievable from the repository for 50 years after initial emplacement. This means that, according to the schedule in Figure 2-9, the repository could be closed as early as 2060. Also, the rationale for assuming repository closure 100 years after first emplacement must be explained beyond the minimal explanation in Appendix E, at E.2.3.5, Timing of Repository Closure. This schedule is arbitrary, and the only number with any current basis is 50 years, as stated in the NWPA.

76

Page 2-15; Section 2.1.2 - Repository Facilities and Operations

Figure 2-9 shows that site characterization ends in 2005 and performance confirmation starts in 2010. The text on page 2-13 discusses "preconstruction performance confirmation." This should be indicated in Figure 2-9. There should also be an explanation of the differences between site characterization activities, preconstruction performance confirmation, and performance confirmation. From the text, at least the first two are remarkably similar. On page 2-16, the Draft EIS states that the "performance confirmation program would continue some site characterization activities through repository closure." This is contrary to the requirement in the NWPA that site characterization activities be completed prior to Site Recommendation (Sec. 114(a)(1)).

77 Page 2-16; Section 2.1.2.1.1 - North Portal Operations Area

It should be pointed out that the design of this part of the repository surface facility, including the buildings and operations in the restricted area, is preliminary and, at best, conceptual. DOE has not even finally decided (contrary to information in the Draft EIS) whether the Waste Handling Building will employ the use of waste transfer pools or use hot cells exclusively.

The Draft EIS fails to adequately describe and evaluate impacts of specific types of facilities needed to receive, package, and handle spent fuel and high-level waste for disposal. The Draft EIS attempts to avoid specific analyses by indicating that the nature of such operations would depend on how the spent fuel is packaged for transport. Nevada contends that the information currently exists for DOE to clearly identify specific operational requirements and to discriminate among alternatives for operations at the North Portal facilities. However, this requires a more adequate, substantive, and site-specific analysis of spent fuel and HLW at reactor and generator facilities and the specific modes to be used for shipment from each site. Such an assessment is clearly within the technical capabilities of DOE and within the appropriate scope of the Draft EIS. DOE should be able to identify, with considerable certainty, the type of package that would be received at the North Portal from each reactor/generator site. With that information, DOE can then specify, in considerable detail, the actual facilities and activities required at the North Portal area. Such a detailed description is needed in order to conduct an adequate assessment of risks and impacts.

Such an analysis would also help to clarify the differential risks and attendant mitigation associated with various handling scenarios. For example, if the analysis showed that a large percentage of the waste would arrive at the North Portal operations area as uncanistered spent fuel (as is very likely, given the market-driven transport system being planned by DOE and commercial utilities), the North Portal Operations Area and facility needs would be considerably different than they would be if most of the waste arrived in dual or multi-purpose canisters.

78 Page 2-20; Section 2.1.2.1.1 - North Portal Operations Area

The Draft EIS should state how the empty canisters would be decontaminated and what would be done with the resultant waste from the decontamination.

79 ... Page 2-21; Sections 2.1.2.1.3 and .4 - Ventilation Shaft Operations Area

The Draft EIS does not describe the method to be used for ventilation shaft construction and does not appear to describe the environmental impacts specific to shaft construction.

79 cont. Section 4., Section 2.1.2.2.1, Subsurface Facility Design and Construction, implies that the shafts are not planned to be constructed by drill-and-blast. This should be clarified.

80 Page 2-23; Section 2.1.2.1.5 - Support Equipment and Utilities

Is electric power available from the Nevada Test Site sufficient for all potential repository construction scenarios involving multiple tunnel boring machines? If additional power is required from external sources, the means by which the power will be transmitted to the repository should be considered in this Draft EIS.

To accommodate repository operations, DOE will need to substantially upgrade the Nevada Test Site (NTS) utility infrastructure as well as utility feeder lines to the NTS. Yet detailed discussions about resolving the utility infrastructure limitations and power supply problems are not provided in the Draft EIS. While several programmatic options are briefly mentioned, the Draft EIS fails to evaluate specific alternatives. The Draft EIS only states that "the approach in all cases would be to use existing power corridors where possible to limit environmental impacts and to reduce the need for additional rights-of-way." The Draft EIS further states that "depending on the option chosen, additional National Environmental Policy Act analysis could be required" (see page 4-72). Because repository development could not proceed without an adequate electrical supply system, DOE must address environmental impacts of providing additional power to the Yucca Mountain site. The Draft EIS fails to provide such an assessment and, thus, is deficient. Moreover, like other significant Draft EIS issues, DOE simply defers selection of alternatives and detailed analysis to an unspecified future NEPA process.

81 ... Page 2-23; Section 2.1.2.2 - Repository Subsurface Facilities and Operations (Including Waste Packages)

The low thermal load repository would include Area 5 in order to provide sufficient underground emplacement area. Area 5 has not been the object of site characterization and, therefore, should not be included in the Draft EIS or repository planning until it has been characterized. According to the NWPA, the Secretary's site recommendation is to be made at the completion of site characterization. In the case of the low thermal load alternative design, site characterization has not been started, much less completed, in a portion of the area included in the Proposed Action. If the low thermal load alternative is to be considered a reasonable alternative, the Draft EIS should be deferred until characterization of Area 5 is satisfactorily completed.

This is especially important in light of currently developing information regarding saturated zone flow and transport. Essentially nothing is known about groundwater flow beneath Area 5 and how it might be influenced by the Solitario Canyon fault and other

81 cont. faults known and unknown. (See page 3-52 that states, "West of the Solitario Canyon fault groundwater probably flows southward either along the fault or beneath Crater Flat.") This introduces a new and major uncertainty in the performance assessment of the repository, to the extent that it precludes any certainty regarding flow paths along which radionuclides would travel from a significant portion of the repository. The Proposed Action is fatally flawed under these circumstances, as is the credibility of the impact analysis in the Draft EIS.

82 Page 2-27; Section 2.1.2.2.1 - Subsurface Facility Design and Construction

Concrete liners are no longer part of the repository design. An accurate, current description of the repository design should be included in the Draft EIS.

Under what circumstances and in what manner would waste packages be moved over other waste packages? Does the technology exist at this time to do this? Have scenarios where waste packages are dropped on other waste packages been evaluated? The Draft EIS should include a discussion of this aspect.

83 Page 2-31; Section 2.1.2.2.1 - Subsurface Facility Design and Construction

Water usage during site characterization and the construction of the ESF was not adequately monitored, evidenced by the multiple quality assurance findings and nonconformance reports written about the tracking of water usage. What other controls would DOE use to ensure that water used during construction of the repository would not affect repository performance?

84 ... Page 2-31; Section 2.1.2.2.2 - Waste Package Design

The waste package design is preliminary and conceptual. The design, as described in the Draft EIS, is no longer the operative design concept, and it is likely to change again as more is learned about the proposed materials and their interaction with various potential near-field environmental conditions at the selected thermal load conditions.

The real purpose of the waste package is to provide structural strength during emplacement and possible retrieval operations and to assure complete waste containment during the period of decay of the primary fission products, Sr-90 and Cs-137, a period of up to 1,000 years. After this period, the geologic barrier is intended to provide the necessary waste isolation for the long-lived radionuclides.

Since the waste package is so central to repository performance and to the amplification or attenuation of impacts from the facility, the Draft EIS should contain a complete and

84 cont. final description of the waste package chosen by DOE to insure waste containment. It would also be appropriate for the EIS to comprehensively evaluate alternative waste package designs and select the preferred design for use in a Yucca Mountain repository. Instead, the Draft EIS seeks to substitute generic descriptions in an attempt to leave maximum room for constantly evolving designs in order to compensate for the poor performance of the geologic barrier system. Given the extraordinarily poor geological waste isolation characteristics of the Yucca Mountain site and without a clearly articulated waste package design, it is impossible to evaluate the environmental and human health impacts of the repository.

85 Page 2-32; Section 2.1.2.2.2 - Waste Package Design

The current design of the waste package has the two layers flipped. The Alloy-22 is now on the outside of the canister with the carbon steel on the inside.

86 Issues of criticality are addressed by stating that neutron absorbers (if needed) would be placed within the waste package so that no criticality could take place "even if the package somehow became full of water." There is no discussion of the resultant possible steam explosion that could occur if water made contact with the waste form. A steam explosion could be almost as bad as a criticality incident. Any kind of explosion inside an emplacement drift could be detrimental to the entire repository block.

87 Page 2-34; Figure 2-21 - Conceptual design of waste package in emplacement drift.

The current conceptual design of the emplacement drift does not include a concrete liner. The current conceptual design of the emplacement drifts should be described in Section 2.1.2.2.3, Waste Package Emplacement Operations.

88 Page 2-37; Section 2.1.2.3 - Repository Closure

This section should include a discussion of alternative design features that may be included, such as drip shields and emplacement drift backfill. It should also discuss the expected effectiveness of seals for ramps and shafts and the basis for the expectation.

This section should describe the closure plans for the performance confirmation drifts and boreholes.

DOE should describe in the Draft EIS sealing materials and placement methods to reduce the creation of preferential pathways for water to contact the waste package.

89 Page 2-37; Section 2.1.2.4 - Performance Confirmation Program

As part of performance confirmation and prior to initiation of waste emplacement, DOE should commit to a demonstration of a full drift emplacement-retrieval cycle as a proof of operational capability.

Page 2-38; Section 2.1.3 - Transportation Activities

See comments on Section 6, Environmental Impacts of Transportation and Appendix J for a detailed critique of transportation issues and impacts presented in the Draft EIS.

90 Page 2-38; Section 2.1.3.1 - Loading Activities at Commercial and DOE Sites

The text states "..the EIS assumes that at the time of shipment the spent nuclear fuel and high-level radioactive waste would be in a form that met approved acceptance and disposal criteria for the repository." In the case of commercial spent fuel, there is no basis for making such an assumption. Given the market-driven, *laize faire* approach planned for transporting spent fuel from reactor sites to Yucca Mountain, the form of the spent fuel to be shipped will be determined by the type of transport canister used and the shipment mode selected. Both of these factors will be determined largely by economic factors and by conditions and infrastructure at each reactor location. DOE will likely deal with widely diverse spent fuel configurations, including different shipping cask configurations, different shipment loads and weights, different conditions of fuel elements, etc. The overly optimistic assumption that spent fuel and HLW received at the repository surface facilities will be in standard forms and require little or no remediation or special handling is erroneous and understates the difficulties associated with the waste acceptance and handling operations at the repository.

The level of effort required at a repository waste acceptance, handling, and processing facility will be one that is unprecedented in volume, diversity of waste forms, and duration. The handling of spent fuel is currently done only on a very limited scale, usually one or two fuel assemblies at a time, at reactor locations. There is no experience with the scale and complexity of operations that would be required to process hundreds of thousands of spent fuel elements (both at points of departure and at the repository surface facilities) over a sustained period of 30 years or more. The Draft EIS completely ignores the unprecedented nature of this effort and, instead, treats it as if it were a routine industrial activity.

91 Page 2-40; Section 2.1.3.2 - National Transportation

The analysis of national transportation impacts associated with the Proposed Action contained in the Draft EIS is both legally and substantively deficient. The Draft EIS presents an inappropriately generic analysis of impacts; fails to identify cross-country shipment modes and routes that would be necessary to implement the Proposed Action; ignores impacts to corridor cities and communities across the nation; misrepresents actual shipment volumes; underestimates the impacts of worse case accidents and terrorist/sabotage events; understates the potential health effects of routine, non-accident shipment operations; employs unrealistic shipping scenarios as the basis for analysis; ignores potentially significant and pervasive socioeconomic impacts associated with the massive and unprecedented shipping campaign required to move waste from generator locations to Yucca Mountain; and generally understates risks to health, safety, and the environment. The State of Nevada's comments regarding the treatment of national transportation issues and impacts can be found in comments on Section 6 of the Draft EIS and Appendix J below.

92 ... Page 2-40; Section 2.1.3.2.1 - National Transportation Shipping Scenarios

The use of two national shipping scenarios that DOE acknowledges as unrealistic is inappropriate for the type of analysis required in a Draft EIS of this scope and importance. Evaluating "mostly truck" and "mostly rail" shipping scenarios grossly oversimplifies the complexities and impacts of the type of shipping campaign that will be required. Such an approach does not "bound" the likely impacts, but serves to obscure them. Any realistic shipping scenario will require a complex mix of truck, rail, and barge transport and a logistics and coordination system that has never before been attempted for materials of the kind to be shipped to a repository.

Information currently exists that would have permitted DOE to specifically identify what shipments from which reactors/generator sites would be shipped by rail, rail-barge, or truck, in what volumes, over what time frames, and along what specific shipping routes. DOE chose not to perform such an analysis, which would have required, among other things, the disclosure of preferred shipping routes and information about the types and numbers of shipments along those routes. The generic analysis that DOE did perform, using unrealistic shipping scenarios, is inadequate and cannot be used as the basis for the identification of potential national transportation impacts or for making future national transportation decisions.

The Draft EIS states: "These [bounding] scenarios illustrate the broadest range of operating conditions relevant to potential impacts to human health and the environment." This statement is incorrect, since the "mostly Legal-Weight Truck" scenario includes rail

92 cont. shipments. Without constructing a new rail line in Nevada or operating an intermodal transfer and heavy-haul truck shipment system in Nevada, the shipments dependant on rail will either have to be repackaged in smaller containers in Nevada or not shipped to the proposed repository at Yucca Mountain.

93 Pages 2-41 and 2-42; Figures 2-26 and 2-27 - Highway and Rail System Maps

The maps do not show the locations of potentially affected Native American tribes in relation to the interstate highway and rail systems. Even in the absence of identified shipping routes (a major shortcoming of the Draft EIS that is discussed in detail elsewhere in these comments), the document should have provided some indication of Native American lands that are traversed by, or are located in proximity to, highway and rail routes. Numerous Native American lands/communities outside Nevada will be impacted by spent fuel and HLW shipments including: Gila Bend, Navajo, San Xavier, and Salt River in Arizona; Umatilla and Cow Creek in Oregon; Miccosukee in Florida; Fort Hall in Idaho; Winnebago in Nebraska; Cattaraugus in New York; Quapau, Ottawa, Modoc, Sac Fox, in Oklahoma; and others. The failure to identify Native lands and communities along transportation routes and to assess impacts of the Proposed Action on those entities is another indication of the inadequate and superficial treatment of transportation impacts in the Draft EIS.

94 ... Page 2-43; Section 2.1.3.2.3 - Mostly Rail Shipping Scenario

There are significant differences in the operation of the shipping campaign if general freight is used instead of dedicated trains. Use of general freight could result in significant delays during shipping, will require shipments to pass through many rail yards that could be avoided, and will probably result in shipments being switched in the UP rail yard near Las Vegas prior to being sent to the Yucca Mountain specific holding track. These actions increase potential exposure to workers and the general population and increase the probability of accidents in rail yards in general and during switching activities.

The last paragraph indicates that, "[s]ome of the logistics of rail transportation to the repository would depend on whether DOE used general or dedicated freight service." The use of general freight service, in which the casks are shipped along with other railcars of freight, should not be considered as a viable alternative. When shipping in general freight, the railroad would pick up rail cars containing radioactive waste and move them along with other freight. Moving such high-level radioactive waste destined for Yucca Mountain under general freight introduces uncertainty and a reduced level of control.

94 cont. Rail cars could be set out at interchange points where they might sit for an undetermined time before being switched to another train for continued movement toward the final destination. Although Federal Railroad Administration regulations require that hazardous materials be moved within 48 hours if not set out at the final destination, there are no regulations regarding the locations where such rail cars may be "parked." Rail cars could be parked at locations where an incident or accident would have high consequence, and in fact, switching locations are often found in such high consequence locations, near or in highly populated areas.

Such handling subjects the rail cars to possible operational dangers associated with several or numerous switches while in general freight status, as well as exposure and security threats while "parked" in unsecured locations. Additionally, in general freight, the special nature of the radioactive waste cars would be obscured to both railroad employees and management as well as the public, leading to further risk as the shipments become routine over time.

95 ... Page 2-44; Section 2.1.3.3 - Nevada Transportation

The State of Nevada finds the analysis of Nevada transportation impacts associated with the Proposed Action contained in the Draft EIS to be legally and substantively deficient. The Draft EIS fails to address the interconnectedness of national and Nevada transportation issues and impacts. Instead, the Draft EIS treats Nevada transportation as if it were entirely isolated from the national transportation system and the characteristics, decisions, and other factors that condition and drive the national spent fuel and HLW shipping campaign. For example, the issue of rail access to Yucca Mountain will have a major impact on the type and number of shipments that occur across the country. Likewise, the viability of, and decision to go forward with, an intermodal transfer facility in Nevada will be a major determinant of modal mix for shipments nationwide. Conversely, decisions made by utilities and contract shippers regarding transportation casks, routing considerations, weather, and many other factors will determine routes that are impacted within Nevada. Acknowledgment of such interconnectedness is not addressed in the Draft EIS.

The Draft EIS contains an inadequate and superficial treatment of Nevada transportation issues and impacts. The Draft EIS fails to evaluate alternative highway routes in a manner that permits the identification of preferred alternatives, and the level of information and analysis is different for various routes. The Draft EIS completely ignores at least one of the most likely highway shipping routes through the State (the NDOT 'B' route). Moreover, the analysis of potential rail spur alternatives is uneven, exclusive of potentially attractive alternatives, lacks specificity, and insufficient for selecting preferred alternatives. Also, the analysis of rail construction impacts and the impacts/necessities of

95 cont. operating a rail line within Nevada are grossly understated. The evaluation of potential intermodal transfer facility locations is based on inadequate, extraordinarily incomplete and uneven information and fails to identify a preferred location, which is essential for adequately assessing impacts of other aspects of the transportation system, both in Nevada and nationally. The assessment of the costs and impacts of heavy-haul transportation on Nevada highways is incomplete and understates the difficulties inherent in an unprecedented activity of such scale and duration, difficulties and costs that will likely make intermodal transport within Nevada infeasible. Finally, the assessment of potential socioeconomic impacts associated with spent fuel and HLW transportation in Nevada is incomplete, inadequate, and fails to address the range of significant impacts to communities along the identified rail spur and to the State as a whole.

96 The Draft EIS assumes that shipment security and escorts, as required under 10 CFR Part 73.26, would be implemented by the licensee (in this case, DOE) or its agent. Under this scenario, the State of Nevada (i.e., the Nevada Highway Patrol) would have no role in escorting or providing security for these shipments. However, it is State of Nevada policy that, in addition to any other security or escort measures provided by the licensee or his agent, appropriate State law enforcement staff will escort each of these shipments and vehicles while traveling on Nevada highways. Costs of such security measures are impacts to the State and should have been assessed in the Draft EIS.

97 ... Other areas directly affecting the State in responding to the unprecedented spent fuel and HLW shipping campaign required to implement the Proposed Action include costs and impacts associated with:

- real time vehicle tracking and the associated costs
- vehicle inspection (legal-weight trucks and heavy-haul trucks)
- equipment (initial purchase, maintenance, and replacement)
- ports of entry and vehicle inspection facilities at intermodal transfer stations
- training (initial first responder, advanced training, and ongoing training)
- accidents and incidents
- emergency response equipment and training
- private/government agency emergency response personnel

97 cont.

- safe havens
- designated and alternative routes
- en route repair facilities, towing of vehicles, and availability of parts to repair trucks
- security of shipping casks during en route repair of heavy-haul trucks
- possible acts of sabotage
- health exposure issues to personnel

None of these costs/impacts on the State of Nevada and local governments are addressed in the Draft EIS.

98

The Draft EIS states: "The EIS analysis assumed that the proposed Interstate bypass around the urban core of Las Vegas (the Las Vegas Beltway) would be operational before 2010." DOE should state the basis for this assumption in the EIS, including a description of the proposed funding and construction schedule for the beltway. Urban growth frequently occurs along newly constructed urban beltways, increasing traffic volumes on these highways. Therefore, the EIS should also include a projection of future growth patterns associated with the proposed beltway and a projection of future traffic volumes on the proposed beltway during the life of the shipping campaign.

See also comments on Section 6 of the Draft EIS.

99

Page 2-44; Section 2.1.3.3 - Nevada Transportation

Specification of Three Scenarios:

The Draft EIS approach is seriously flawed for several reasons. DOE states "that it cannot predict the specific transportation mode (truck or rail) of each shipment to the repository." Therefore, none of the options described on page 2-44 accurately describe the Proposed Action for Nevada transportation and hence, do not accurately bound the potential impacts. The statement that DOE cannot predict the specific mode for each shipment implies that DOE cannot control the mode of shipment. Even if one of the options is ultimately selected, sites could ship by any of the modes. Therefore, the legal-weight truck option could result in shipments by rail to Nevada. Without rail access, DOE will be forced to either repackage the materials before shipping them to the Yucca Mountain site or to ship them by heavy-haul. If the rail or heavy-haul option is selected,

99 cont. sites could ship by legal-weight truck, resulting in many more shipments through Nevada than projected. Thus, it is impossible to accurately predict the impacts unless DOE selects a preferred alternative and implements some method of control over the mode selection for shipments.

DOE has not adequately demonstrated the technical, regulatory, economic, or environmentally acceptable feasibility of any of the options. As will be discussed in more detail later in these comments, there are serious flaws with each option. In summary, all of the rail route options (and hence, most of the heavy-haul route options) have serious land use, environmental, technical, and economic problems. The concept of an extensive heavy-haul shipping campaign on public highways may not be legally valid and poses significant traffic safety concerns. The legal-weight truck option is itself dependant upon the feasibility of either rail or heavy-haul access and thus, is not an independent option.

100 .. Page 2-45; Figure 2-28 - Southern Nevada highways

A major concern with the Draft EIS analysis is the assumption that the yet-to-be-completed Las Vegas Beltway will be available for waste shipments and that the area around the beltway will remain less populated and less congested than I-15 and the "spaghetti bowl" intersection of I-15 and U.S. 95. Given the growth rates experienced by Clark County over the past two decades and the urbanization already occurring in the area of the beltway, it is likely that traffic and congestion along the beltway will substantially increase by the time waste shipments would begin. This concern is supported by population projections from the Clark County Department of Comprehensive Planning that show a population of more than 451,000 within two miles of the beltway and more than 1.2 million within five miles by 2010. Housing units at two miles in 2010 are estimated at over 181,000 and nearly 602,000 at five miles. Employment for this same population is estimate at over 313,000 (at 2 miles) and over 625,000 (at 5 miles from the beltway).[19]

The Draft EIS entirely ignores the impacts associated with this level of population growth and the impacts of superimposing a major spent fuel and high-level waste shipping campaign on the major transportation artery for the population base. Such impacts are magnified when the characteristics of a heavy-haul shipping campaign of the type, volume, and duration required for the Proposed Action are factored in.

[19] Source: Clark County Department of Comprehensive Planning, memorandum from Cherie Garrity to Jim Rhode, Nevada Highway Patrol, dated December 6, 1999.

100 cont.

The City of North Las Vegas points out that the initial proposed beltway between I-15 and U.S. 95 will not meet Interstate freeway standards until well after waste shipments begin under the Proposed Action. Initially, the beltway will be a two to four lane road with at-grade intersections. The Draft EIS fails to address impacts associated with the sustained use of such a highway for spent fuel and HLW shipments, including heavy-haul truck shipments.

101

Page 2-47; Section 2.1.3.3.1 - Nevada Legal-Weight Truck Scenario

The Draft EIS completely ignores the costs and impacts associated with the type of vehicle inspection and escort operations that would be required upon entry into Nevada. Prior to transporting waste through Nevada, safety compliance of vehicles, loads, and drivers must be assured by appropriate State agencies. Legal-weight trucks would need to be inspected at port of entry facilities where vehicle and driver compliance verification with state and federal laws and regulations would be performed, shipping papers reviewed, and escorts assigned to accompany trucks. To capture commercial vehicles entering the state on I-15, ports of entry need to be constructed at or near Mesquite and Jean/Sloan.[20]

Costs to build ports of entry include land acquisition, construction, equipment and training, personnel, utilities, and other on-going or related expenses. Details of these costs are contained in the Nevada Highway Patrol study Base Case Scenario-High Level Transportation (see Attachment R). Other activities could also be conducted at the port of entry. These activities could include vehicle inspection, issuing NDOT oversize load permits, and other related permit activities.

The ports of entry should have one inspection bay and pit that is segregated and protected from the other bays to provide maximum protection to employees and others using the facility during an inspection of vehicles transporting radioactive shipments.

The Nevada Highway Patrol estimates initial (start-up) costs for required ports of entry for inspection of legal-weight truck shipments at over $43 million, with subsequent annual costs for operating the ports of entry at over $6 million (see Attachment R).

102

Page 2-47; Section 2.1.3.3.2 - Nevada Rail Scenario

DOE's rail corridor selection study is flawed. The first selection criteria used by DOE to select potential routes was land use compatibility. For this criteria, DOE selected

[20] Should NDOT designate alternative routes, port of entry locations would need to be reviewed.

102 cont. corridors based upon using "land under public ownership, to the greatest extent possible, to minimize land-use conflicts." Favorable topography was used as a selection criteria only within "areas not excluded because of land-use conflicts" (Nevada Potential Repository Preliminary Transportation Strategy, Study 1, April 1995, page 25).

There are serious problems with this approach. Land ownership does not accurately reflect land-use. Most western ranching operations are based upon a combination of privately owned fee land and grazing leases on publicly owned lands. In many, if not all cases, the ranching unit depends on these grazing leases to be economically viable. Most grazing leases are held by the ranches that can access the lease as a logical part of their operation. Splitting an existing operation with a rail line that will limit access to the leased land can have significant adverse effects on the operation of the ranch. Using the avoidance of privately owned land as the corridor selection process without regard to the existing ranching operations' use of private and public lands may very well result in greater impact on an operation than using private land.

Most of the private land in western States with high percentages of federally owned land is land with gentle topography. Early settlers selected the flatter land for their own. The land with rugged topography was not settled and remained in public ownership. This shift to rugged terrain to avoid private land is a dominant factor in most of the routes selected for further study in the 1990 Preliminary Rail Access Study, as reflected by the following: "An option was selected from the Caliente area in order to avoid land use impacts encountered in most of the southern areas of Nevada. ... The base route has the most favorable land-use compatibility, but would incur significant costs due to the complex engineering and construction required to traverse rough terrain" (page 17). "However, the checkerboard pattern of private and public land ownership surrounding the railroads across northern Nevada makes the complete avoidance of private land difficult. The minimum impact departure point is a location about 5 miles west of Carlin. The terrain in this area is so rugged that private developers were uninterested in the land, and as a result, the greater portions of the terrain were left in BLM ownership" (page 21).

By using land ownership for the first selection criteria, DOE's selection process actually favored more rugged terrain where construction of the proposed rail line is more difficult. This creates many additional land use impacts due to the extensive cuts and fills required by unfavorable topography. These cuts and fills will further exacerbate the problem faced by ranchers in moving livestock and equipment across the rail line.

103 Crucial habitat for big game is frequently located in or near rugged terrain. This is especially true for crucial winter habitat. Daylight cuts required to traverse rugged terrain also pose a significant threat to big game, which tend to use these areas for movement, especially in times of heavy snow cover. When trapped in a daylight cut, big game

103 cont. cannot escape from an oncoming train, resulting in significant mortality rates for big game in these areas. Thus, the selection criteria that favors more rugged terrain by virtue of avoiding private land ownership greatly increases the potential impact on biological resources.

104 Roadless areas are also more likely to be found in rugged terrain. Virtually all potential wilderness areas are located on public lands. The selection criteria that avoids private lands results in more potential impact to roadless areas and potential wilderness areas.

105 The Nevada rail scenario is also based on the concept of a branch rail line constructed, owned, and operated by DOE that connects the mainline rail system to the Yucca Mountain site. This calls into question the jurisdictional relationship of the branch rail line to both Federal Railroad Administration (FRA) regulations and State oversight through Nevada's participation in the FRA State Rail Safety Program. Currently, there is one other government-owned track leading to the Hawthorne Weapons Depot that has been deemed nonjurisdictional because of its Department of Defense ownership.

The Draft EIS does not address the issue of safety oversight of the spur trackage and operations. The Draft EIS should clearly define the role that existing rail safety oversight should and will play. The Draft EIS should outline the limits to which DOE rail operations will submit to safety regulation by the State and other federal agencies. Clearly, the rail operations should comply with all current and future rail safety regulations of the State and the FRA. The ability to conduct inspections on any DOE rail operations, as with any other short line, is in the public interest. The DOE operation should acknowledge its submission to state oversight and its adherence to State and federal rail safety regulations.

DOE should specifically acknowledge the rights of the State to inspect the construction, operations, rolling stock, and track of any DOE owned or operated railroad. Additional resources and costs to the State in carrying out these activities are impacts that should have been assessed and quantified.

106 Page 2-49; Section 2.1.3.3.2.1 - Rail Line Construction

The Draft EIS states: "Construction activities would include the development of construction support areas; construction of access roads to the rail line construction initiation points and to major structures to be built, such as bridges; and movement of equipment to the construction initiation points. The number and location of construction initiation points would be based on such variables as the route selected, the length of the line, the construction schedule, the number of contractors used for construction, the

106 cont. number of structures to be build, and the locations of existing access roads adjacent to the rail line."

The construction activities listed cannot be completed without some environmental impact and will require appropriate mitigation measures. Without a detailed description of these activities, it is impossible to conclude that they can be completed without causing unacceptable adverse environmental impacts, even with mitigation measures. Until these construction activities are specified, DOE cannot conclude that the Proposed Action will not result in unacceptable impacts, as required by NEPA.

395 Other than indicating that the rail line would be built to Federal Railroad Administration standards, the Draft EIS makes no mention of construction inspection or safety oversight of rail lines or operations by State or federal agencies.

Ballast requirements: Construction of the railroad in any of the proposed rail corridors will require significant quantities of ballast and probably significant quantities of sub-ballast. The Draft EIS does not provide a description of the source for these materials. The quantity of ballast and sub-ballast required should be accurately defined and sources for the material described. Quarrying the ballast and sub-ballast could result in significant environmental impacts not assessed in the Draft EIS.

Installation of Fencing: The description of the Proposed Action should include the location and type of fencing to be installed. Without this information, it is not possible to assess the impacts of the Proposed Action, particularly on wildlife and on land use. The two agencies listed could, in fact, request conflicting requirements for fencing based upon the impact within their area of jurisdiction. Depending on the types and locations of fencing, the Proposed Action could create significant impacts to wildlife, particularly where the proposed corridors cross critical habitat areas.

107 Page 2-50; Section 2.1.3.3.2.2 - Rail Line Operations

The Draft EIS estimates a total of about five trains per week to the repository, but does not include an estimate of the number of trains leaving the repository. This would presumably include return of empty shipping casks as well as additional unloaded cars that were used to ship materials to the site. One cannot automatically assume that the number of unloaded trains leaving the repository will be the same as the number of loaded trains arriving. Therefore, it is not possible to assess the impacts of the rail line from the description of the Proposed Action.

Although discussed in the references to the Draft EIS, this Draft EIS does not discuss the different options for ownership and operation of the rail line or the possibility that the rail

107 cont.

line would be used for other purposes than the Proposed Action described in the Draft EIS. Use for other types of shipments could increase the impacts of the Proposed Action above that described in the Draft EIS.

Again, other than indicating that the rail operations of any DOE rail line would meet Federal Railroad Administration standards for maintenance, operations, and safety, the Draft EIS makes no mention of safety oversight of rail operations by state or federal agencies.

108 ..

Page 2-50; Section 2.1.3.3.3 - Nevada Heavy-Haul Truck Scenario

DOE has not demonstrated that heavy-haul truck is a feasible option to transport railroad casks to the proposed repository. States are required to enforce weight and size limitations on Interstate systems and on routes providing reasonable access to and from the Interstate. The penalty for failure to do so is the withholding of a State's National Highway System apportionment. States may issue permits for overweight and/or oversize vehicles if the load meets the definition of a nondivisible load as defined at 23 CFR 658:

Nondivisible load or vehicle:

(1) As used in this part, nondivisible means any load or vehicle exceeding applicable length or weight limits which, if separated into smaller loads or vehicles, would:

(i) Compromise the intended use of the vehicle, i.e., make it unable to perform the function for which it was intended;

(ii) Destroy the value of the load or vehicle, i.e., make it unusable for its intended purpose; or

(iii) Require more than 8 work hours to dismantle using appropriate equipment. The applicant for a nondivisible load permit has the burden of proof as to the number of work hours required to dismantle the load.

(2) A State may treat emergency response vehicles and casks designed and used for the transport of spent nuclear materials as nondivisible vehicles or loads.

The decision as to whether or not to treat casks for the transport of spent nuclear materials as nondivisible is left to the discretion of the states. The Federal Highway Administration (FHWA) adopted a single definition of nondivisible loads to apply to both oversize and overweight loads, since "Congress has authorized the States, in identical terms, to issue overweight and oversize permits 'for those vehicles and loads which cannot be easily

108... dismantled or divided [(23 U.S.C. 127(a); section 4006(a) of the ISTEA, 49, U.S.C. app. 2311(j)(1)]'" (58 FR 11455)

Casks designed and used for the transport of spent nuclear materials were added to the definition of nondivisible loads in the preamble to the final rule. FHWA stated, "Spent Nuclear Fuel: The Pennsylvania DOT pointed out that the FHWA informed the American Association of State Highway and Transportation Officials (AASHTO) several years ago that the FHWA regarded overweight casks used to move spent nuclear fuel as nondivisible. This determination was not reflected in the SNPRM (Supplemental Notice of Proposed Rule Making). The casks used to transport spent nuclear materials, especially nuclear fuel, are extraordinarily strong and heavy, both to prevent a release in case the transporter vehicle was involved in an accident and to block radiation that would penetrate lighter materials. Some of these containment devices can make a vehicle overweight even before the nuclear materials are loaded. These vehicles cannot be used for any other cargo or reduced to legal weights without frustrating their purpose. A new provision has therefore been added which essentially states that specially designed casks used to move spent nuclear fuel meet the definition of a nondivisible load." (59 FR 30409)

In the Supplemental Notice of Proposed Rule Making, FHWA stated: "Nonetheless, nondivisible load permits should be used sparingly. Loads which are inherently divisible, including bulk items such as liquids, grain, or cement, would not qualify as 'nondivisible.' Nor would shipments consisting of more than one of a unit item or assembly, which by itself may be nondivisible. In such cases, items can be removed until the load meets the legal limits. Nondivisible load permits are not 'loopholes' in Federal law, and the FHWA expects to see the number of nondivisible lad permits stabilize or even decline in the next few years." (58 FR 11457)

FHWA further clarified the intent of the definition of nondivisible loads with an additional example. "A similar argument has been made, although not in this rulemaking, that tank vehicles weighing more than 80,000 pounds should be eligible for nondivisible-load overweight permits because a partially loaded tank of legal weight is susceptible to cargo surge that can make the vehicle unstable and even cause accidents in turns or emergency maneuvers. By this reasoning, a nondivisible-load overweight permit would be authorized to increase safety. Proponents of this position do not explain the reason tanker operators purchase vehicles that necessarily exceed applicable weight limits when fully loaded. It is certainly true that tank trucks must be operated with particular care; that is the reason the FHWA's commercial driver's license regulations require drivers of these vehicles to obtain a special endorsement. But the fact is that liquids, like two concrete panels, are easily divisible. If a safety element were added to the definition of a

108 cont. nondivisible load, the concept of nondivisibility could lose all meaning if economic interests were to masquerade as safety issues." (59 FR 11457)

FHWA's intent when adopting the definition of nondivisible loads was to reduce the number of permits issued for overweight and oversize vehicles. Casks for transporting spent nuclear fuel were added to the definition of nondivisible since the design of the cask requires heavy materials for strength and shielding, resulting in some cases for the need for overweight vehicles. This definition, however, clearly applies to casks that were designed for highway transport, not those designed for rail. In the Supplemental Notice of Proposed Rulemaking, FHWA stated that "shipments consisting of more than one of a unit item or assembly, which by itself may be nondivisible," are not considered nondivisible. DOE can transport the material in casks that meet the requirements for legal weight and size trucks; they are simply proposing to ship "more than one of a unit item or assembly" by putting many more fuel rod assemblies in a cask designed for rail than they could with legal-weight truck casks.

In FHWA's example of tank vehicles, they also noted that "the concept of nondivisibility could lose all meaning if economic interests were to masquerade as safety issues." In this case, DOE is not even claiming a safety benefit for the use of rail casks, but rather just one of convenience. Since the use of rail casks is clearly optional and the material could be shipped in legal-weight casks, DOE's proposed use of rail casks transported on overweight and oversize vehicles clearly does not meet the definition of nondivisible load and does not qualify for an overweight and oversize permit based upon nondivisibility of the load.

109 .. Page 2-50; Section 2.1.3.3.3 - Nevada Heavy-Haul Truck Scenario

Heavy-haul vehicles of the type and quantity described in the heavy-haul truck scenario present significant concerns and impacts not addressed in the Draft EIS. Training for inspectors to properly inspect these unique vehicles must be scheduled and performed in a timely manner to insure the safety of all concerned. Vehicle inspection areas must be established at the intermodal transfer station and include appropriate equipment, manpower, and environmentally safe employee working areas.

Escorts for these heavy-haul vehicles will not only provide the usual escort responsibilities, but will also include responsibilities to control and clear large expanses of roadway and conduct preventative sweeps ahead of the load, keeping other traffic moving in an orderly fashion, and interacting with security teams.

Impacts from non-fatal (injury/property) accidents are not addressed in the Draft EIS. However, it is likely that most accidents involving heavy-haul truck (and legal-weight

109 cont.

truck) shipments would cause injury or property damage, rather than fatalities.[21] These accidents will have a substantially larger impact than portrayed in the Draft EIS, especially with traffic congestion, reduced travel lane expectancy, and the necessity to reroute traffic due to highway blockage.[22]

The projected speed of 20 to 30 miles per hour for heavy-haul vehicles is highly optimistic, especially during peak or congested traffic periods. The Nevada Highway Patrol estimates that a more realistic speed would be 12 to 18 miles per hour, which will significantly increase traffic congestion and disruption along affected highways.

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Page 2-51; Section 2.1.3.3.3.1 - Intermodal Transfer Stations

This section describes the possible locations, configurations, and operations at an intermodal facility. It points out the increased handling and logistics introduced into any multi-modal transportation campaign to the Yucca Mountain site. It refers to transfer cranes and movement of casks from rail cars to heavy-haul trucks. This added transfer of the casks introduces increased risks to any transportation campaign. This movement, which would not be necessary in a rail-only shipping campaign, increases the possibility of an accident or damage to the shipping casks or the containers inside.

This scenario also contemplates heavy-haul truck transport primarily through congested metropolitan highway systems where impacts of such transport have not been adequately assessed.

The issue of general freight versus dedicated trains is expanded upon in this section. Intermodal transfer station operations would depend on whether the railcars that carried spent nuclear fuel and high-level radioactive waste arrived on dedicated or general freight trains. DOE states that there will be operational differences for the intermodal transfer station between the dedicated train and general freight options. The Draft EIS, however, does not contain sufficient information on these differences to allow an evaluation of the difference in impacts between the two options. The difference between staging requirements for the heavy-haul vehicles for the two options should be described. If general freight is used, the Draft EIS states that the "General freight trains would switch from the main Union Pacific track to an existing or newly constructed passing track." The Draft EIS does not state where the existing or newly constructed passing track would be located. If it is located at the intermodal transfer station, this would significantly alter the design of the station. If a new passing track is constructed at a location independent

21 Section 6.2.4.2.1

22 See Attachment S for comparing fatal and injury crash rates for large trucks.

110 cont. of the station, this would create potential impacts that have not been evaluated. Even if an "existing passing track" is used, this would probably require the Union Pacific to construct a new passing track for other railroad traffic.

Any delivery by dedicated trains would move directly into the intermodal facility for cask inspection and transfer to trucks. Shipments via general freight would be "set out," as is typical for railroad operations, on a siding at the intermodal facility. Then a "local" or rail yard locomotive would make the final move into the facility. Again, this clearly introduces another move that involves coupling and uncoupling cars, adding another element of potential human error or mechanical failure.

111 ..

Page 2-53; Section 2.1.3.3.3.1 - Intermodal Transfer Stations

The intermodal transfer station would accept railcars as they arrived (24 hours a day, 7 days a week), but it would normally dispatch heavy-haul trucks during early morning daylight hours on weekdays, consistent with current Nevada heavy-haul shipment regulations. The Draft EIS does not contain sufficient information on the schedule of arriving shipments to the station and the schedule on dispatch of heavy-haul trucks from the station to allow an evaluation of the impacts. During winter time, the restriction on travel during daylight hours will significantly limit the time available for travel from the station to the proposed repository. In December, for example, there are only about 10 daylight hours available for travel. Depending on the location of the intermodal transfer station, dispatch of the heavy-haul trucks in the "early morning daylight hours" could result in heavy-haul trucks traveling through the Las Vegas urban area during rush hour.

The Draft EIS does not provide any information on the impact of limiting travel to weekdays. Given the restriction on travel during daylight hours, this means that casks arriving at the station Friday through Monday morning cannot be dispatch until Monday morning. To comply with NRC requirements, a significant number of heavy-haul trucks will have to be dispatched on Monday mornings. The Draft EIS should provide information on this scheduling requirement and include an evaluation of the impacts of having multiple heavy-haul trucks dispatched during a short time-frame on Monday mornings. Since travel is also prohibited on holidays, this problem will be even worse over three-day holiday weekends.

The number of casks arriving over a weekend could vary significantly depending on whether DOE decides to use general freight or dedicated trains. DOE should state in the Draft EIS its preferred option for the type of service utilized so that an estimate of the number of railcars arriving over a weekend can be made to evaluate impacts of scheduling options. Conceivably, if DOE opts for dedicated train service, the dispatch of

111 cont. trains from shipping sites could be optimized to prevent an excessive number of casks arriving at the intermodal transfer site over weekends.

112 Page 2-53; Section 2.1.3.3.3.2 - Highway Routes for Heavy-Haul Shipments

DOE seems to believe that a heavy-haul vehicle of the configuration shown on this page is able to attain speeds of 20-30 miles per hour. Nevada officials believe this is a very optimistic estimate, considering the historical operation of multi-axle, multiple tractored vehicles in this state, and given the grades that need to be traversed along any of the proposed heavy-haul alignments. DOE also states that "if necessary," they would perform "road upgrades" (e.g., widening the shoulders and constructing turnouts and truck lanes; upgrading intersections that are inadequate to handle heavy-haul truck traffic; increasing asphalt thickness [overlay] of some sections; and upgrading engineered structures such as culverts and bridges). This statement clearly represents an assumption that Nevada's highway network can accommodate a major heavy-haul shipping campaign with little remedial action. Nevada presently permits approximately one vehicle a year in the configuration shown. The highway system as it now exists cannot sustain the accumulation of axle loads this type of campaign would produce. In fact, infrastructure improvements involving lane construction and widening would be required in both directions for almost the entire length of any of the heavy-haul routes evaluated in the Draft EIS.

113 Page 2-53; Section 2.1.3.3.3.2 - Highway Routes for Heavy-Haul Shipments

Road upgrades for candidate routes, if necessary, would involve four kinds of construction activities: (1) widening the shoulders and constructing turnouts and truck lanes; (2) upgrading intersections that are inadequate for heavy-haul truck traffic; (3) increasing the asphalt thickness (overlay) of some sections; and (4) upgrading engineered structures such as culverts and bridges. The overlay work would include upgrades needed to remove frost restrictions from some road sections.

The Draft EIS does not contain sufficient analysis of the road upgrade requirements necessary to accommodate these heavy-haul shipments. Southern Nevada experiences extreme heat during the summer. The potential of the heavy-haul trucks causing severe rutting of asphalt surfaces during times of excessive heat should be evaluated. The need to replace asphalt surfaces with concrete to avoid rutting should be evaluated. In areas that experience winter snowfall, snow melt could create saturated roadbed conditions, resulting in pavement damage from heavy-haul trucks. The feasibility of some of the heavy-haul route options depends on upgrades required to remove frost restrictions on some road segments. The upgrades necessary to remove frost restrictions on these roads should also be discussed to justify the feasibility of these options. The possible need to

113 cont. change road surfaces from flexible pavement surfaces (asphalt) to rigid pavement surfaces (concrete) should also be discussed. If rigid pavement surfaces are necessary, this could significantly alter the estimated cost of the heavy-haul option.

The Draft EIS also does not contain adequate information to demonstrate that the heavy-haul trucks will not significantly reduce the expected life of pavement surfaces. Although DOE contractors admit that a detailed analysis of road wear/damage, based on the current plan for heavy-haul, must be performed to provide final estimates for reduction of road life (*Nevada Potential Repository Transportation Strategy, Study 2, Volume 1*, TRW, February 1996, p.6B8), this analysis was not conducted. Rather, an unsupported assumption that estimated pavement wear would increase by 10 percent was used, even though they recognized that pavement wear would be a major cost driver of the heavy-haul truck option (ibid. p. 6B9).

114 Page 2-54; Section 2.1.3.3.3.2 - Highway Routes for Heavy-Haul Shipments

The Draft EIS assumes that most borrow material for construction could come from existing Nevada Department of Transportation borrow areas, if the State agreed. Most road design projects attempt to balance cut and fill requirements during construction of the roads. Therefore, it is not reasonable to assume that borrow material will be available in existing borrow areas for the extensive fill requirements necessary to construct truck climbing lanes and other road improvements. Obtaining fill material from other areas could result in significant impacts not discussed within the Draft EIS.

The last sentence in the second paragraph of the first bullet says, "This parking area would be near the U.S. 6 and U.S. 95 interchange at Tonopah." The point where U.S. 6 and U.S. 95 meet in Tonopah is an intersection in town. It is hardly a place to park this type of truck. This is a busy intersection, not a freeway-type interchange.

115 Page 2-56; Section 2.1.4 - Alternative Design Concepts and Design Features

The NWPA calls for the repository to isolate the waste, not "limit the release and transport of radionuclides." DOE states in Section 1 of this Draft EIS that a repository "is a system for permanently isolating radioactive materials....." Therefore, this section should discuss how the design features of the repository will <u>isolate</u> the waste.

As previously discussed, the level of design is insufficient for Site Recommendation, as well as for a license application to the NRC.

116 Page 2-57; Section 2.1.4.1 - Design Features and Alternatives to Limit Release and Transport of Radionuclides

Of the five design features listed in the category "Barriers to limit release and transport of radionuclides" in Table 2-4, only one - additives and fillers - actually serves to limit release and transport of radionuclides. The remaining four, drip shields, backfill, waste package corrosion-resistant barrier, and ground support options serve only to delay releases and do not eliminate or substantially reduce releases of radionuclides, the true measure of repository performance. The ideal goal of repository performance is to eliminate the potential for release of emplaced radionuclides. The realistic objective is to limit releases, at whatever time they occur, to acceptable levels. The Draft EIS analysis indicates that a Yucca Mountain repository cannot meet this objective, relative to expected peak doses resulting from released radionuclides after the short period of time (300 to 1,000 years) during which the major fission products decay. Juvenile failure of components of the engineered barrier system could result in radionuclide releases prior to the time major fission products have decayed to very low levels.

Many of the features and alternatives discussed in this section and elsewhere in the Draft EIS are actually part of DOE's current design for a Yucca Mountain repository. As such, the impacts of these features and alternatives should have been fully addressed in the Draft EIS. For example, the current repository conceptual design (not the design described in the Draft EIS) calls for the waste packages to be covered by a continuous titanium drip shield. The Draft EIS should examine the impact on the national (and perhaps international) titanium resource from the increased demand caused by the use of titanium drip shields in up to 100 miles of repository tunnels.

117 The addition of design features and alternatives is not for the simple purpose of improving barriers that limit the release and transport of radionuclides, as stated in the Draft EIS. Such characterization understates the role of these engineered "fixes." These design features are essential to demonstrate repository compliance with waste isolation and health and safety criteria. Such reliance on engineered barriers is contrary to the NWPA requirement that the geology of a repository site function as the principal barrier to the migration of radionuclides and that engineered systems function only to add redundancy to the system. As such, heavy reliance on engineered design features as the primary source of waste isolation means that the project, as described in the Draft EIS and in other DOE documents, is inconsistent with the requirement for geologic isolation contained in the Nuclear Waste Policy Act of 1982, as amended.

118 Page 2-57; Section 2.1.4.2 - Design Features and Alternatives to Control the Thermal/Moisture Environment in the Repository

Neither this section nor Appendix E (at E.2.2.6) considers the obvious alternative to problems associated with thermal output of the spent fuel: let it age in surface storage for the 80 to 100 years needed to reduce the decay heat to a level that does not require special measures in repository design or create large uncertainties in the nature of the near-field environment that would significantly affect repository performance. This alternative should be comprehensively evaluated in the Draft EIS as a reasonable alternative.

119 Any continuous postclosure ventilation considerations should eliminate all options that result in postclosure openings from the interior of Yucca Mountain to the surface. (See Appendix E at E.2.2.3). Any openings would constitute a large and unacceptable uncertainty in postclosure performance that could not be mitigated. Site characterization studies have shown that, due to the fractured nature of the rock, Yucca Mountain is a naturally ventilated setting above the water table. This fact must be taken into account in long-term performance assessment.

120 Page 2-58; Section 2.1.4.3 - Design Features and Alternatives to Support Operational and Cost Considerations

DOE should describe and analyze its preferred design concept in the Draft EIS rather than plan to "evaluate the environmental impacts associated with the updated design in the Final EIS." This is an undue limitation on the public's ability to review and comment on this NEPA document and is based only on DOE's self-imposed repository program schedule.

121 ... Page 2-58; Section 2.1.5 - Estimated Costs Associated with the Proposed Action

The cost of the repository program should include the whole program, including a breakdown for each thermal load, each packaging scenario, and all transportation scenarios. Given the broad uncertainty in the design of the repository in the Draft EIS, the cost estimate for the monitored geologic repository lacks any substantive basis. The same is true for waste acceptance, storage, and transportation.

The costs estimates associated with the Proposed Action contained in the Draft EIS are grossly understated. The State of Nevada commissioned an independent study of program costs in1998 (see Attachment T, "An Independent Cost Assessment of the Nation's High-Level Nuclear Waste Program"). The study found that DOE's proposed program, as it was then conceptualized, would cost $53.9 billion (in 1996 dollars). The study also found that, at most, the Nuclear Waste Fund could be expected to generate

121 cont.

$28.1 billion (in 1996 dollars), leaving a taxpayer liability of at least $25.8 billion. The study did not take into account many of the costly "design features and alternatives" DOE now considers essential for the Yucca Mountain facility. It also did not analyze the effect of probable early power plant closures that could significantly reduce the amount of funds generated by the fee imposed on nuclear-generated electricity, the primary source of the Nuclear Waste Fund.

The Draft EIS fails to assess the impact of the projected revenue shortfall on DOE's ability to implement the Proposed Action. By understating the real costs of the project and failing to reconcile costs with available revenues, DOE obscures a major issue that goes to the heart of the viability of the entire project.

122 ...

Page 2-59; Section 2.2 - No-Action Alternative

See comments above on Section 1.4.3.4, No-Action Alternative

NEPA requires that federal agencies, in preparing environmental impact statements supporting major federal decisions and projects, consider alternatives to the action being proposed, including the alternative of taking no action. Because the Nuclear Waste Policy Act specifically exempts DOE from the need to examine alternatives to geologic disposal or to the Yucca Mountain site, the principal alternative for comparison with the Proposed Action in the Draft EIS must be the No-Action Alternative. In the Draft EIS, DOE has chosen two No-Action Alternative scenarios that are unrealistic, unreasonable, and legally deficient.

The Draft EIS postulates a situation where, instead of a repository at Yucca Mountain, spent nuclear fuel and high-level radioactive wastes are stored on-site at reactor and generator locations for a period of 10,000 years. In the first "No-Action" scenario, DOE assumes that active institutional control is maintained for the entire time, while under the second scenario, institutional control ceases after the first 100 years.

123

Both scenarios are wholly inappropriate, even absurd. The Council on Environmental Quality (CEQ) interprets the No-Action Alternative as "the federal agency not acting at all," i.e., not constructing and operating a repository at Yucca Mountain. In the absence of a repository, it is unacceptable to assume that spent fuel and HLW would simply be left forever at reactor sites. The most plausible No-Action scenario is one where there would be some period (50 to 100 years) of at-reactor storage, most likely in dry storage configurations, combined with the application of waste reduction technologies and followed by some form of a revised (and, hopefully, dramatically improved) process to site and construct storage and/or disposal facilities.

122 cont.

DOE's No-Action Alternative scenarios cannot be defended on the basis of reasonably foreseeable actions in the absence of a decision to move ahead with the development of a repository. Instead, what DOE appears to have done is select scenarios designed to generate the greatest public alarm and political pressure in favor of its Proposed Action. In so doing, DOE has violated the clear intent of NEPA that a realistic and reasonable No-Action Alternative be evaluated and compared to the Proposed Action.

124

Page 2-60; Section 2.2.1 - Yucca Mountain Site Decommissioning and Reclamation

If Yucca Mountain is not used as a repository under the No-Action Alternative, all openings should be sealed, not just gated. Under the NWPA, the site would be permanently removed from consideration as a repository.

DOE should state that the activities discussed in this section will be carried out according to federal and State requirements and as required by BLM in the applicable right-of-way grants that are, and have been, in place throughout Yucca Mountain site investigations.

This section provides no detail about reclamation procedures, their application, and their chances for success. This issue is elaborated on in Attachment M to these comments.

125

Page 2-61; Section 2.2.2.1 - Storage Packages and Facilities at Commercial and DOE Sites

It is beyond the scope of this Draft EIS to assume, without further DOE commitment, how DOE spent fuel and high-level radioactive waste would be stored at DOE facilities. Most of the high-level waste is currently in liquid form in underground storage tanks and will still be in 2002, when the No-Action Alternative is assumed to start.

126

Page 2-67; Section 2.2.2.3 - No-Action Scenario 2

This paragraph conflicts with the third paragraph on page 2-59 that describes the two scenarios for the No-Action Alternative. The information should be consistent.

127

Page 2-67; Section 2.2.3 - No-Action Alternative Costs

This cost analysis is of no substantive value because, as stated above, neither of the No-Action Alternative scenarios would ever be implemented. Therefore, any cost analysis or comparison in this Draft EIS is not relevant.

128 cont.

Page 2-69; Section 2.3.1 - Alternatives Addressed Under the Nuclear Waste Policy Act

The Draft EIS should not consider any plan to emplace more than 70,000 MTHM at Yucca Mountain for the reason stated in the third paragraph of this section, i.e., the NWPA prohibits this action. Therefore, the discussion of this plan in Section 8 should be removed from the Draft EIS.

129

This section of the Draft EIS discusses the provisions of the Nuclear Waste Policy Act of 1982 and the amendments to that Act in 1987 that relieved DOE from having to evaluate alternatives to geologic disposal, the Yucca Mountain site, and the time of the initial availability of the repository. The actual language in the Act states that "the Secretary of Energy ***need not consider*** ..." such alternatives in preparing the requisite environmental impact statement. DOE is, therefore, not prohibited from examining these alternatives, but chose not to in the Draft EIS.

Nevada believes that, given the extraordinary nature, national scope, costs, and potential impacts of the Yucca Mountain project, DOE should have exercised its discretion and included a thorough evaluation of alternative approaches for addressing the nuclear waste problem. Such an approach would have served to better inform Congress, the Executive Branch, and other affected parties of the true range of alternative approaches that are available for managing the nation's spent fuel and high-level waste and allowed those other potential approaches to be compared and contrasted with the Proposed Action.

130

In discussing the provision of the 1982 Act that indicates DOE need not consider alternatives to geologic disposal, the Draft EIS references the 1980 EIS that selected deep geologic disposal as the preferred method for disposing of spent fuel and HLW. The Draft also refers to the National Academy of Sciences (NAS) endorsement of deep geologic disposal. The facility set forth in the Draft Yucca Mountain EIS and in more current DOE reports and design documents is not, however, consistent with the definition of a deep geologic repository. Geologic disposal, as envisioned by the 1980 EIS and the NAS, means that the geologic formation in which the waste is placed is the principal barrier to assure that the waste remains isolated for the required time. Under the 1980 EIS and NAS concept, engineered barriers such as the waste package, backfill, etc. were to provide redundancy for the system. It was never intended that such engineered barriers would be used to compensate for deficiencies in the geologic environment.

What the Draft EIS sets forth in the Proposed Action is the opposite of the concept of deep geologic isolation. DOE's plans for Yucca Mountain place primary reliance for waste isolation on various engineered systems (i.e., hardware designed to compensate for the poor waste isolation characteristics of Yucca Mountain itself). In order to make the site meet the radiation exposure standards, the engineered facility at Yucca Mountain

130 cont. requires waste packages designed to last for at least 100,000 years, continuous titanium drip shields placed over the waste packages, special absorbent materials inside the waste packages, and numerous other engineering "fixes" that have evolved over the years in response to findings about the poor quality of the site itself. Such engineered barriers would be acceptable if they were used solely for redundancy. However, when they become the primary waste isolation system, the facility is no longer a geologic repository in the sense envisioned by the 1980 EIS and the NAS.

Given the almost full reliance on engineered barriers for waste isolation, the Yucca Mountain facility would perform just as well in an above ground industrial building. The performance calculation results would likely be about the same.

Since the Nuclear Waste Policy Act specifically requires that DOE pursue geologic disposal for the nation's spent fuel and high-level radioactive wastes, and since the definition of geologic disposal is derived from DOE's own 1980 EIS and prior and subsequent findings of the NAS, the Draft EIS and the Proposed Action it is intended to support are in violation of the spirit and the letter of that Act.

131 Page 2-70; Section 2.3.2 - Repository Design Alternatives Eliminated From Detailed Study

The Draft EIS should acknowledge and describe the two factors that have served to eliminate a whole suite of potential repository designs and have driven the current general design concept. The two factors are: 1) the discovery of rapid infiltration and flow of water in fractures in the unsaturated zone (contrary to the original conceptual model of very slow porous flow downward through Yucca Mountain), and; 2) the incorporation of large, horizontally emplaced waste packages in drifts required by the now-defunct development of the Multi-Purpose Container that replaced the concept of thin-walled stainless steel, vertically emplaced waste packages. These factors together reflect the finding that a Yucca Mountain repository system must rely on a robust engineered barrier system because the natural barriers of the site are not capable of providing significant waste isolation alone. The key design requirement that is central to Yucca Mountain repository performance is a waste package that has a projected long life relative to the regulatory compliance period.

Page 2-70; Section 2.3.3 - Nevada Transportation Alternatives Eliminated from Detailed Study

See comments below on Section 6 of the Draft EIS.

Page 2-72; Section 2.3.3.2 - Potential Highway Routes for Heavy-Haul Trucks and Associated Intermodal Transfer Station Locations Considered but Eliminated from Further Detailed Study

132 DOE eliminated the development of a new road for heavy-haul trucks from further detailed evaluation because the construction of a new branch rail line would be only slightly more expensive and transportation by rail would be safer (no intermodal transfers) and more efficient (TRW 1996, page 6C7). The analysis cited is based on the constraints for grade and curvature used for heavy-haul vehicles designed for highway use. DOE did not consider the feasibility of adapting trucks designed for heavy-haul in mining activities to the transport of spent fuel casks. These vehicles have the advantage of being able to handle extremely heavy loads (up to 400,000 tons) without the constraints on grade and degree of curvature required for vehicles designed for highway transport. Allowing significantly increased grades, sharper curves, and different surfacing materials (e.g., gravel) could significantly reduce the cost of constructing dedicated heavy-haul roads.

133 Page 2-74; Section 2.4.1 - Proposed Action and No-Action Alternative

This section of the Draft EIS concludes that "analyses showed that the environmental impacts associated with the Proposed Action would be small ..." This statement is not supported by the data and assessments in the Draft EIS. As discussed in comments relative to Sections 4, 5, and 6 of the Draft EIS (below), data that DOE ignored and/or analyses they failed to undertake clearly indicate that the impacts associated with the Proposed Action could be substantial. These impacts would affect people and the environment in Nevada and in cities and communities across the country and would be costly in monetary terms and in terms of human health, safety, and well-being.

134 Page 2-74; Section 2.4.2 - Short-Term Impacts of Repository Construction, Operation and Monitoring, and Closure

The Draft EIS states that the "estimated short-term (to 100 years) costs for the Proposed Action would be about $29 billion, and those for the No-Action Alternative would be as much as $57 billion for the same period." This statement is not only inaccurate, but gratuitous. As shown in Attachment T, the actual costs for implementing the Proposed Action will be almost $54 billion, even without many of the costly engineered fixes and alternatives that DOE has added to the project in the past two years. Furthermore, the analysis of the unrealistic No-Action Alternative scenarios provides no basis for comparison with the Proposed Action. The cost of storing spent fuel and HLW at generator sites, in the absence of a repository or central storage facility, would be closer to $4 to $5 billion (see discussion of on-site storage in Attachment T).

135 Page 2-74; Section 2.4.3 - Long-Term Impacts of the Proposed Action and the No-Action Alternative

Because the No-Action scenarios presented in the Draft EIS are unreasonable and unrealistic, the comparison of impacts with the Proposed Action represents a meaningless exercise and should be eliminated. Unless DOE decides to re-scope the EIS and identify a realistic and feasible No-Action Alternative, the type of comparison attempted in this section of the Draft EIS serves no useful purpose.

136 Page 2-75; Table 2-7 - Impacts Associated with the Proposed Action and No-Action Alternative

Long-term air quality: It is possible that there would be carbon-14 releases to the air from the postclosure repository. It is incorrect to say there would be no air releases.

Because the No-Action Alternative scenarios are, as stated previously, unrealistic and unreasonable, comments on the No-Action Alternative scenario impacts listed in Table 2-7 will not be provided.

137 Page 2-77; Table 2-7 cont.

Utilities, energy, materials, and site services: The impacts of enhancing the electric power delivery system to the Yucca Mountain site should be considered both on-site and off-site, if new transmission facilities are required. Section 3.1.11.2, Utilities, does not provide information on pages 3-89 to -92 on expected electric power use. It only speaks to current availability to the NTS and historical use by Yucca Mountain project activities.

Page 2-79; Section 2.4.4 - Impacts of the Transportation Scenarios

See comments on Section 6 of the Draft EIS (below).

138 Page 2-79; Section 2.4.4.1 - National Transportation

The summary of national transportation impacts is based on inadequate and incomplete data and analyses and does not reflect the impacts posed by the Proposed Action to people, communities, and the environment along national shipping routes. Since specific routes are never identified, analyses of impacts to at-risk communities are never attempted in the Draft EIS. No effort is made to identify and evaluate the potential for substantial socioeconomic impacts in corridor states and communities (see comments relative to Sections 4, 5, and 6 below). The use of fatalities (either latent cancer fatalities (LCFs) or accident fatalities) as the measure of transportation impacts is inadequate and serves to grossly understate the full range of negative impacts on people and the

138 cont. environment associated with the Proposed Action. As noted in subsequent comments, the models and assumptions used to generate LCFs, transportation accident rates, and accident probabilities and severity are deficient and understate the consequences of a national shipping campaign of the size, complexity, and duration needed to implement the Proposed Action. In addition, entire categories of potential impacts (such as socioeconomic impacts, morbidity, quality of life, etc.) are simply ignored.

139 Page 2-80; Section 2.4.4.2 - Nevada Transportation

The analyses and data contained in the Draft EIS are inadequate to support the conclusion that environmental impacts for each of the ten implementing alternatives for waste transportation in Nevada would be small. The State of Nevada's evaluation (see comments relative to Section 6 of the Draft EIS) shows that risks and impacts could be substantial; that DOE has ignored key areas of potential impacts altogether; that spent fuel and HLW transportation could be major drivers of a wide rage of socioeconomic, health and safety, and environmental impacts; and that impacts would affect individual communities and the State as a whole.

140 Page 2-81; Section 2.4.4.2 - Nevada Transportation

The Draft EIS states, "With the exception of Land Use, differences in environmental impacts for the ten implementing alternatives related to incoming shipments by rail would be small, so environmental impacts do not appear to be a major factor in the selection of transportation mode, route, or corridor in Nevada for incoming rail shipments." This statement is inaccurate. Rail operations associated with heavy-haul shipments present major problems for the operational highway network in Nevada. The Draft EIS ignores such impacts as traffic queuing, failing structural sections, remedial actions for reducing traffic accidents, and institutional anomalies (such as providing a portable crane capable of lifting overturned vehicles and casks).

141 ... Page 2-81; Section 2.4.4.2 - Nevada Transportation

The statement in the Draft EIS that environmental impacts for each of the 10 implementing Nevada transportation alternatives would be small is unsupportable. As discussed in these comments, DOE has failed to develop sufficient information on the description of the Proposed Action to adequately characterize the environmental impacts for Nevada transportation. In many cases, DOE's impact analysis is also based upon incomplete or missing environmental data due to the cursory analysis conducted on the potential transportation corridors. DOE has also incorrectly dismissed some identified impacts as minor (e.g., impact on crucial wildlife habitats). Therefore, the conclusion that the environmental impacts would be small is not a valid conclusion.

141 cont.

Similarly, the statement made in the second bullet on page 2-81 cannot be supported. That statement reads, "With the exception of land use, differences in environmental impacts for the 10 implementing alternatives related to incoming shipments by rail would be small, so environmental impacts do not appear to be a major factor in the selection of transportation mode, route, or corridor in Nevada for incoming rail shipments."

As discussed above, DOE has not adequately assessed the environmental impacts of the 10 implementing alternatives. Therefore, it is not possible to draw the conclusion that the difference in environmental impacts are not a major factor in the selection of the transportation mode, route, or corridor. Furthermore, DOE has identified significant differences in land use impacts that should be a major factor in this decision. Therefore, this conclusion is not valid.

142

Page 2-81; Section 2.5 - Collection of Information and Analyses

This Draft EIS should be reissued when all the information on which it is based is available, complete, and of defensible quality.

143

Page 2-82 and page 2-83; Table 2-9 - Comparison of Impacts for Nevada Rail Implementing Alternatives and for Legal-Weight Truck Shipments

In this table, DOE attempts to provide a comparative summary of the impacts of the Nevada rail versus legal-weight truck alternatives. However, without rail access or heavy-haul shipments, there is no identified means of making over 300 shipments of naval spent fuel to the proposed repository. Therefore, any comparisons in this table are not valid, since they are not based on a complete description of the Proposed Action and thus, do not include a complete summary of the potential impacts.

144 ...

Page 2-86; Section 2.5.1 - Incomplete or Unavailable Information

The text under this section states that "some of the analyses in the Draft EIS had to use incomplete information." In fact, ***most,*** if not all, of the analyses are based on incomplete and, in some cases, deficient information. (See comments on Sections 3, 4, 5, and 6 of the Draft EIS.) The State of Nevada does not consider the information contained in the Draft EIS and used in the analyses to be adequate or sufficient to support the conclusions regarding the potential for and severity of impacts.

Most of the analysis of impacts on the Nevada transportation alternatives is based upon incomplete or missing information. This is primarily due to DOE's failure to select a preferred alternative and a reasonable number of alternatives for Nevada transportation. The Council on Environmental Quality regulations cited, however, do not allow DOE to

144 cont

make a NEPA decision based on this incomplete or unavailable information. The CEQ regulation cited by DOE states:

(a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.

(b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement:

1. a statement that such information is incomplete or unavailable;

2. a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;

3. a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and

4. the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

Since the information needed to make an informed decision on the transportation impacts is neither exorbitant in cost to obtain nor unobtainable, paragraph (a) above is applicable. The information necessary to make an accurate assessment of the Nevada transportation should be obtained and should be included in an environmental impact statement prior to any agency decision.

145... This section and, in particular, the statement, "In addition, DOE might not complete some of the studies and design development for the repository until after it has issued the Final EIS" is not consistent with the requirements of the NWPA. Upon completion of site characterization (Sec. 114(a)(1), the Final EIS will accompany the Secretary's Site

145 cont. Recommendation Report. That report is to include, among other things, "a description of the proposed repository, including preliminary engineering specifications for the facility" (Sec. 114(a)(1)(A). Based on this information, the Draft EIS is not only insufficient pursuant to NEPA, but it is also not in compliance with the NWPA.

146 Page 2-86; Section 2.5.2 - Uncertainty

The statement that "the results and conclusions of analyses often have some associated uncertainty" is a huge understatement. Every aspect of the Yucca Mountain program is characterized by massive uncertainties. There is pervasive uncertainty regarding the design of the repository facility - surface and subsurface. There is major uncertainty associated with assessments of waste isolation performance, uncertainties that are compounded by the substitution of assumptions and judgement for unavailable data. Almost every aspect of the transportation system is rife with uncertainties that the Draft EIS does little or nothing to reduce. There is inherent uncertainty in all of the risk calculations and models, as well as in the predictions of radiation exposures from project activities. In short, uncertainty is a defining characteristic of the Yucca Mountain program.

This uncertainty itself can create impacts and be a factor that leads to the amplification of impacts that might occur. How DOE handles uncertainty in the design and construction of the repository could result in overly optimistic assumptions for waste isolation capabilities and lead directly to greater radiation exposures in the future and higher incidence of accidents. The Draft EIS should have addressed the issue of uncertainty as a fundamental characteristic of the Proposed Action and assessed what effects and impacts could be expected from a program with such unprecedented and unmitigated levels of uncertainty.

As presented in this Draft EIS, the uncertainties from all sources, both in repository performance and system design, as well as environmental impacts, are of such range and magnitude that a decision to select the preferred alternative cannot be supported by this document.

147 Page 2-87; Section 2.6 - Preferred Alternative

The text in this section states that "The analyses in this EIS did not identify any potential environmental impacts that would be a basis for not proceeding with the Proposed Action." The text goes on to say that "DOE has not chosen any transportation mode, corridor, or route as preferred at this time."

147 cont. The information and analyses contained in the Draft EIS are insufficient and so burdened by uncertainty, assumption, and speculation that they do not support DOE's conclusion of no impact (see comments on Sections 4, 5, and 6 of the Draft EIS). In addition, the selection of transportation modal mix, rail or heavy-haul corridors, intermodal facility decisions and locations, and national and Nevada highway and rail routes are integral aspects of the Proposed Action, as set forth in the Draft EIS and in practical and operational terms. It is entirely inappropriate for DOE to conclude the Proposed Action poses no significant environmental impacts when decisions on critical and inseparable elements of that Action are being postponed to some undefined future time.

The Draft EIS must consider the Yucca Mountain program in a holistic sense. If the preferred alternative is to proceed with a repository at Yucca Mountain, then the analyses associated with that alternative must include the complete set of actual elements that make up the Proposed Action. It is no more possible to separate the surface facilities for the proposed repository from the subsurface facility, than it is to separate the transportation system components from the waste acceptance and disposal systems. It takes the entire package to implement the Proposed Action, and each of the components must be described and analyzed with sufficient detail and specificity to enable an adequate identification and assessment of impacts. That cannot occur when large elements of the Proposed Action are left undefined.

442 The Council on Environmental Quality regulations require that the agency preparing the EIS "[i]dentify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference" (40 CFR 1502.14(e)). DOE admits that it has not chosen the preferred transportation alternative at this time and that when it does, additional field surveys, state and local government consultations, environmental and engineering analyses, and National Environmental Policy Act reviews will be required. DOE's own guidance document on the preparation of environmental impact statements also cautions against improper segmentation of connected actions and directs that connected actions should be considered together in a single NEPA document. It specifically recommends that DOE "include transportation activities as part of the proposed action when the transportation activities would be necessary to make the action happen"*(Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*, U.S. Department of Energy, Office of NEPA Oversight). The disposal of waste at the proposed repository cannot happen without transportation. Therefore, DOE should have included a preferred transportation alternative within the Draft EIS and conducted all of the necessary analyses to reach a decision.

SECTION 3. AFFECTED ENVIRONMENT

148 Page 3-1; Section 3.1 - Affected Environment at the Yucca Mountain Repository Site at the Conclusion of Site Characterization Activities

Section 3.1 defines the affected environment as it was at the end of site characterization. The documentation is in several environmental baseline files. This approach ignores and circumvents the issue that an environmental baseline did not exist prior to site characterization and, therefore, no impacts of that phase could be evaluated. Thus, for the Draft EIS, the affected environment was as it stood after being impacted by site characterization, with the absence of a true, undisturbed baseline as intended by NEPA regulations. The importance of pre-disturbed baseline information in the Environmental Impact Assessment and NEPA processes is discussed in Attachments A, B, D, E, F, and G.

149 Page 3-2; Section 3.1 - Affected Environment and the Yucca Mountain Site at Conclusion of Site Characterization Activities

The baseline information description for the "socioeconomic environment" in the Yucca Mountain region, as reflected in the Draft EIS, is inadequate and deficient. As documented in comments relative to Draft EIS Sections 3, 4, and 5, baseline information relative to socioeconomic conditions must include information by which impacts on the State's major industrial sectors can be measured. Such baseline information would include information on tourism and tourism-related industries; business and industrial relocations and economic development activities; image data relative to how Nevada and Las Vegas are perceived and the vulnerability of these images to Yucca Mountain related activities; State and local government revenues generated from tourist-related sources (gaming, taxes, sales taxes, room taxes, etc.); and other related information.

150 Page 3-3; Table 3-1 - Regions of influence for the proposed Yucca Mountain repository

The Draft EIS inappropriately defines regions of influence in an overly narrow and restrictive manner that serves to disenfranchise important affected populations. The region of influence for "cultural resources" is described in Table 3-1 as "land areas that the proposed repository would disturb ... and areas in the analyzed land withdrawal where impacts could occur." The actual area for potential cultural resource impacts from the project is much broader than this narrow definition. The region of influence should include all Native American communities potentially affected by the repository or by repository-related nuclear waste transportation. This includes not only cultural sites within narrow "disturbed" areas or within the 230 square mile proposed land withdrawal,

150 cont.

but also tribes, reservations, and communities impacted by rail or highway transportation routes.

In addition, the cultural resources region of influence must include both Native American communities and sites of religious or historic significance along specific transportation routes. The Proposed Action is an undertaking that is national in scope and encompasses, as an integral and inextricable part of the program, a system of national highway, rail, and barge routes that must be analyzed for areas of important cultural resources, especially those relating to Native peoples and cultures.

Table 3-1 also unnecessarily and inappropriately truncates the "socioeconomic environment" region of influence by limiting it to Clark, Lincoln, and Nye Counties. Even the incomplete and overly general analyses contained in later sections of the Draft EIS acknowledges that a number of other counties will be affected, primarily by rail spur development and operation; intermodal facility siting, construction, and operations; heavy-haul truck transportation; and highway transport of spent fuel and HLW waste. In addition, the State of Nevada, as a whole, will be affected by repository activities from impacts on the State's major industries, impacts to the State revenue base, and impacts to State agencies that have responsibilities for repository activities (highway regulation/ maintenance, law enforcement, emergency management/response, etc.).

Since the Proposed Action encompasses a national radiological materials shipping campaign of unprecedented proportions, duration, geographic scope, and potential impacts, the socioeconomic environment region of influence should also include cities and communities located along all of the specific national transportation routes. Attempting to constrict the region of influence for the Proposed Action is inappropriate and renders the Draft EIS deficient in its scope and approach to impact identification and assessment.

151 ..

Page 3-7; Section 3.1.1.3 - Potential Repository Land Withdrawal

This section does not provide a substantive rationale for the size and dimensions of the proposed withdrawal area. It also does not discuss the necessity for the inclusion of the one square kilometer parcel of private land, which is an operating patented mining claim and water supply well adjacent to Highway 95.

In the first paragraph in this section, the Draft EIS fails to qualify the statement "Because all of these lands are not under permanent DOE control, a land withdrawal would be required." The Draft EIS provides limited information about the current "non-permanent" withdrawal status of the referenced DOE lands that would encompass a repository land withdrawal. Specifically, the Draft EIS should describe the current

151 cont. withdrawal status of DOE-controlled lands within Area 25 of the NTS and adjacent Air Force-controlled lands (i.e., the lands on the NTS and the Nellis range that would be necessary to support a repository at Yucca Mountain). The Draft EIS should also address any environmental management sites within the proposed land withdrawal area, including Area 25, that would be subject to DOE long-term stewardship.

152 Page 3-9; Table 3-4 - Current land ownership and public accessibility to the analyzed land withdrawal area.

Except for the one patented mining claim referenced in this table, the title of the table is incorrect and misleading. While the patented mining claim may be "owned" by a private party, none of the remaining lands given in the table are under federal ownership. All of the lands defined in the table, except for the one mining claim, are public lands. The title of the table should be changed to reflect the lands under public ownership, albeit temporarily withdrawn for federal use.

153 Page 3-12; Section 3.1.2.1 - Air Quality

Were data collected since 1995 on air quality? If so, why wasn't it presented here? If not, why not?

154 Page 3-21; Section 3.1.3.1 - Physiography (Characteristic Landforms)

There is uncertainty associated with the age of the last eruption of the Lathrop Wells cone. The range of the uncertainty should be stated here.

155 Page 3-24; Section 3.1.3.1 - Physiography (Characteristic Landforms): Selection of Repository Host Rock

The discussion on the repository host rock should indicate that, during construction of the ESF, more significant ground support methods than originally expected were required to achieve "stable openings."

156 Page 3-24; Section 3.1.3.1 - Physiography - Potential for Volcanism at the Yucca Mountain Site

Again, there is uncertainty associated with the age of the Lathrop Wells volcano. The latest activity could have been thousands of years more recent than the 75,000 year age indicated.

157 Page 3-25; Section 3.1.3.1 - Physiography - Potential for Volcanism at the Yucca Mountain Site

The estimated probability of a dike disrupting the repository during the first 10,000 years after closure has uncertainty associated with it. The expert panel members' estimates of the annual probability ranged over about three orders of magnitude, and the probability indicated here represents an aggregation of the members' estimates.

158 Page 3-29 to 30; Section 3.1.3.3 - Modern Seismic Activity - Seismic Hazard

Given the large uncertainty in fault lengths shown in Table 3-8, there should be a discussion in the text regarding the uncertainty that this introduces into the estimates of seismic risk.

159 The Final EIS should include the updated results of Dr. Wernicke's research relative to tectonic deformation and make any necessary adjustments in seismic and volcanic risk estimates.

160 Page 3-30; Section 3.1.3.4 - Mineral and Energy Resources

The EIS should show the locations of existing mining claims in the proposed withdrawal area, despite DOE's belief that economic mineral potential of the area is low.

161 Page 3-31; Section 3.1.3.4 - Mineral and Energy Resources

The text should read, "...no **currently** economic deposits.." As any geologist will tell you, technology and demand can change a currently uneconomical deposit into an economical one almost overnight.

162 Page 3-31; Section 3.1.4.1.1 - Regional Surface Drainage

The Draft EIS does not contain any information regarding potential discharge of contaminated groundwater that would not meet either the Nevada Water Quality Standards or the California Water Quality Standards. The Draft EIS should be reissued to include a discussion on the potential for migration of contaminants in the groundwater and possible discharge at points in Nevada and California. The question of whether this discharge would meet both Nevada's and California's Water Quality Standards should also be addressed.

163 Page 3-36; Section 3.1.4.2 - Groundwater

The statement that there is a "firm basis of understanding of the hydrology of the region." is true only in DOE's eyes. There is still controversy over which direction the groundwater flows and how fast. Also, the cause of the large hydrologic gradient immediately north of Yucca Mountain has not been determined. In addition, uncertainties related to groundwater flow patterns from Pahute Mesa into Forty-Mile Wash and the relationship to groundwater movement beneath Yucca Mountain should also be discussed in the Draft EIS.

164 Page 3-38; Section 3.1.4.2.1 - Regional Groundwater

Figure 3-13 should depict the entire Death Valley Regional Groundwater Flow System, not just a portion of the system, and include the associated groundwater flow paths. The Draft EIS states that the Death Valley Regional Groundwater Flow System is a closed system with groundwater not leaving the system except by evapotranspiration. Figure 3-13 should graphically show this.

165 Page 3-39; Section 3.1.4.2.1 - Regional Groundwater

The distribution of infiltration across the Yucca Mountain block is questioned. The distribution of infiltration used in the Draft EIS is highest at the crest. There are indicators which would suggest that peak infiltration is on the western flank of the mountain block. Infiltration in this western block region may be underestimated and its effect unknown.

166 Only the water quantity for the low thermal load is given here. What is the quantity for the intermediate and high thermal loads, and why were the data not given?

167 Page 3-41; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

What would be "sufficient quantities of water" for DOE to collect? There are more than a few places in the ESF that dripped water.

168 Page 3-42; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Is perched water found only below the proposed repository horizon?

Why wasn't Chlorine 36 also used here, along with tritium?

169 Page 3-46; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Water Source and Movement: The description of the significance of Chlorine-36 in determining the age of subsurface water and in estimating the time it takes water to travel from the surface, through the repository horizon, and into the aquifer below is misleading. The real significance of the Chlorine-36 studies is that it has been conclusively demonstrated that the travel time for water to move from the surface of Yucca Mountain to the repository horizon is less than 50 years. The entire Chlorine-36 discussion in the Draft EIS appears intended to obscure this fact.

170 Define and quantify "relatively rapid water movement."

171 Define and quantify "very small amounts" of fallout. What is the basis for the assumption of "very small amounts" of fallout?

172 Page 3-47; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Give the best estimate of groundwater travel time, not just less than 10,000 years.

173 Page 3-49; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The Draft EIS should discuss more fully the fluid inclusion work on the calcite and opal veins and coatings underway at UNLV. The Draft EIS contains a brief discussion of the controversy over evidence that hydrothermal activity may have occurred at Yucca Mountain in the past and could reoccur during the lifetime of the repository. The text gives the misleading impression that this matter has been resolved in DOE's favor as a result of a NAS review of the issue. In fact, the issue is the subject of an ongoing joint study being implemented by the University of Nevada Las Vegas, DOE, and the State of Nevada. Preliminary indications from data and analysis emerging from this study indicate that fluid inclusions found in calcite-silica deposits at depth within the exploratory tunnel at Yucca Mountain are of hydrothermal origin. Work is ongoing to confirm this finding and to discover the age of the fluid inclusions. The outcome of this study has significant implications for the suitability of Yucca Mountain as a repository site and for the viability of the Proposed Action as described in the Draft EIS.

174 Page 3-51; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The discussion about the lack of data on the lower carbonate aquifer is another indication of the deficiencies of the Draft EIS. Single borehole tests are meaningless in this context. More testing should be performed to corroborate this data before using it in analyses and conclusions for the Draft EIS.

175 Page 3-52; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Provide the actual feet/mile or meters/kilometer for the slope of the water table east of the Solitario Canyon fault.

176 Page 3-53; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The use of the word "probably" in the third paragraph on this page does nothing but cause one to doubt the veracity of the statement.

Why is the average net infiltration rate on this page given as 4.5 millimeters over 220 square kilometers but on page 3-44, it is given as 4.5 millimeters over 230 square kilometers? Also, why wasn't the infiltration rate for the repository area used instead of the rate from the larger study area?

The statement that the groundwater pathway beneath Yucca Mountain is southerly conflicts with Figure 3-13 and other figures used in various DOE presentations that show an initial eastward flow of the groundwater, then down Fortymile Wash.

177 Page 3-54; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define and quantify the term "small" as used in the sentence regarding the volume of water pumped from USW VH-1.

178 Page 3-57; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The values in Table 3-17, Water chemistry of volcanic and carbonate aquifers at Yucca Mountain, are basically meaningless for comparison since, by DOE's own admission, the values shown for the lower carbonate aquifer all come from one well. (See comment for page 3-51.)

179 Page 3-59; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define the "active life of the repository."

180 Page 3-59; Section 3.1.5 - Biological Resources and Soils

This section only briefly addresses Biological Resources and Soils, referring to the *Environmental Baseline Files* (TRW 1999k and TRW 1991). The discussion in this section omits the physical environment that, together with the biological components, comprise the ecosystem involved. Ecosystems are not discussed at all, and that level of

180 cont. ecological organization is ignored. The same is true for the discussions of Biological Resources related to transportation on pages 3-107 and 3-127. With respect to ecosystems, the Draft EIS states on page 3-59 that many of its studies for this aspect of the document "....did not use an integrated ecosystem approach and, therefore, are of little value for evaluating impacts of the repository." This deficiency negates the sufficiency and credibility of the biological and ecological aspects of the entire Draft EIS. Further discussion of this matter appears in Westman (1985), Wiesner (1995), Salk and others (1998), Caldwell (1998), Clark and Canter (1997), Ortolano (1997), Gilpin (1997), and Bartlett and Malone (1993), as well as in Attachments D, E, F, and N to these comments.

181 Page 3-68; Section 3.1.6.2 - Native American Interests

The treatment of Native American issues and impacts in the Draft EIS is entirely inadequate. The Draft EIS ignores potential impacts to Native communities from the transportation of spent fuel and HLW, both in Nevada and nationally. It presents a sanitized section on "Native American Views of the Affected Environment" (Page 3-70), but fails to reflect the strong and ubiquitous opposition to the Yucca Mountain program on the part of Native peoples in Nevada and California.

182 The Draft EIS fails to reflect that most Native Americans in Nevada see the unwanted disturbance of cultural resources as the inevitable outcome of the Yucca Mountain project. While mitigation of disturbed archaeological sites is seen by some as a marginally acceptable alternative, most would prefer that no disturbance take place at all.

183 The discussion also fails to recognize that the Native American tribes in the immediate vicinity of the Yucca Mountain project area and along potential transportation routes are, for the most part, economically disadvantaged. Reservations and communities in Nye, Lincoln, and Inyo counties are rural and isolated and either lack a land base or have land bases too small to support their populations by ranching or other locally common means. A large number of people are unemployed, underemployed, and/or are living below the poverty level. Educational levels have improved in recent years, but without job opportunities in local communities, people must leave to take advantage of their training. Any negative statewide economic impacts associated with or caused by the repository or repository-related nuclear waste transportation will have a disproportionate impact on such communities because of these depressed baseline conditions.

184 ... The Draft EIS is completely silent on Native American communities and interests that will be affected by the transportation of spent nuclear fuel and HLW nationally. There are numerous areas of reservation lands and Native communities located along potential highway and rail shipping routes. However, since the Draft EIS does not explicitly identify those routes, DOE has chosen not to address Native American (or any other)

184 cont. issues or impacts in communities outside Nevada. This is a major legal and substantive deficiency of the Draft EIS.

185 ...

Page 3-71; Section 3.1.7 - Socioeconomics

The Draft EIS fails to adequately describe the socioeconomic environment at risk of significant impacts from the Proposed Action. The Draft fails to describe the environment with respect to Nevada's major economic sector and discuss why the State's tourism-based economy is especially vulnerable to impacts associated with the proposed Yucca Mountain facility and related transportation of spent fuel and HLW. As noted in comments relative to Sections 4 and 5 of the Draft EIS, the State of Nevada, affected local governments in the State, the Nevada University System, and DOE's own contractors have identified tourism, economic development, business in-migration, and related areas as being potentially vulnerable to the extraordinarily negative and stigmatizing characteristics of high-level nuclear waste facilities and activities. The Draft EIS is deficient in not including these areas in its definition of the socioeconomic environment and comprehensively addressing potential impacts in subsequent sections of the document.

A considerable body of research was complied by the State of Nevada between 1986 and 1998 and was available to DOE for use in preparing the Draft EIS. The State's comments on DOE's 1995 Notice of Intent to prepare an environmental impact statement for the Yucca Mountain program set forth a comprehensive description of the available research, data, and findings. The Draft EIS completely ignores this work and fails to address the most significant and far reaching areas of likely socioeconomic impacts.

A complete and in-depth treatment of the impact studies and their findings can be found in three major summary reports on Nevada socioeconomic studies published in 1989, 1993, and 1995, respectively.[23] In addition, two major books dealing with the policy implications related to the findings of Nevada's socioeconomic research have been published by the State of Nevada's study team.[24] The State's Technical Review Committee has also issued two reports based on the State's findings, and a summary of

[23] Ref. (1) "An Interim Report on the State of Nevada Socioeconomic Studies," (June, 1989); (2)"State of Nevada Socioeconomic Studies of Yucca Mountain 1986 - 1992: An Annotated Guide and Research Summary," (June 1993); and (3) "State of Nevada Socioeconomic Studies Biannual Report: 1993 - 1995," (June, 1995).

[24] Ref. One Hundred Centuries of Solitude, by James Flynn, et al., Westview Press, Boulder, Colorado (1995); and The Dilemma of Siting a High-Level Nuclear Waste Repository, by D. Easterling and H. Kunreuther, Kluwer Academic Publishers (1995).

185 cont.

the Nevada research was published in the ***Proceedings*** of the National Academy of Sciences.[25]

186

As noted in comments on Section 3.1 above, the Draft EIS inappropriately restricts the "region of influence" to three Nevada counties (Clark, Nye, and Lincoln). The region of influence must also include counties and areas affected by rail spur development and operation; intermodal facility siting, construction, and operations; heavy-haul truck transportation; and highway transport of spent fuel and HLW waste. In addition, the State of Nevada, as a whole, will be affected by repository activities in terms of impacts on the State's major industries; impacts to the State revenue base; and impacts to State agencies that have responsibilities for repository activities (highway regulation/ maintenance, law enforcement, emergency management/response, etc.).

Since the Proposed Action encompasses a national radiological materials shipping campaign of unprecedented proportions, duration, geographic scope, and potential impacts, the socioeconomic environment region of influence should also include cities and communities located along all of the specific transportation routes nationwide. Attempting to constrict the region of influence for the Proposed Action is inappropriate and renders the document deficient in its scope and approach to impact identification and assessment.

187

Page 3-76; Section 3.1.7.3 - Payments Equal to Taxes

The Draft EIS briefly discusses the Payments Equal to Taxes (PETT) paid to State and local governments under Section 116 of the Nuclear Waste Policy Act. It is unclear what purpose this discussion serves since it is not part of a larger description of State and local revenues. The Draft EIS should have described the status of State and local government revenue systems (of which PETT is a very small element) as a basis for examining the potential impacts of the Proposed Action on State and local government finances. As noted in comments on Section 4 of the Draft EIS, the proposed Yucca Mountain project has the potential to result in significant impacts to Nevada's tourism-based economy, leading to fewer tourist visits and to reduced gaming, sales, room, and related taxes. Because of the State's unique revenue system and the way sales and gaming taxes are collected and distributed to local governments, even a relatively small decline in tourism can have significant impacts to State and local government revenues. An understanding

[25] Ref. "Interim Statement of the Technical Review Committee on the Yucca Mountain Socioeconomic Project," by G. F. White, et al. (January, 1990); "Nuclear Waste's Human Dimension," by K. Erikson, et al., in Forum for Applied Research and Public Policy, Fall, 1994; and "Socioeconomic Studies of High-Level Nuclear Waste Disposal," in Proceedings of the National Academy of Sciences, Vol. 91, pp. 10786 - 10789, November, 1994.

187 cont. and explication of Nevada's unique revenue system is a prerequisite for carrying out any meaningful socioeconomic impacts assessment

188 Page 3-79; Section 3.1.8 - Occupational and Public Health and Safety

It is known that there is some high-level waste residue from the nuclear rocket program buried at an unknown location in Area 25 of NTS. The Draft EIS must contain affirmative information regarding its location and assure that, if it is in the proposed withdrawal area, it will be recovered and managed according to applicable laws, regulations, and orders. Also, there are reportedly some 20 contaminated sites within the portion of Area 25 of the NTS that is included in the proposed withdrawal area. Before issuance of a Final EIS, these areas must be fully rehabilitated under the jurisdiction of NTS so they are not passed on to OCRWM where they would remain a continuing hazard.

189 Page 3-83; Section 3.1.8.2 - Radiation Environment in the Yucca Mountain Region

This section references *Bechtel 1998, page 7-5*, the Annual Site Environmental Report for the Nevada Test Site. All of the off-site radiological doses in this report are given as EDE, effective dose equivalents. EPA's Clean Air Package 1988 (CAP-88 PC) program was used to calculate the doses. The dose being calculated is actually the committed effective dose equivalent (CEDE) and should not be given as an EDE.

190 Page 3-93; Section 3.1.12.4 - Existing Low-Level Radioactive Waste Disposal Capacity

The implication is given that repository-generated low-level waste might be disposed at the NTS low-level waste disposal site. Currently, the Yucca Mountain Project is not authorized to use this disposal site. If the repository is developed as planned, the low-level waste generated will not be considered NTS on-site generated waste. Therefore, as suggested in other sections of this Draft EIS, DOE should plan for the low-level waste generated at the repository to be shipped off-site to a commercial disposal site. See also comment for page 4-18; Section 4.1.12.2

The Final EIS should update the status of available and proposed commercial low-level waste disposal facilities.

191 ... Page 3-98; Section 3.2.1 - National Transportation

The description of the affected environment related to the national transportation system for spent fuel and HLW is substantively and legally deficient. The description in the Draft EIS is wholly inadequate as the basis for assessing impacts. The affected

191 cont. environment for transportation must include the ***specific*** communities along the ***specific*** transportation routes identified for the shipment of spent fuel and HLW to Yucca Mountain. This information exists, as do the analytical tools for identifying specific routes, and should have been included in the Draft EIS.

388 The statement in the last sentence of the second paragraph that "no new land acquisition and construction would be required to accommodate these shipments" is misleading. There may well be additional land acquisitions and construction required once DOE identifies the specific shipping routes nationwide (something the Draft EIS fails to do). In the case of transuranic waste shipments to the Waste Isolation Pilot Plant in New Mexico, DOE agreed to pay for bypasses around/near Sante Fe and Roswell. There were also safe parking facilities that needed to be improved in other states. It is very likely that, once states and cities become aware of the nature, volume, and duration of the shipping campaign needed to support the Proposed Action, DOE will be forced to assist with the construction of bypasses or other infrastructure improvements.

389 In addition, the one hundred percent rail transportation scenario contained in the Draft EIS is impossible without substantial investments at reactor sites for infrastructure to accommodate large rail casks. Many reactor locations cannot currently accommodate these types of transportation casks. Information as to which generator sites will require such upgrades is available. The Draft EIS should have evaluated the costs and impacts of such improvements.

192 Page 3-99; Section 3.2.1.3 - Barge and Heavy-Haul Truck Transportation

As stated above, the Draft EIS does not address impacts to infrastructure at either end of the shipping stream (e.g., required improvements at reactor sites or highway upgrades in Nevada).

193 Page 3-99; Section 3.2.2 - Nevada Transportation

The Draft EIS fails to describe the affected environment for likely alternative highway routes within Nevada. In particular, the Draft EIS fails to describe and analyze the NDOT 'B' route that enters the State via I-80 at Wendover, proceeds south to Ely on US 93Alt/US93, then west to Tonopah on US 6, and south to Yucca Mountain via US 95. The NDOT 'B' route is considered to be the most likely alternative route to avoid the metropolitan Las Vegas area, and any analysis of Nevada transportation is inadequate if this route is excluded.

194 The description of the affected environment is also deficient because it does not include specific information for all specific communities and Native American reservations

194 cont. potentially affected by the shipment of spent fuel and HLW. Such information should be included for every community along highway routes, main line rail routes, rail spur alternatives, and heavy-haul truck routes.

195 Page 3-100; Section 3.2.2.1 - Environmental Baseline for Potential Nevada Rail Corridors

The Draft EIS states: "DOE expects waste quantities generated by rail line construction and operation to be minor in comparison to those from repository construction and operation. As such, no discussion of existing waste disposal infrastructure along the routes is provided." It is true that waste quantities generated by rail line construction and operation should be minor in comparison to those from repository construction and operation. The comparison, however, is meaningless. Most of the rail construction would take place far from the repository, much of it in remote, sparsely populated areas. Waste generated during the rail construction will undoubtedly not be hauled to the same disposal site as waste generated during repository construction. Rather, it will be disposed in facilities along the corridor.

What is significant, therefore, is the volume and type of waste generated by rail line construction and operation in comparison to the capacity of waste disposal facilities along the various corridors. Given the remote, sparsely populated areas crossed by the proposed rail line, solid waste disposal facilities probably do not have sufficient capacity to handle waste generated during rail construction. Many times construction waste is not compatible with the waste handling facilities at existing sites. (Note: This same discussion applies to the construction of intermodal transfer station and heavy-haul routes.)

196 Page 3-100; Section 3.2.2.1.1 - Land Use and Ownership

The definition of region of influence for land use is too narrow. Impacts to land use may occur that do not result in a change of ownership or use. For example, bisecting a ranch with a rail line will have substantial impacts on that operation. It will be difficult for the rancher to move equipment and livestock from one side of the rail line to the other. Because of the difficulty in operating the ranch that is now split into two pieces, the value of the ranch will be reduced. This will have significant impact on the rancher without changing the ownership or the use of the land. The region of influence for land use should include all of the land under the ownership or lease of agricultural operations that will be crossed. (Note: this same discussion applies to the intermodal transfer station and heavy-haul routes.)

197 ... The region of influence for biological resources is also too narrowly defined. Habitat outside the corridor is considered in the regional of influence only if that habitat is

197 cont. disturbed by rail line construction and operations. Several of the corridors cross or pass near to crucial big game habitat. Human activity is known to reduce the value of crucial habitat, particularly crucial winter habitat. Frequent trains passing through or near to crucial habitat could significantly reduce the value of that habitat even though the habitat was not physically "disturbed" by construction or operation. The region of influence for biological resources should include all habitat potentially affected, not just disturbed, by construction and operation of the rail line (Note: This same discussion applies to the intermodal transfer station and heavy-haul routes.)

198 ... Page 3-112; Section 3.2.2.1.5 - Cultural Resources

Although archaeological inventories and testing have occurred at Yucca Mountain itself as part of site characterization activities, historic property surveys meeting the Secretary of Interior's Standards have not been conducted for the railroad corridors. As the Draft EIS acknowledges, ethnographic studies for these corridors are lacking and must be conducted to identify sites to which a tribe might attach religious or cultural significance. Were any of the rail routes used historically as transportation routes? Direct impacts would occur as a result of the construction of lines, but the Draft EIS fails to note that historic or cultural landscapes might also be impacted as a result of this construction. Again, DOE needs to consult with the State Historic Preservation Office (SHPO) regarding the definition of this Area of Potential Effect (APE).

Additionally, the Programmatic Agreement (DOE 1988b, all), referenced in this section, regards site characterization activities solely and should not be used for the entire project. The programmatic agreement states that:

> *Whereas, development of the repository and other facilities specified in the Nuclear Waste Policy Act are not within the scope of this Programmatic Agreement, but will be dealt with through additional consultation with the Advisory Council on Historic Preservation (Council) per the Council's regulations "Protection of Historic Properties" (36 CFR Part 800 as revised on September 2, 1986) (Appendix 1);*

Amendments to the National Historic Preservation Act and subsequently to 36 CFR Part 800 necessitate a new agreement that includes Native Americans as signatories where the APE (as identified within the transportation systems) crosses the Moapa Indian Reservation and Las Vegas Paiute Indian Reservation. As per the new regulations, the SHPO is identified as a consulting party and should be involved in negotiations for a new programmatic agreement.

198 cont.

This section on cultural resources for the rail corridors provides insufficient data to determine location and numbers of historic properties. DOE needs to consult with SHPO to identify consulting parties and define an APE. DOE needs to prepare a new programmatic agreement that details how it will identify, evaluate, and treat historic properties and how the consultation process shall occur.

199

Page 3-113; Section 3.2.2.1.5 - Cultural Resources

Native American Interests: The Draft EIS states that, "... while transportation issues are of extreme importance to [Native Americans], at present they cannot provide specific comments on any of the Nevada transportation alternatives ... due to the absence of systematic ethnographic studies for any of the proposed project areas." Since the Draft EIS acknowledges at least the potential for significant impacts to Native American cultural resources, it is incumbent upon DOE to carry out the needed ethnographic studies as part of its work in preparation of the Draft EIS. DOE has had almost 17 years to do this work, and failure to do it should not exempt DOE from its obligations under NEPA. In addition, a considerable body of information exists as a result of research carried out by the State of Nevada between 1986 and 1998. This research was available to DOE at the time it was preparing the Draft EIS. Summaries of the State's Native American studies reports are found in Appendix II of these comments.

200

Page 3-114; Section 3.2.2.1.6 - Socioeconomics

The Draft EIS is deficient in its description of the socioeconomic component of the affected environment. The Draft EIS fails to include any description of socioeconomic conditions/factors at the State level that stand to be impacted by the Proposed Action. State-level revenues and expenditures, such as costs and other impacts to State agencies affected by the project (such as the State Department of Transportation, Department of Motor Vehicles and Public Safety, the State Health Division, and other agencies) and impacts to the State's major economic sector are all missing from the Draft EIS - either in Section 3 or in subsequent sections on impact assessment.

Please refer to previous comments regarding the inappropriateness of limiting the socioeconomic scope of the Draft EIS to just three counties in DOE's truncated "region of influence."

See detailed comments regrading the inadequacy of DOE treatment of socioeconomic conditions and impacts in comments on Section 4 of the Draft EIS.

201 Page 3-124; Section 3.2.2.2.3.1 - Surface Water

The paragraph on highway routes for heavy-haul trucks provides comments on the robustness of vehicle and cask but provides no evaluation of what would be needed if a flash flood overturned a shipment, spilling the cask off a truck or rail car. Lifting one hundred ton or larger casks requires a portable crane that does not exist in Nevada.

202 Page 3-129; Section 3.2.2.2.4 - Biological Resources

The second paragraph under the section dealing with the "Caliente Route" states that SR 375 intersects US 93; in fact, it is SR 318 that intersects US 93.

203 Page 3-133; Section 3.2.2.2.5 - Cultural Resources

The State Historic Preservation Office comments on highway corridors and intermodal transfer stations are the same for rail corridors. Insufficient data is presented to determine the location and number of historic properties. DOE needs to consult with SHPO to identify consulting parties and define an APE. DOE needs to prepare a new programmatic agreement that details how it will identify, evaluate, and treat historic properties and how the consultation process shall occur. In addition, the State requests responses to the following questions:

4. Has consultation with Native Americans proceeded regarding the highway systems and intermodal transfer stations?

2. Has DOE examined whether the use of highways has the potential to affect historic properties?

204 Page 3-134; Section 3.2.2.2.6 - Socioeconomics

The Draft EIS states: "Section 3.1.7 contains socioeconomic background information on the three counties (Clark, Lincoln, and Nye) most involved in the heavy-haul routes." The section referenced contains very little information on the expected future population of these areas during the period of operations. To accurately predict the impact of heavy-haul operations, future population projections are necessary. These projections are required in order to forecast traffic volumes on the affected highways. Without these projections, the impact of operations on the level-of-service for the affected highways cannot be assessed. In the Las Vegas urban area, the area where growth is expected to occur given the proposed construction of urban area bypasses should also be projected. Highway improvements are known to affect growth patterns in urban areas. Without

204 cont.

projecting the change in growth patterns associated with the urban bypasses, the projected traffic volumes on these roads cannot be predicted.

The Draft EIS inaccurately concludes that "[t]he candidate heavy-haul intermodal transfer station sites and routes would not appreciably affect counties other than those in which the facilities were located." This statement ignores the fact that heavy-haul transportation and the location of an intermodal transfer facility in Nevada would be primary impacts on public perceptions of risk and the stigmatizing effects of the Proposed Action. Impacts from heavy-haul transport and intermodal facility activities would be statewide. State-level impacts would accrue to State agencies required to respond to, or otherwise deal with, the shipments of waste and the operations of an intermodal transfer facility. The State's principal economic sector could also be affected, with resulting impacts to State revenues and, due to Nevada's unique taxation/revenue distribution system, to all seventeen of Nevada's counties.

See comments relative to Section 4 on the treatment of socioeconomic conditions and impacts in the Draft EIS.

205 ...

Page 3-139; Section 3.2.2.2.11 - Existing Traffic on Candidate Routes for Heavy-Haul Trucks

Current levels of service are of little value in assessing the impact of heavy-haul operations on traffic flow and safety. The projected baseline should include predicted levels of service during the time frame of heavy-haul operations. This prediction should be based upon reasonably expected future highway improvements and projected population growth.

The implication of noting that the existing levels of service exclude the planned Las Vegas Beltway is that the level of service is expected to improve when the beltway is completed. This very well might not be the case. Studies have demonstrated that in growing urban areas, growth takes place along transportation corridors, negating any improvement in traffic flow from route improvements. This was recently demonstrated for the Denver urban area where studies of an extensive improvement planned for the highways in that area predict insignificant change in traffic flow.

SECTION 4. ENVIRONMENTAL CONSEQUENCES OF REPOSITORY CONSTRUCTION, OPERATION AND MONITORING, AND CLOSURE

206 Page 4-1; Section 4 - Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure

The fact that DOE did not address the ecosystem level of organization for the Draft EIS renders an accurate interpretation of ecological impact assessment impossible. Attachments G, F, H, I, J, K, and L discuss this issue, as do Westman (1985), Bartlett and Malone (1993), Salk and others (1998), Wiesner (1995), Caldwell (1998), Clark and Canter (1997), Ortolano (1997), and Gilpin (1997).

An equally important issue is that biological field studies conducted by DOE and used for the EIA process were improperly designed and statistically analyzed, thereby negating much of the information in the Draft EIS, Section 4. Study design and statistics are discussed in Attachments G and Q.

Performance confirmation is not an option. The use of the term "could" is incorrect, and the statement conflicts with the statement in Section 4.1.

207 Page 4-1; Section 4.1 - Short-Term Environmental Impacts of Performance Confirmation, Construction, Operation and Monitoring, and Closure of a Repository

The Draft EIS fails to adequately reflect the unique and highly controversial nature of the Yucca Mountain program and the impacts that are likely to derive from the Proposed Action. In the time line presented in Figure 4-1, there are a number of decision points that will generate considerable public and intergovernmental conflict. A decision to recommend Yucca Mountain for development as a repository in 2001, for example, will inject considerable conflict into the relationship between the State of Nevada and the federal government. This conflict will have implications that will be manifest in a number of ways, including possible considerable legal costs to the State and the federal government. As part of the analysis in Section 3, the Draft EIS should have examined impacts related to the conflict-inducing nature of the project.

As written, Section 3 treats the proposed Yucca Mountain repository as just another federal program, with no attention paid to the one-of-a-kind, controversial, extremely long duration, and extraordinarily complex program that is characterized by irreducible uncertainties in almost every aspect of its design and implementation. The overly general, off-the-shelf impact assessment contained in Section 3 is entirely inadequate and inappropriate for a program of the type and complexity presented by the Proposed Action. Nevada continues to believe, as stated in the State's Scoping Comments on DOE's 1995

207 cont. Notice of Intent, that DOE should have prepared a programmatic EIS for the repository project and then tiered separate EISs to it for the Yucca Mountain repository facilities, the rail spur corridor selection, the selection of Nevada and national highway and rail routes, and the intermodal transfer facility. Such an approach would more accurately reflect the complex and interconnected nature of the various elements of the program and allow DOE to better assess and address environmental impacts program wide. It would also have enabled DOE to deal more directly and effectively with the wide range of uncertainty presented by each aspect of the program.

208 Page 4-1; Section 4.1 - Short-Term Environmental Impacts of Performance Confirmation, Construction, Operation and Monitoring, and Closure of a Repository

The statement under "Preconstruction Performance Confirmation Activities" gives the impression that site characterization will continue well past Site Recommendation, indicating that the suitability of the site will be determined before site characterization activities are complete, but after Site Recommendation, contrary to Section 114(a)(1) of the NWPA.

209 Page 4-3; Section 4.1 - Short-Term Environmental Impacts of Performance Confirmation, Construction, Operation and Monitoring, and Closure of a Repository

The text states that closure would include "Potentially backfilling the main drifts, access ramps, ventilation shafts, and connecting openings." This is not fully consistent with the description of closure in Section 2.1.2.3, Repository Closure. That section states closure would include, "filling of the main drifts, access ramps, and ventilation shafts; and sealing of openings, including ventilation shafts, access ramps, and boreholes." These two statements must be reconciled, and the commitment to backfilling and sealing must be maintained.

210 Page 4-4; Section 4.1 - Short-Term Environmental Impacts of Performance Confirmation, Construction, Operation and Monitoring, and Closure of a Repository

This Draft EIS is deficient because it lacks a design for the repository and adequate information regarding transportation routes. Until this information is available for the project, this Draft EIS should be rescinded and reissued only when the information is available for public review.

211 Page 4-5; Section 4.1.1.1 - Impacts to Land Use and Ownership during Performance Confirmation and from Land Withdrawal

Why is such a large area being considered for withdrawal? The repository area itself is much smaller than this, including all the surface facilities (870 acres). This appears to be an attempt by DOE to control a large area around the repository to act as a buffer zone for contamination from the repository. In this manner, no one would have access to this area for at least one hundred years or longer, thereby providing DOE with a much longer distance to the accessible environment.

It is unclear whether the Proposed Action would result in additional restricted access lands (i.e., more than what is now restricted for Yucca Mountain) from the withdrawal of BLM property. If access is restricted for additional lands, the Draft EIS should discuss impacts associated with reduced recreational opportunities.

212 Page 4-6; Section 4.1.1.2 - Impacts to Land Use and Ownership from Construction, Operation and Monitoring, and Closure

Public land is just that, land for the public. Just because the land is public doesn't mean there will be no potential conflicts on land use.

213 This section precludes backfill of the emplacement drifts. This is inconsistent with the design features and alternatives that are being held open to bound the impacts of the different thermal load alternatives and is inconsistent with the current design approach.

214 Page 4-6; Section 4.1.2 - Impacts to Air Quality

This section uses the boundary of the proposed land withdrawal area as the basis for calculation of impacts to the maximally exposed member of the public. As noted above, the proposed land withdrawal area is extraordinarily large compared to the repository operations area. This provides a large dilution factor for air quality analyses. The impact calculations in this section should be provided for the boundary of the operations area, rather than a distance of nearly 20 km from the operations area. This comment applies to all relevant analyses provided in Section 4. It also applies to Section 4.1.8.1, Radiological Accidents, where the maximally exposed offsite individual is placed 11 km west of the repository surface facility. In all cases, the maximally exposed offsite individual should have the characteristics of a subsistence farmer.

215 Page L-3; Figure L-1 - Yucca Mountain site topography, floodplains, and potential rail corridors

This map should include the entire proposed withdrawal area, indicating the 100 and 500 year flood zones as well as rail and road corridors. Since the withdrawal area would be considered part of the Yucca Mountain repository site, the entire site and any proposed construction or improvements must be considered in the floodplain assessment.

216 Page L-9; Section L.3.1.1 - Flooding

The nearest man-made structure within Fortymile Wash is the NTS road leading to Yucca Mountain. It should also be noted that, within the last decade, flooding has crossed and caused closure of U.S. Highway 95 at Fortymile Wash.

217 Page L-10; Section L.3.2 - Existing Environment Elsewhere in Nevada

Since floodplains have not been defined along any of the potential rail corridors, there is insufficient environmental information in this Draft EIS and floodplain assessment to assist in making a selection of transportation mode or rail transport route.

218 Page 4-10; Section 4.1.2.2.2 - Radiological Impacts to Air Quality from Construction

The Draft EIS should be consistent in its use of millirem and person-rem. The definition of person-rem should be given here, not later in the Section.

This section has inconsistencies in reporting dose. This section reports the dose for the maximum exposed individual offsite for a five-year period and the dose of a maximally exposed non-involved worker as an annual dose. This appears to have been done to keep the numbers for the worker low.

219 Page 4-11; Section 4.1.2.3.1 - Nonradiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

What analysis supports the value of 10 micrograms per cubic meter used as the concentration for cristobalite?

220 Page 4-13; Section 4.1.2.3.2 - Radiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

Define and quantify "very small" releases of other noble gases.

Were any analyses performed for accident scenarios for this section?

221 Page 4-15; Section 4.1.2.3.2 - Radiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

Define and quantify "minimal" and "very small."

222 Page 4-18; Section 4.1.3 - Impacts to Hydrology

The Draft EIS should give a map delineating the "region of influence." Is this region the same as the proposed 150,000 acres withdrawal area?

223 Page 4-19; Section 4.1.3 - Impacts to Hydrology

Define and quantify "minor changes", "minor impacts", "extremely small", and "very low."

224 Page 4-20; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

What methods would be established to control water application amounts for surface and subsurface dust suppression? DOE's track record for controlling and tracking water usage during site characterization is weak, at best.

225 Page 4-22; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

The Draft EIS should provide actual details of the plan for managing spills and radiological contaminant leaks, not just give a reference as an "example" of what might be done.

226 Page 4-23; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

The Draft EIS should provide the actual surface environmental monitoring plan.

227 Page 4-24; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

The statement "If DOE selected a rail corridor or heavy-haul route....." should be changed to "When a rail corridor or heavy-haul route is selected...." Also, wouldn't NEPA documents other than a floodplain/wetlands assessment be required?

228 Page 4-25; Section 4.1.3.3 - Impacts to Groundwater from Construction, Operation and Monitoring, and Closure

This section discusses the potential for contaminant migration to the groundwater and does not state whether any impacts to groundwater quality are predicted. It appears that DOE did not analyze potential water quality impacts of the repository project, especially consequences of long-term repository performance. The Draft EIS should indicate what analysis was used to determine impacts to water quality, if any, and show any impacts to water quality that might occur.

229 Page 4-29; Section 4.1.3.3 - Impacts to Groundwater from Construction, Operation and Monitoring, and Closure

What type of general groundwater flow patterns changes would be expected from pumping more than 0.72 million cubic meters from the western portion of Jackass Flats? Although the Draft EIS states that the changes would be "small," the changes expected and any impacts from these changes should be discussed here.

230 Page 4-31; Table 4-11 - Land cover types in the analyzed land withdrawal area and the amount of each that repository construction and disposal of excavated rock would disturb (square kilometers)

It is interesting that the DOE did acknowledge potentially adverse consequences to the ecosystem from different thermal loading schemes in this table. However, the thermal loading issue with respect to biological resources is avoided in Table 4-12, page 4-35, which summarizes overall impacts from the repository, by stopping the summary after repository closure and ignoring the critical long-term ecosystem impacts. This is further discussed in Attachments G, F, O, and P.

231 Page 4-38; Section 4.1.5.2 - Impacts to Cultural Resources from Construction, Operation and Monitoring, and Closure

As stated previously, a new programmatic agreement should be negotiated that deals with issues of protection and treatment of historic properties during construction. Although DOE asserts that "the overall effect of the repository on the long-term preservation of the archaeological and historic sites in the analyzed land withdrawal area would be beneficial," the SHPO notes that the land withdrawal for the repository effectively prevents access by Native American cultural practitioners, as well as archaeologists intent on research. At best, the overall effect might be considered neutral.

232 Page 4-38; Section 4.1.5.2 - Impacts to Cultural Resources from Construction, Operation and Monitoring, and Closure

Native American Viewpoints: The 1986 Environmental Assessment (EA) for Yucca Mountain stipulated that, "[i]f the Yucca Mountain site is approved for site characterization, [Native American impacts] will receive appropriately detailed treatment in research to be performed during the Environmental Impact Statement process."[26] The EA also made special note of the "potential for impacts on Native American cultures from [SNF and HLW] transportation activities" and stated that "[t]his aspect will receive appropriately detailed treatment ... if Yucca Mountain is approved for site characterization."[27] The Draft EIS, however, fails to specifically address potential impacts to Native American communities in Nevada (and in states through which SNF and HLW will be shipped to a Yucca Mountain repository). Such impacts include effects on Native culture, economics, infrastructures, emergency response/preparedness requirements, state-tribe relationship effects that may be caused by state routing or risk management decisions, implications for tribal sovereignty, Native land claim issues and impacts, and other areas potentially impacting Native peoples and communities. The Draft EIS should have contained a detailed description of the activities undertaken, the data collected, and the analyses done to adequately evaluate potential effects of the Yucca Mountain program on Native peoples and communities across the country. The Draft EIS should also have included an analysis of the impacts of the transportation of spent fuel and high-level waste.

233 The State's scoping comments on the 1995 Notice of Intent pointed out that assessment of potential Yucca Mountain impacts for Native American communities requires special attention to the unique laws, regulations, history, and culture of these peoples. In order to estimate potential impacts, the Draft EIS must provide an understanding of both the current and past relationship of Native American people to federal, state, and local governments and communities. Particular attention must be paid to specific Native American communities and connections and claims to the repository site. A similar assessment should be made for ancillary facilities, transportation routes, and other program-related activities. Topics to be addressed should include:

1. A historical description of Native American experiences in the areas affected by the repository program, including the issues of land claims, treaty obligations, federal laws relating to cultural and religious rights of Native Americans,

[26] U.S. Department of Energy. Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada, May, 1986, pp C.4-30.

[27] Ibid, pp C.7-42.

233 cont.

unsettled political and legal issues, the potential applications of Indian law to repository issues, including transportation route selection and use, and the description of current and future socioeconomic conditions for Native Americans.

2. The economic structure of Native American communities and how these conditions might be affected by the Proposed Action.

3. A specific description of any direct and indirect employment, spending, and public service effects for Native Americans.

4. The location of Native American communities in relation to transportation routes, including the potential for accidents and emergency response to accidents.

5. The potential stigma impacts on Native American communities and businesses, including those economic activities now in development or likely to be developed in the future.

6. The role of the repository program in Native American political activities, including how the program might influence tribal or community behaviors.

7. The effect of the repository program on Native American relations with other governmental entities, including neighboring rural and urban communities, as well as county, state, and federal governments.

8. Assessment of the quality of life impacts of the program, including the conditions of psychological stress and its effects upon Native American community behaviors. The ways in which the repository program might influence or change Native American culture is especially important to a socioeconomic impact assessment.

9. Evaluation of the attitudes and opinions of Native American people toward the repository program, the DOE management of this and other activities important to them, and the effects upon their support or opposition.

The Draft EIS fails to adequately address any of these areas.

234 ...

The State's research has shown that Native American tribes around Yucca Mountain and along transportation routes have unique governments. As independent federally recognized entities, tribal governments have a role equivalent to states in most federal undertakings. They also have a special status according to various environmental and cultural protection acts and in the Nuclear Waste Policy Act of 1982. To date, none of

234 ... the tribes in the study area has been granted "affected Indian Tribe" status under the NWPA, although several have applied.

235 The repository project has also spilled over into the campaign by the Western Shoshone National Council, a political entity made up of representatives from many Western Shoshone tribes, to reclaim lands under the Treaty of Ruby Valley of 1863. This has brought the Western Shoshone and other tribal governmental entities into conflict with DOE as well as with other federal and state agencies. Because of the unique governmental position of tribes, their interests are not likely to be well protected or even properly represented in deliberations over the repository. They may also come into conflict with neighboring local governments over differences in positions regarding the repository, thus increasing their isolation from intergovernmental interaction.

236 Most Native Americans in Nevada see the unwanted disturbance of cultural resources as the inevitable outcome of the Yucca Mountain project. They clearly would prefer that no disturbance take place at all and do not believe that impacts associated with the proposed repository would be mitigable.

237 The Native American tribes in the immediate vicinity of the Yucca Mountain project area and along potential transportation routes are, for the most part, economically disadvantaged. Reservations and communities in Nye, Lincoln, and Inyo counties are rural and isolated and either lack a land base or have land bases too small to support their populations by ranching or other locally common means. A large number of people are unemployed, underemployed, and/or living below the poverty level. Educational levels have improved in recent years, but without job opportunities in local communities, people must leave to take advantage of their training. Any negative statewide economic impacts associated with or caused by the repository or repository-related nuclear waste transportation will have a disproportionate impact on such communities because of these depressed baseline conditions. The Draft EIS fails to address such impacts.

234 cont. DOE should also begin government-to-government consultations with federally recognized tribes in states other than Nevada where shipments of nuclear waste will cross tribal lands or travel within close proximity to tribal lands. The Draft EIS should discuss this consultation and should also include an assessment of the potential impacts to tribal lands and resources.

238 ... Page 4-39; Section 4.1.6 - Socioeconomic Impacts

The analyses of socioeconomic impacts contained in the Draft EIS are entirely inadequate and ignore major areas of potential negative effects associated with the Proposed Action. The impact assessment is limited only to the areas of employment, population, economic

238 cont.

measures (personal income, gross regional product, and government expenditures), housing, and public services. There is no attempt to evaluate the effects of the Proposed Action on the State's major economic sector - the tourism/gaming industry - or to examine impacts of the project on property values, economic development, State and local government revenues, State agencies, intergovernmental issues, and other important areas.

Perhaps the most important deficiency in the Draft EIS' treatment of socioeconomic impacts is the failure to analyze in any way the impacts of the Proposed Action on Nevada's most significant economic sector, the tourism/gaming sector. The Draft EIS contains no explanation for why such an analysis was not undertaken, and it ignores extensive comments and information on this matter provided by the State of Nevada and affected local governments in response to the 1995 Notice of Intent. The failure to address this crucial area of likely and significant impact is, of itself, grounds for finding the Draft EIS legally and substantively deficient.

The State of Nevada formally initiated a comprehensive study of the socioeconomic impacts of a proposed high-level nuclear waste repository at Yucca Mountain in 1986, after the Nevada site had been chosen as a potential waste disposal site. Between 1987 and 1995, this study has produced over 250 reports and work products, plus numerous publications in scientific and academic literature.[28] Summaries of research reports produced under the State's study are attached to these comments (see Appendix I).

State research has demonstrated that a major potential source of impacts from the Proposed Action stems from intense, negative perceptions and avoidance behaviors by the public in response to a high-level radioactive waste repository. This fact, combined with the vulnerability of the Nevada economy to changes in its public image, could produce large negative impacts. These are not "psychological" impacts. They are real, measurable economic effects that derive directly from the Proposed Action and are substantiated by a considerable body of scientific research and evidence.

The great public and media interest in the radioactive waste program makes it almost certain that any association with these negative perceptions will adversely affect Nevada's attempts to attract tourists, conventions, migrants, and new business investments. This would be especially damaging in the event of a nuclear waste accident associated with Las Vegas, one of the world's major tourist destinations and a dominant

[28] A detailed summary of the State of Nevada research can be found in the publication, "State of Nevada Socioeconomic Studies of Yucca Mountain 1986 - 1992: An Annotated Guide and Research Summary," NWPO-SE-056-93 (June, 1993). See also "State of Nevada Socioeconomic Studies Biannual Report, 1993-1995," by James Flynn, et. al. (July, 1995).

238 cont. contributor to Nevada's economy and tax revenues. The conclusion of the Nevada researchers and the State's Technical Review Committee is that stigma impacts could be very negative and very large.

Existing research on stigma effects and potential impacts provides a viable theoretical and methodological base that DOE should have used in the Draft EIS to undertake a detailed assessment of these types of impacts on Nevada's economy, public revenues, public services, and community quality of life. DOE's assessments should have taken into account the increasingly competitive gaming and tourist marketplaces and the important role that any negative perceptions and stigma could have in affecting an economy uniquely reliant on tourism revenues. It is very possible that, through the social amplification of risk process, even relatively minor events or accidents could have serious economic consequences. Such impacts would dwarf any projected benefits that might be derived from project employment and spending.

While Nevada's economic base may be especially vulnerable to stigma impacts, the Draft EIS should have addressed stigma effects for program facilities and transportation routes, wherever they might be located in the nationwide system.

The analyses of so-called "standard" socioeconomic impacts contained in the Draft EIS is inadequate and incomplete. The analysis in the Draft EIS ignores impacts to State and local government revenues, public services such as those related to emergency management and response, intergovernmental systems and relationships, and the unique tax and revenue redistribution systems that characterize Nevada's fiscal environment.

A comprehensive and integrated discussion of the need for an adequate assessment of economic impacts of the Proposed Action is contained in Appendix I of these comments.

A summary of State of Nevada research findings covering each major area of socioeconomic impact assessment is contained in Appendix II of these comments.

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Page 4-39; Section 4.1.6.2.1 - Impacts to Employment

The Draft EIS fails to evaluate potential impacts to employment that could result from stigma-induced impacts on the Las Vegas and State economies. For example, research by the State of Nevada has shown that, should the repository project cause just one large hotel/casino <u>not</u> to locate in Nevada in the future, the immediate impacts to southern Nevada could be upwards of 14,200 jobs and almost $500 million in revenue lost

239 cont. annually to the local economy.[29] While the contribution of repository-related jobs to the local economy is insignificant (as demonstrated by the analysis in the Draft EIS), the potential negative effects of the Proposed Action on employment in the State could be significant and should have been addressed.

240 ... Page 4-43; Section 4.1.6.2.3 - Impacts to Economic Measures

The Draft EIS fails to analyze the potential impacts of the Proposed Action on the State's revenue base. While the repository's direct contribution to personal income, gross regional product, and governmental expenditures is insignificant, the potential stigmatizing effects of the project could have substantial impacts on revenues in the future. State research has shown that a one-percent drop in visitors in the year 2010 as a result of stigma-induced impacts from the Yucca Mountain project would cause a loss of about $155 million in visitor spending in the Las Vegas area; a five percent decline would mean a loss of over $775 million; and a ten-percent drop in visitation would result in over $1.5 billion in losses. (For comparison, the recessions of 1980 and 1981 resulted in Las Vegas visitor declines of between 1% and 1.5%.) The same research indicates that, for each one percent decline in tourism, State revenues would be reduced by approximately $7 million and employment in Clark County would drop by over 7,000 jobs.

The Draft EIS also fails to accurately analyze the impacts to the Nevada economy from population growth that is not directly related to the gaming sector. Under the State's tax and revenue system, any repository-related increases in population will cost the State and local governments more for providing public services than such increases would provide in revenues. This difference has been estimated at between $670 to $1,000 per person, per year.[30] This is a consequence of the "standard effects" of the project and is separate from any stigma-induced economic effects that may occur during the life of the program.

Different economic activities in Nevada have widely diverse revenue-cost implications for municipal, county, and state governments. Casino enterprises, for example, generally have positive impacts on government revenues versus costs. Due to the net mine proceeds tax, mining enterprises have positive impacts - if the mine is productive over the

[29] "Tourism Economics and Nuclear Waste," by the Nevada Agency for Nuclear Project (July, 1995).

[30] The dependence of Nevada state and local jurisdictions on revenue contributions of visitors is unique and results from the fiscal structure of the state. Other economic developments, private or public, that do not expand the contributions of visitor spending will also have negative fiscal impacts. Public expenditures per person would have to be provided for repository-related population in excess of revenues these people would contribute through taxes, fees, etc. This means that, in the absence of payments made by DOE for mitigation or compensation or changes in the Nevada tax/revenue structure, the repository program will consistently produce significant negative fiscal impacts even without negative stigma-related effects.

240 cont.

long term. Federal government enterprises generate sales and use tax revenues, as well as payments in lieu of taxes, but generally these do not cover costs of project-related population growth.

Nevada collects significant revenues from non-residents via various gaming, sales, cigarette, liquor, and motor fuels taxes and redistributes these revenues to local governments. Thus, a repository effect that impacts one or more of these revenue bases (e.g., a stigma effect on visitor-gaming) could have wrenching effects at all government levels throughout the state.

Because Nevada's revenue structure is dominated by state-collected and/or state-distributed revenues, analysis and projection of revenues on an entity-by-entity basis, as is partially attempted in the Draft EIS, has inherent limitations in Nevada, and reliable projections at the entity level must include a statewide dimension. Models such as REMI (used as the principal economic assessment tool in the Draft EIS) have significant limitations in accurately modeling revenue aspects of local and regional economies in light of Nevada's unique fiscal circumstances.

241 ...

Page 4-43; Section 4.1.6.2.4 - Impacts to Housing

Like population and employment, the Draft EIS treatment of housing ignores a major area of potential impact. State of Nevada researchers, DOE contract researchers, and independent researchers have documented the fact that nuclear waste facilities and nuclear waste transportation can have significant effects on property values under certain circumstances. For example, research conducted for DOE on the impacts to property values of transporting foreign research reactor spent nuclear fuel in South Carolina, published in June 1999, found that shipments of such materials in urban areas were directly responsible for lowering property values "in a substantive manner."[31] Other researchers have reported similar findings in relation to transuranic waste shipments through New Mexico. In 1991, courts in New Mexico awarded $338,000 to a home owner whose property had been devalued by plans for a highway bypass for transuranic waste shipments.[32]

[31] "Nuclear Waste Transportation and Residential Property Values: Estimating the Effects of Transient Perceived Risks," by Kishore Gawande and Hank Jenkins-Smith, University of New Mexico (June, 1999).

[32] Komis v City of Sante Fe, New Mexico (February, 1991). The case was originally heard in state District Court, and the award was upheld by the New Mexico Supreme Court. The case is especially relevant because the diminution in property values was demonstrated by survey research that indicated people would pay less for property that is known to be in proximity to a nuclear waste shipping route.

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The Draft EIS should examine the potential for negative impacts to property values along proposed nuclear waste shipping routes in Nevada, especially those within urban areas. In addition, the Draft EIS should make some attempt to assess property value impacts on the Las Vegas and Nevada housing markets in general (i.e., what effects would any loss in property values along transportation routes have on the housing markets in general?).

242 ...

Page 4-44; Section 4.1.6.2.5 - Impacts to Public Services

The analysis of impacts to public services in the Draft EIS is inadequate and incomplete. The Draft EIS fails entirely to examine the effects of the Proposed Action on State-level public services and State agencies. A June 1998 report prepared for the State of Nevada found that costs to State agencies alone for preparing for and responding to repository-related shipments of spent fuel and HLW in Nevada would be almost $498 million for the first three years of the project.[33]

The Draft EIS also fails to adequately assess costs and impacts to local governments for preparing for nuclear waste shipments, training response and other emergency preparedness personnel, obtaining necessary equipment, and related activities. Inter-jurisdictional impacts resulting from the nature of the emergency response systems in Nevada, the existence of and need for inter-county mutual support agreements, multi-county training requirements, etc. would also occur. Such costs are direct impacts associated with the Proposed Action and should have been clearly identified and assessed in the Draft EIS.

Public service impacts should be calculated on a use/revenue basis for: (1) services provided to the Yucca Mountain project by state, local, and private utilities (subject to market and service regulation, e.g., electric, water, gas, etc.); (2) services provided to employees and their households; (3) services required by the indirect and multiplier effects of the project and project employees; and (4) services by state and local governments that are mandated by federal law or represent official responses by state and local officials and agencies to the activities of the Yucca Mountain project. The public services to be assessed should include:

- All state and local government services that contribute to the Yucca Mountain project. This would include services for health and safety, emergency management and response, transportation, regulation (e.g., permitting, licensing, and oversight), legal and judicial actions, and support for the public infrastructure.

[33] "The Fiscal Effects of Proposed Transportation of Spent Nuclear Fuel on Nevada State Agencies," by Planning Information Corp. and Alvin Mushkatel, Arizona State University (June, 1998).

242 cont.

- State and local public services to the direct, indirect, and induced population and households resulting from the Yucca Mountain project, including the proportional and marginal costs for education, police and public safety, criminal justice, libraries, recreation and parks, local transportation, welfare, and publicly mandated services such as economic development. The cost estimates should include expenses for all community services, facilities, equipment, infrastructure, and staff.

The assumption in the Draft EIS that public services impacts related to the Proposed Action would be small in comparison to the overall employment and population of the region of influence does not mean that impacts cannot or will not be significant. Without a complete assessment, the significance of these impacts cannot be known.

Because the State's tax and revenue systems rely on tourism/gaming revenues to pay for growth in other sectors, public services impacts associated with additional repository-related population growth would generate negative fiscal impacts for state and local jurisdictions. Although such negative fiscal impacts would result from any non-gaming industry economic development, there is a distinction between the state's willingness to subsidize desired economic diversification and its willingness to subsidize the fiscal effects of a repository. As such, public services impacts and costs must be identified under the provisions of NEPA and the Nuclear Waste Policy Act.

243 Pages 4-44 through 4-60; Section 4.1.7 - Occupational and Public Health and Safety Impacts

Based on the Draft EIS, health impacts to workers and the public from initial construction through continuing construction, operation and monitoring, and eventual closure of the repository are expected to be relatively non-existent. A critical review of this apparent lack of danger to workers and the public reveals a disregard for analytical consistency on the part of the Department of Energy, the application of different measurement standards for workers and the public, and the use of a large number of unverifiable assumptions. The resulting analysis is confusing, at best, to both technicians and the public and provides virtually no basis for a scientifically valid decision making process. For example:

Section 4.1.7.5.1 indicates that only 1.5 to 2.0 worker fatalities related to industrial hazards will occur during the entire 110-120 years of construction, operation, and closure. This is inconsistent with other information in the Draft EIS.

Section 4.1.7.5.2 states that, based on a 50-year work life, impacts to workers in all phases of the repository activities will result in only 2.5-4.0 Latent Cancer Fatalities over 110-120 years. The highest collective dose is estimated to occur in relation to the

243 ... uncanistered, low thermal load scenario and is calculated at 10,700 person-rem over the 110-120 years of operation. (NOTE: Section 7.1.7, "Short-Term Impacts in the Yucca Mountain Vicinity" indicates a collective dose to workers of 77 person-rem, which is inconsistent with Table 4-33 referenced in this section.)

Section 4.1.7.5.3 summarizes public health impacts in all phases of repository development as resulting in only 0.14-0.41 Latent Cancer Fatalities and indicates that "additional LCFs from short-term activities" will equal less than 0.4 or an increase of 0.01% over the existing average occurrence. Over the full range of construction and operation of the repository, the highest annual dose to the public is identified as 1.5 mrem "or less."

Section 4.1.8.1 informs the reader that, in the event of a catastrophic earthquake, the worst case population exposure would cause only 0.0072 Latent Cancer Fatalities. A summary of exposure statistics for all potential environmental accidents shows that less than 0.02 additional LCFs would occur in the general population.

Section 4.1.15.5.2 illustrates that there will be absolutely no deterioration of worker safety or resulting increase in accidents during the manufacture of disposal containers and shipping casks because there would be no unusual demands on existing facilities.

Section 4.2.1.2.7 states that no health and safety impacts (other than industrial hazards) will occur during the construction sub-period related to retrieval. However, during the 11-year operations sub-period, while industrial hazards will remain about the same for all thermal load scenarios and the LCF for the Maximum Exposed Worker with a total exposure of 6950 millirem will be 0.015, the "calculated LCF" for all workers during retrieval is given as 0.19. During this same period, the Maximum Exposed Individual (MEI) in the public will receive 5.5 mrems, and the LCF is estimated to be 2.8×10^6. The "total population" collective dose is listed as 28 "person-rems," with LCFs equaling 0.014. "Exposure to the public for operations only" is noted as 0.1 Latent Cancer Fatalities. Surface and subsurface workers end up with a low 0.003 LCF probability and 0.19 LCFs during the retrieval period.

Section 8.2.7 informs the reviewer that the cumulative impacts of the Nevada Test Site activities and historic dose scenario, combined with whatever impacts will or will not occur as a result of Yucca Mountain activities, will result in "less than 1 additional LCF." Whether this number was calculated in addition to already identified LCFs related to Yucca Mountain and indicates only the increase occurring from NTS is unclear.

Reciting dose numbers and LCF estimates only serve to reinforce the fact that, based on information provided by DOE, it is virtually impossible to determine whether there will,

243 cont. or could be, any measurable worker or public health and safety impacts as a result of the proposed construction and operation of a Yucca Mountain repository. Based on these inadequacies, the State specifically requests a re-draft of the Occupational and Public Health and Safety analysis contained in the Draft EIS.

Existing sections on health and public safety are written in confusing jargon and conflicting technical terminology and do not provide opportunity for the public or decision makers to distinguish between routine radiological risk and radiological exposure risk related to the Proposed Action. The Draft EIS suffers from extensive shortcomings in analytical and statistical methods and serves to overstate DOE's ability to analyze potential radiation effects related to the Proposed Action.

386... From the 1950s until the present, Nevada communities and citizens have received radiation exposures from activities at the Nevada Test Site (NTS). Cumulative impacts resulting from radiologic exposures related to the proposed Yucca Mountain repository, detonation of over 900 nuclear tests, continued acceptance and storage of low-level nuclear waste in increasing volumes, and the potential for storage of mixed wastes at NTS all contribute to the need for protection of Nevada communities to ensure that the health and safety of their citizens are not adversely affected.

Nevada has no current capability to identify exposures or to monitor health impacts resulting from waste disposal activities at Yucca Mountain or the NTS. State health information data collection and analysis resources are inadequate to the task. Rural communities have virtually no such resources. The capacity to evaluate data in order to identify health effects from specific sources and types of exposures is either inadequate or non-existent. In addition, no work has been done, nor does local capacity exist, to address possible radiologic exposures to individuals who live or work within 6 to 40 meters (20 to 130 feet) of a nuclear waste highway route or a nuclear waste rail route, either in Nevada or along national waste transportation routes.

In December 1999, a State Agency-level working group was formed for the purpose of identifying needs and resources for improving radiological health information and assessment capabilities in Nevada. The State has reached an agreement with DOE that will provide funding for an upgrade of the State Cancer Registry. While this work is of great importance to Nevada, it will not provide a much-needed "snapshot in time" evaluation of current health in conjunction with monitored radiation levels.

What is needed in order to accurately and adequately address cumulative health impacts as outlined in the Yucca Mountain Draft EIS is a program to collect and monitor baseline data before and after any new radiologic waste-related programs are implemented and a study of the radiological exposures and health consequences of high-level waste

386 cont. shipments proposed to be transported through Nevada communities and along national transportation routes.

Such a program should include:

- Regular, periodic reports on the health status of State and targeted/at risk communities through the design and use of a "snapshot in time" radiological data collection and monitoring program;
- An environmental monitoring program to address sources of radiation exposure from transportation, handling, storage, and disposal of high-level waste and spent nuclear fuel; and
- An outreach and education program designed to address public concerns regarding health issues related to high-level waste and spent nuclear fuel transport, storage, and disposal.

A health and environmental assessment and monitoring program should be developed in conjunction with the Nevada Division of Health, the State of Nevada, and other interested parties and be included in the final Yucca Mountain EIS.

244 Page 4-58; Table 4-32 - Estimated impacts to workers from industrial hazards for all phases

The statistics shown in this table are based on a DOE worker data base that is not consistent with national labor statistics. The national labor statistics data base should be used because repository construction and operation will best resemble an industrial work environment with an emphasis on daily work production and efficiency, rather than a DOE work environment where meeting production goals is not so closely linked to a profit motive. This approach would be consistent with the analysis approach used in Section 4.1.15, Impacts From Manufacturing Disposal Containers and Shipping Casks.

Page 4-60; Section 4.1.8.1 - Radiological Accidents

See comment on Section 4.1.2, Air Quality, above.

245 ... Page 4-65; Section 4.1.8.3 - Sabotage

The Draft EIS makes the dangerously faulty and unsupported assumption that "[t]he repository would not represent an attractive target to potential saboteurs due to its remote location and the low population density in the area." In fact, the repository could be a very attractive terrorist target. It is an extraordinarily high-profile facility that will

245 cont. generate a great deal of national and international media coverage should it ever become operational. A considerable amount of heated public controversy will be associated with the facility during site recommendation, licensing, and construction. Even a small incident could generate considerable media attention, and a serious terrorist/sabotage incident would gain wide-spread coverage. In addition, the very remoteness and isolation of the facility could actually help make the repository a more attractive and vulnerable target. For years, demonstrators infiltrated the Nevada Test Site during the period of underground testing, often eluding elaborate security measures and managing to reach the actual locations of tests before being apprehended. A successful attack need not require penetration of the facility itself. Repository surface operations could be especially vulnerable to attacks using man-portable anti-tank weapons that could be deployed from some distance away by terrorists infiltrating the perimeter of the site.

246 The Draft EIS examines a scenario involving low-level exposures in the waste-handling building which can contain radionuclides but not a more serious incident outside of a building, such as a breached cask/container in Caliente. (See Appendix A, section A 2.2/A 2.3) The assumption made in the Draft EIS that "rural targets" for terrorists are non-desirable has recently been proven wrong with the Amtrack derailment in Arizona. The proposed intermodal transfer station would make an attractive and potentially vulnerable target secluded in a canyon with clear overhead shots available.

247 Page 4-67; Section 4.1.11.1 - Impacts to Utilities, Energy, Materials, and Site Services from Performance Confirmation

This section should give more detail as to what existing sources and suppliers would be used; what wells would be pumped; and what regional suppliers of power would be used. Have there been any discussions with these existing sources and suppliers? Also, does this section cover performance confirmation activities throughout the operating life of the repository?

248 ... Page 4-71; Section 4.1.11.2 - Impacts to Utilities, Energy, Materials, and Site Services from Construction, Operation and Monitoring, and Closure

The "range of options" discussed under Repository Electric Power Supply Options should be more detailed. One cannot adequately determine impacts from a "range of options."

This section should be updated in the Final EIS to reflect the new ownership relationship between Nevada Power and Sierra Pacific Power Company.

Since it is acknowledged that the existing electric power service does not have the capacity to serve a Yucca Mountain repository, the environmental impacts of the

248 cont. alternatives available to upgrade the service should be evaluated in this Draft EIS rather than being deferred to a possible later NEPA analysis.

249 Page 4-72; Section 4.1.11.2 - Impacts to Utilities, Energy, Materials, and Site Services from Construction, Operation and Monitoring, and Closure

Construction Material: The Draft EIS fails to evaluate the impact on titanium resources from the planned use of titanium drip shields in 100 miles or more of emplacement tunnels. The current repository design calls for the use of such drip shields as an integral part of the waste isolation system. The Draft EIS, however, addresses only the use of concrete, steel, and copper as the primary construction materials. The impact of extraordinarily large amounts of titanium for waste package protection should be addressed.

250 The current repository design approach does not include concrete drift liners. The Final EIS must define the current proposed repository design, as noted above.

251 Page 4-75; Section 4.1.12.2 - Waste and Materials Impacts from Construction, Operation and Monitoring, and Closure

The Draft EIS states that low-level radioactive waste generated as a result of repository operations would be disposed of at the Nevada Test Site (Page 4-78). Since the Yucca Mountain repository would be a NRC-licensed facility for commercial spent fuel disposal, it may not be appropriate or possible for DOE to dispose of LLW at NTS facilities that are unregulated and intended solely for the disposal of defense LLW. The Draft EIS should assume that any LLW generated through repository operations would be disposed of off-site in commercial LLW disposal facilities licensed under NRC regulations. Impacts of such disposal (including the transportation of LLW from Yucca Mountain to the identified commercial LLW disposal facilities) should be identified and fully assessed.

252 Page 4-78; Section 4.1.12.2 - Waste and Materials Impacts from Construction, Operation and Monitoring, and Closure

The Draft EIS erroneously assumes that DOE has the authority to dispose of commercial low-level waste at the Nevada Test Site. This is <u>not</u> the case. Disposal of low-level waste at the NTS is strictly limited to low-level waste classified as defense low-level waste, i.e., waste generated as part of national defense activities such as production of special nuclear materials for use in atomic weapons. With few exceptions, low-level waste generated by repository operations would be classified as commercial low-level waste. By classification, the low-level waste generated by repository operations would be no

252 cont. different from low-level waste generated by ongoing maintenance activities at commercial power reactors. Under the Atomic Energy Act, the low-level waste generated from ongoing maintenance at commercial power reactors is regulated by the Nuclear Regulatory Commission, not DOE. Moreover, the waste disposal facilities at the NTS would not and could not meet NRC licensing requirements for low-level waste disposal. Given these facts, the Draft EIS should include a discussion of how DOE would dispose of low-level waste generated from repository activities. This discussion should include an analysis of transportation risks associated with shipping the waste to one or more commercial disposal facilities outside Nevada.

253 ...

Page 4-81; Section 4.1.13 - Environmental Justice

The Draft EIS concludes that, because DOE has assumed that no significant environmental or health and safety impacts exist within the Proposed Action, no "disproportionately high and adverse human health or environmental effects on minority and low income populations" will occur. Unfortunately, this approach does not include a thorough analysis of income scenarios along waste transportation routes, either in Nevada or along national routes identified in the Draft EIS. In addition, if DOE had utilized updated census figures for North Las Vegas, Nye County, Lincoln County, Esmeralda County, White Pine County, Inyo County, etc., along with current figures related to low-income and poverty level status in the U.S., a significantly larger percentage of Nevada and U.S. citizens might have come under the "low-income" or "poverty" umbrella for purposes of an Environmental Justice analysis.

First, one must assume there will be adverse impacts to worker and public health and safety as a result of the Proposed Action. At the very least, the Department of Energy should have made a more concerted effort "to collect, maintain and analyze information assessing and comparing environmental and human health risks...[and] use this information to determine whether their programs, policies and activities have adverse health or environmental effects on environmental justice populations." (Executive Order 12898, February 11, 1994) What is missing in the DOE health impacts analysis process is any apparent attempt to collect or maintain information over the long-term, or to conduct any kind of information system formation, other than computer modeling and projections. The "no environmental justice impacts" assumption was based on the original flawed assumption of no adverse health impacts.

Further, in the case of DOE's use of outdated economic and census data, the 1994 Executive Order on environmental justice clearly states that "federal agencies shall share information and eliminate duplication of effort through use of existing data systems <u>and cooperative agreements among federal agencies and with state, local and tribal governments</u>." (emphasis added) The State of Nevada, Clark County, Lincoln County

253 ... and Nye County all offered updated databases, the counsel of experienced socioeconomic analysts and technicians, and current income reporting data to the Department of Energy. DOE steadfastly and repeatedly refused to use the information and, in violation of Executive Order 12898, did not cooperate with state, local, and tribal governments in its determination of the presence or lack of an environmental justice impact within the Proposed Action.

In addition, EO 12898 pointedly states that any federal agency conducting an environmental justice analysis must "...ensure that public documents relating to human health or the environment, are concise, understandable, and readily accessible to the public." DOE's Yucca Mountain health impacts analysis is neither concise nor understandable and, therefore, does not provide an appropriate legal basis for determining the presence or absence of environmental justice impacts.

The current U.S. measure of poverty was instituted in the early 1960s and "no longer provides an accurate picture of the differences in the extent of economic poverty among population groups or geographic areas of the country, nor an accurate picture of trends over time." (*Measuring Poverty: A New Approach.* The Panel on Poverty and Family Assistance, 1998. National Academy Press, Washington, DC)

The Panel stated in its recommendations that "We believe a reasonable range for the initial threshold for the reference family of two adults and two children is $13,700 to $15,900 (in 1992 dollars)." DOE used $12,674 for the same family size for the analysis in the Draft EIS. This same panel concluded that "the current measure does not accurately reflect differences in poverty across population groups and across time. We conclude that it would be inadvisable to retain the current measure for the future." Estimates of the official number and percent of people in poverty are published every year by the Census Bureau, with the most recent estimates available in *Poverty in the United States: 1998.* As of September 1999, the official poverty measure used in the 1998 report was under review by an interagency committee chaired by the Office of Management and the Budget. These figures have been, and continue to be, easily accessible.

Using measures based on the work of a National Academy of Sciences (NAS) panel, which published a report in 1995 that included a series of recommendations concerning improving the official poverty measure, experimental income (poverty) thresholds using 1997 as a base year are: (Table 1.0 - Source: Consumer Expenditure Survey, 1998.)*

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Year	Current Official Threshold	Change in Median FCSU	FCSU 1998-Backdated using new information
1990	$13,254	$13,342	$13,028
1991	$13,812	$13,843	$13,576
1992	$14,228	$14,253	$13,985
1993	$14,654	$14,791	$14,403
1994	$15,029	$15,166	$14,772
1995	$15,455	$15,545	$15,191
1996	$15,911	$15,744	$15,639
1997	$16,276	$15,998	$15,998
1998	$16,530	$16,401	$16,248

*The U.S. Census Bureau's "Poverty Thresholds 1998" used an even higher number for the reference family of two adults and two children. As of September 30, 1999, the 1998 figure used by the Bureau was $16,530. In addition, the Census Bureau acknowledged that, in 1998, "the application of the NAS recommendations instead of the official measure implies that an additional 5.1 million people are living in poverty in the U.S."

According to the U.S. Census Bureau Population Survey of March 1999, the official measure of the number of poor and poverty populations in 1998, using experimental measures, was 34,476,000 people, or 12.7% of the U.S. population. Based on this information, it is obvious that low-income and poverty figures used by DOE in the Yucca Mountain Draft EIS do not accurately reflect differences in poverty across population groups and across time. A re-assessment of low-income and poverty levels in Nevada is necessary and added to this re-assessment should be figures related to communities along all transportation routes proposed in the Draft EIS.

In addition, DOE inaccurately uses the terms "low-income" and "poverty level" interchangeably. "Low income" is defined by the U.S. Department of Housing and Urban Development as 80 percent of the median family income for the area, subject to adjustments for areas with unusually high or low incomes or housing costs. "Very low-income" is defined as 50 percent of the median family income for the area, with the same adjustments. FY1999 income limits are easily accessible on the World Wide Web at www.huduser.org\data\factors.html. Poverty level income in the U.S. is shown in Table 1.0 (above).

While DOE's use of 1990 outdated population and income-level statistics might be somewhat understandable, based on the time frame in which the Draft EIS was completed, it is not understandable or acceptable to disregard standard and accepted

253 cont.

statistical projection tools in estimating health and environmental justice impacts. Data used by DOE will be a minimum of two decades old, if and when the proposed repository begins operation in 2010. The point is not whether an environmental justice "case" can be proved, but rather that DOE's analysis is incomplete, insufficient, and inadequate for decision making purposes. The entire Environmental Justice approach should be re-calibrated, based on a newly designed environmental and public health and safety analysis and using 1999 income and population estimates as a base for more accurate extrapolations to the date of proposed repository start-up.

The concept of environmental justice promotes the fair treatment of people of all races, incomes, and cultures with respect to the development, implementation, and enforcement of environmental laws and policies. Fair treatment implies that no person or group of people shall shoulder a disproportionate share of the negative environmental impacts resulting from domestic and foreign policy programs. Nevada has been unfairly targeted to shoulder a disproportionate share of the negative impacts of America's nuclear legacy and the full burden of the U.S. nuclear power industry's inability to understand or deal with its own waste problems. This is an environmental justice issue, clear and simple.

254

Page 4-85; Section 4.1.14 - Impacts of Thermal Load and Packaging Scenarios

The maximally exposed individual for this analysis should be a subsistence farmer located at the boundary of the repository operations area. This would be equivalent to a maximally exposed individual adjacent to an operating nuclear reactor. There is no rationale provided to locate the maximally exposed individual 20 km from the operating repository surface facility.

255

Page 4-88; Section 4.1.15.3 - Components - Disposal Containers

The description of the disposal containers does not represent the current design approach. The Final EIS must define the disposal container design.

256 ...

Page 4-98; Section 4.2.1 - Impacts from Retrieval Contingency

Because the NWPA requires DOE to maintain the ability to retrieve the waste for at least 50 years after the start of emplacement, DOE should have included this requirement in the Proposed Action. This is another example of the deficiency of the Draft EIS.

The Draft EIS should describe the manner in which the canisters would be removed in the event of a retrieval. These canisters will be hot and radioactive. Does DOE have the capability of retrieving the waste, if it becomes necessary?

256 cont. The retrieval scenario used in the Draft EIS and the attendant assessment of impacts are inadequate. The retrieval scenario assumes that DOE would simply remove the waste from the repository and store it above ground at a site in Midway Valley. This scenario seriously understates the impacts and implications of having to remove spent fuel and HLW after it has been emplaced. The scenario fails to assess what happens to the waste after it has been removed and appears to assume that it can be left indefinitely in above ground storage. This is an inaccurate assumption.

In the event DOE discovers problems with Yucca Mountain that are so serious as to warrant the retrieval of the emplaced waste, it will almost certainly mean that the site is unsuitable for long-term disposal. In that event, it is entirely inappropriate to assume that it will be safe to store the same materials above ground in the same area for an indefinite period or in lieu of a repository. Rather, the retrieval scenario should have assessed the full range of implications, including the need to revisit a credible siting process for a disposal facility, the requirements for a shipping campaign to move the spent fuel and HLW to a more suitable site(s), and all the impacts associated with such a major, long-term undertaking.

Understanding the extraordinary problems that would be presented in having to remove waste from a repository, find a new disposal/storage site(s), and then transport the waste to the new site is important in order to assess the wide range of impacts associated with this aspect of the Proposed Action. The retrieval scenario and all its implications are important and integral aspects of the Yucca Mountain project and must be thoroughly understood and evaluated in the Draft EIS. This has not been done.

257 Page 4-99; Section 4.2.1.1 - Retrieval Activities

The figure on this page gives inadequate detail as to the exact location of the proposed waste retrieval and storage area, even when combined with Figure 3-12. The figure on this page should give more detail as to the exact location of the storage area.

258 ... Page 4-100; Section 4.2.1.2 - Impacts of Retrieval

See comments relative to Section 4.2.1 above. The Draft EIS fails to evaluate one of the most obvious areas of potential impact associated with retrieval, namely the costs of the effort and the related impacts to federal, state, and local governments. The costs associated with retrieval, especially if costs of finding alternative disposal and/or storage sites and transporting waste to them are factored in, will be considerable - certainly in the tens of billions of dollars. Such costs will impact the federal budget for years and could spill over as impacts on the State of Nevada and local governments in the event those

258 cont. entities are required to perform regulatory, law enforcement, emergency management, transportation safety, and a variety of other activities as a result of the retrieval action.

This section of the Draft EIS also fails to evaluate the very significant impacts associated with a new disposal site identification process. Such impacts would be national in scope and would be amplified by the attendant media and political attention related to a failure of such proportions as to require removal of emplaced spent fuel and HLW from Yucca Mountain.

259 Page 4-102; Section 4.2.1.2.3 - Impacts to Hydrological Resources from Retrieval

Under the scenario described in the Draft EIS, the impacts to surface water and groundwater from retrieval will be confined to short-term effects such as runoff rate changes, drainage, infiltration rate changes due to the existence of the above ground storage facility, and demand for water. Because the Draft EIS, as written, does not postulate any alternative but to leave the waste at Midway Valley indefinitely, the document should assess the impacts associated with contamination of surface and subsurface water as storage canisters and systems fail over long periods of time. Such an analysis should assess the radiological risks and health effects to populations using water from aquifers contaminated over long periods of time.

260 Page 4-104; Section 4.2.1.2.5 - Impacts to Cultural Resources from Retrieval

These impacts should be addressed within the programmatic agreement. DOE must consult with tribes that consider these places to have cultural or religious significance.

261 ... Page 4-105; Section 4.2.1.2.6 - Impacts to Socioeconomics from Retrieval

The Draft EIS treatment of socioeconomic impacts of retrieval (limiting them to merely the effects of employment during the retrieval period) is entirely inadequate and grossly understates the real impacts associated with such a dramatic and far reaching event.

The Draft EIS should comprehensively examine the impacts of the retrieval scenario on the State of Nevada and on the State's principal economic sector. (See comments on Socioeconomics for Section 4.1.6 above and contained in Appendix I of these comments.) The decision to remove waste from a Yucca Mountain facility will undoubtedly be accompanied by considerable national and international media attention. The decision will have been made amidst major public and political controversy and concern regarding the safety of the facility. Such a situation will have considerable stigmatizing potential that could easily spill over to the State and the State's tourism industries. In many ways, the need to retrieve waste would be a worst case situation for

261 cont. generating broad and potentially substantial economic impacts statewide, since it would mean that the repository's waste isolation systems had failed and that such failure was receiving major media attention.

262 Page 4-107; Section 4.2.1.2.7 - Table 4-56: Radiological health impacts from retrieval operations

The uncertainty in these calculated doses and risks should be provided. The operational procedures are conceptual, at best; therefore, the uncertainties associated with various operations scenarios should be provided as part of this evaluation.

263 Page 4-108; Section 4.2.1.2.8 - Impacts from Accidents During Retrieval

The analysis of the aircraft crash scenario should include explosives aboard the aircraft, since any aircraft that would crash in this vicinity would likely be an Air Force training jet with weapons that could include explosives. (See also comments on Appendix H.)

264 ... Page 4-110; Section 4.2.2 - Impacts from Receipt Prior to the Start of Emplacement

The entire contingency related to centralized interim storage of spent fuel and high-level radioactive waste and early waste shipments to a Nevada facility is dealt with in three short paragraphs in the Draft EIS. The Draft EIS attempts to rationalize this truncated evaluation by stating that "the impacts resulting from the construction and staging of a Waste Staging Facility would be similar to those from the implementation of a retrieval contingency described in Section 4.2.1." This is an erroneous assumption.

In fact, early receipt of waste at an above ground facility would generate impacts similar to the start of repository activities. Significant impacts can be expected across the country with the onset of spent fuel and HLW transportation operations. Early initiation of such shipments will likely result in increased impacts as state and local communities are forced to scramble to prepare for shipments and upgrade emergency response and related capabilities. In Nevada (as well as in cities and communities around the country), the onset of shipments and the initiation of waste receipt could trigger stigmatizing impacts and begin to negatively affect the State's principal economic sector. (See comments on Section 4.1.6 and Appendix I of these comments.)

If the Proposed Action includes a contingency for early waste acceptance at an above ground storage facility, such contingency must be analyzed and impacts assessed to the same level and degree as for the repository itself. This includes evaluating risks and impacts associated with construction, facility operations, and transportation (including how waste will get to such a facility given the early onset of operations, the feasibility of

264 cont.

constructing a rail spur and the accelerated schedule, the impacts of intermodal and heavy-haul transport, and the impacts of legal-weight truck transport).

The assumptions in this analysis must be described. The Draft EIS seems to assume all waste arriving would be contained in uniform dimension canisters. If waste handling different from that anticipated for the conceptual retrieval operations is required, the impacts of this action must be evaluated.

SECTION 5. ENVIRONMENTAL CONSEQUENCES OF LONG-TERM REPOSITORY PERFORMANCE

265

Page 5-2; Section 5 - Environmental Consequences of Long-Term Repository Performance

As noted above, it is incorrect to assert that the evaluation of the No-Action Alternative can be used to inform the Secretary of Energy's decision on whether to recommend the Yucca Mountain site to the President for development of a repository. The No-Action Alternative scenarios are not reasonable scenarios, and the Draft EIS acknowledges this situation in Section 1.4.3.4. Therefore, the NEPA analysis is insufficient, and the Secretary's use of the analysis in making any decision would be improper.

266

Page 5-3; Section 5.1 - Inventory for Performance Assessment Calculations

By not including more radionuclides in the impact calculations, the risk is artificially minimized. The emphasis should be on "accurate" impact calculations, not "efficient" calculations.

Does the waste inventory contain any "classified" radionuclides? If so, the Draft EIS should indicate this and discuss the impacts of these radionuclides on the dose to humans and the environment.

The discussion on radionuclides with short half-lives should give the range of numbers of years, not just the statement of "generally less than several hundred years."

There should be an evaluation of the uncertainty that waste package inventory averaging introduces to performance. Because the model relies on different infiltration rates over different parts of the repository, the distribution of packages of "real" waste with different composition ratios could result in some "real" waste being released and transported in quantities and compositions not accounted for by averaging.

267 Page 5-5; Section 5.1 - Inventory for Performance Assessment Calculations

What is the analytical basis for the inventory of neptunium-237 being increased by 58% to account for the decay of americium-241?

268 Page 5-6; Section 5.1 - Inventory for Performance Assessment Calculations

Plutonium should be included in both the radionuclide inventory assessment and the chemical toxicity assessment. Recent evidence indicates that plutonium moves more quickly than originally thought.

269 Page 5-8; Section 5.2.2 - Components of the Waste Package

The current design of the waste package has the Alloy-22 on the outside of the stainless steel, and the thicknesses of both materials has changed. The Draft EIS should use the correct information.

270 Page 5-10; Section 5.2.3.1 - Limited Water Contacting Waste Package

The discussion regarding water movement in the unsaturated zone appears to state that DOE cannot adequately model the flow regime over time. Since the model looked only at movement after the heat effects, the reader cannot determine the effects of the heat on the UZ system and the concurrent changes to the flow regime.

The discussion on uncertainty fosters the belief that this Draft EIS contains insufficient data to adequately evaluate the site for suitability.

The output of the TSPA model is highly dependent on seepage rate into the drifts; however, the results of critical studies on the movement and chemistry of water after the thermal pulse are not yet available, according to the text in this section. It should be stated clearly that repository performance projections provided in this Draft EIS are tentative, at best, and are subject to large adjustments pending further information on crucial aspects of heat effects on the assumed characteristics of the natural barrier system and its interaction with the engineered barrier system (which currently is not the same as that described in this Draft EIS). This uncertainty alone is sufficient to declare the projected performance of the repository in this Draft EIS premature and lacking in credibility.

271 Page 5-11; Section 5.2.3.1 - Limited Water Contacting Waste Package

The last sentence of this section should state that the rate of water movement through the unsaturated zone can be from 50 years to thousands of year, not less than 100 years to thousands of years, as stated in this section.

272 Page 5-11; Section 5.2.3.2 - Long Waste Package Lifetime

It should be made clear that the waste package degradation models are essentially unsupported by reliable long-term data and are based largely on extrapolation and assumptions of expected behavior. In addition, the waste package design analyzed in this Draft EIS is not the design currently under consideration. Therefore, the TSPA products in this Draft EIS are invalid.

273 Page 5-12; Section 5.2.3.3 - Slow Release of Radionuclides From Waste Package

The waste form degradation model is based, in part, on speculation regarding the mechanisms of water contacting the waste form and the unresolved matter of the solubility of Neptunium-237, which is critical to dose calculations. This model is not valid under these circumstances.

274 Page 5-15; Section 5.2.3.4 - Reduction in Concentration of Radionuclides and Chemically Toxic Materials During Transport

Performance associated with alternative saturated zone flow models should be calculated. The six-stream-tube model is arbitrary and not based on any data. Furthermore, the assertion that alternative models would not result in significant differences in calculated doses is based entirely on the speculative long life of the waste packages that supposedly would result in delay of nearly all releases beyond 10,000 years. It is incorrect for the Draft EIS to assert that it is unimportant to have a clear understanding of saturated zone flow because the waste package will delay releases beyond the period of regulatory concern. Characterizing the saturated zone flow is a key function of site characterization that must be completed prior to site recommendation and cannot be ignored simply on the assertion that the waste package lifetime makes it unnecessary. By so doing, an important element of the multi-barrier concept has been evaded.

275 Page 5-16; Section 5.2.3.6 - Nuclear Criticality

The Draft EIS should provide more information as to what "minor effects" a nuclear criticality incident would have on repository performance and what analysis was performed to support this conclusion.

276 Page 5-17; Section 5.2.4.1 - Uncertainty Associated With Societal Changes, Climate, and Other Long-Term Phenomena

The statement regarding benefits from future human activities such as technology for radiation removal from water and the environment and cures for cancer is not relevant in this Draft EIS. These concepts cannot be offered or committed to as mitigation measures and surely cannot be justified as an excuse for releasing radionuclides to the environment. This statement should be removed.

The time and magnitude of the projected peak dose is sensitive to the idealized climate cycle pulses. The uncertainty associated with the superpluvial pulses should be illustrated.

This section fails to include the potential for global climate change to affect repository performance and environmental consequences. The oversight also exists in Section 5.9, page 5-46, Consequences to Biological Resources and Soils. The section does address the thermal loading effect (Table 5-18, page 5-47) to biological resources and soil. However, the potential temperature increases are overly conservative and their estimated ranges from low to high are ignored. Clearly, there is a potential for vegetation to disappear above the repository and for the soil cover to be eroded away. The consequences of this to the site's geohydrology and repository performance should be addressed in Section 5.4.1, 5.4.2, and 5.4.3. These weaknesses exist because DOE failed to adopt an ecosystem approach for the Draft EIS, as recommended in Attachments F, G, K, and L and by Bartlett and Malone (1993), Clark and Canter (1977), and Salk and others (1998).

277 Page 5-18; Section 5.2.4.2 - Uncertainty Associated with Currently Unavailable Data

The list of priority factors requiring additional data and analysis should include Saturated Zone Flow and Transport. (See comment on Section 5.2.3.4, Page 5-15).

It would seem appropriate, due to the importance of this project, that DOE would want to complete the analyses of the eight study areas listed below in order to provide more valid data upon which to base decisions safeguarding the population of this state. Trying to assess the impact on the State without complete information is akin to second-guessing future security.

1. Drift seepage and percolation to depth

2. Effects of heat and excavation on flow
3. Dripping onto waste packages

277 cont.

4. Chemistry of water dripping on waste packages

5. Integrity of the corrosion-resistance waste package barrier

6. Integrity of the spent nuclear fuel cladding

7. Formation and transport of radionuclide-bearing colloids

8. Transport in the unsaturated zone

The Draft EIS contains other areas that lack data for proper decision making: transportation mode feasibility; transportation operation studies; long-term site quarantine; further groundwater mapping; transmutation; and the simple effect of heating the rock. The Final EIS should not be issued until these further studies are complete and the results incorporated into the EIS analysis.

278

Page 5-20; Section 5.2.4.3.2 - Weighting of Alternative Conceptual Models

The reference designs of the repository and waste package in the Draft EIS are not the designs currently under consideration. This alone undermines DOE's ability to use the TSPA results in this Draft EIS for selection of the preferred alternative.

There has been considerable debate over the actual flow paths that would be followed by the radionuclides released from the repository. Modeling results performed by the State of Nevada (Lehman and Brown, 1994, Lehman and Brown, 1995) indicate major differences may exist in flow path direction, velocity, and sorptive capability compared to that used in the latest assessments by DOE, including the Draft EIS, if all data sets are utilized.

By failing to evaluate credible alternative models or opposing views of the saturated zone, DOE is not in compliance with NEPA. Being out of compliance with NEPA means automatic noncompliance with the NWPA. DOE is specifically out of compliance with NEPA 1502 for not summarizing, discussing, or using important data sets. DOE has failed to evaluate credible opposing viewpoints and does not propose testing to reduce uncertainty in the choice between alternative conceptual flowpaths. (See Attachment U for a more detailed discussion of this issue.)

279 ...

Page 5-21; Section 5.2.4.3.3 - Uncertainty and the Proposed Action

The Draft EIS should compare the "lumped" performance analyses to the discrete analyses with each type of uncertainty isolated. This would provide information on the

279 cont. relative importance of each type of uncertainty so a value assessment can be made of various types of uncertainty reductions. For example, it would be important to know the relative importance of conceptual model uncertainty in the saturated zone flow model, as discussed above.

280 Page 5-22; Section 5.2.4.3.5 - Confidence in the Long-Term Performance Estimates

This section of the Draft EIS concludes with the statement, "The EIS performance assessment represents a 'snapshot in time' and ongoing work will refine that snapshot." In fact, the performance assessment is not analogous to a "snapshot" at all. A snapshot implies a reasonable representation of reality. The Yucca Mountain performance assessment represents a compilation of incomplete data, buttressed by assumptions and guesswork, and analyzed using models of questionable validity in order lend an illusion of accuracy to its conclusions.

281 Page 5-22; Table 5-3 - Confidence in the long-term performance of the repository system in relation to groundwater contamination

Table 5-3 does nothing but show that DOE has insufficient information about Yucca Mountain to make a suitability determination.

The statement of high confidence in the solubility of Neptunium-237 in this table is inconsistent with information on Page 5-13. Overall, this table suggests only low to medium confidence in the most important factors in the TSPA. Based on this, it is premature to use the performance assessment in the Draft EIS to support any decision regarding the preferred alternative. A new performance assessment based on higher confidence in the critical models should be issued for review and comment, as part of a re-issued Draft EIS

282 ... Page 5-26; Section 5.4 - Waterborne Radiological Consequences: Box: Maximally Exposed Individual

The Maximally Exposed Individual (MEI) should be an age/gender weighted subsistence farmer. The added level of conservatism is justified in light of large uncertainties associated with dose projections in this Draft EIS and the small increase in dose that would be experienced by this MEI, compared to the maximally exposed individual proposed in this Draft EIS. The full pathway dose rates should be calculated for the subsistence farmer described above, rather than from the Amargosa Valley survey data referenced on Page 5-31.

282 cont. The definition of the Maximally Exposed Individual in the Draft EIS is not the same as the Reasonably Maximally Exposed Individual used by EPA in their proposed standard for Yucca Mountain. There should be consistency between these two documents.

283 Page 5-27; Section 5.4.1 - Consequences from the Groundwater Exposure Pathway for the High Thermal Load Scenario

The assumption that radionuclides would mix in the unsaturated zone has no basis. DOE's own statement, on page 5-10, implies that DOE cannot adequately model the unsaturated zone.

Diluting the concentration of the yearly infiltration from Yucca Mountain into the 17.3 million cubic meters of water use in Amargosa Valley is not conservative. Data from Nye County drilling indicates that the flow is compartmentalized, and there would not be a large amount of dilution of the radionuclides. This statement applies also to the similar dilution used in the Intermediate and Low Thermal Load scenarios.

284 Page 5-28; Section 5.4.1 - Consequences from the Groundwater Exposure Pathway for the High Thermal Load Scenario

The discussion of the waste package lifetime should be rewritten to indicate the new configuration of the waste package, i.e., the Alloy-22 on the outside.

285 Page 5-30; Section 5.4.1 - Consequences from the Groundwater Exposure Pathway for the High Thermal Load Scenario

The discussion about the construct of the mean implies that DOE really doesn't know when the peak dose will occur and, in all probability, can't know when it will occur.

286 Page 5-30; Table 5-7 - Peak Radionuclide Concentrations

The Draft EIS should provide Maximum Contaminant Levels (MCLs) as set by EPA for drinking water systems to compare with the peak radionuclide concentrations given in this table.

287 ... Page 5-34; Section 5.4.3 - Consequences from the Groundwater Exposure Pathway for the Low Thermal Load Scenario

This section states there will be no change in the infiltration rate for the low thermal load scenario because areas used for the low thermal load scenario would have different rates of infiltration as opposed to the high thermal load scenario. This statement makes no

287 cont. sense. The Draft EIS should show the analysis used to support this statement and give the infiltration rate for Area 5.

288 Page 5-34; Section 5.4.3 - Table 5-13: Population consequences from groundwater releases of radionuclides during 10,000 years after repository closure for the low thermal load scenario

This table shows the scaling factor for changing the dose rate for the maximally exposed individual into a dose rate for a member of the population was computed by diluting 46 acre-feet of water infiltrating through the repository by the annual water use in the Amargosa Valley of about 14,000 acre-feet. If exposures are to be calculated at Lathrop Wells, or anywhere along Highway 95 or north of Highway 95, then these dilution volumes are probably too high and inaccurate, especially given a compartmentalized system.

289 Page 5-37; Section 5.4.4 - Sensitivity Study on the Fuel Cladding Model

Based on the information provided, there is no technical basis to assume any specific quantitative performance credit for cladding, other than zero. Until such time as reliable information indicates cladding will provide more than "some impediment to radionuclide mobilization if the waste package was breached," no performance credit should be taken for the cladding. This is justifiably conservative, given the high uncertainty in waste package failure coupled with the high uncertainty of cladding degradation over time.

290 Page 5-38; Section 5.5 - Atmospheric Radiological Consequences

What analysis supports the expectation that Iodine-129 will dissolve in the groundwater rather than migrating as a gas?

291 Page 5-38; Section 5.5.1 - Carbon-14 Source Term

This analysis is highly sensitive to the large uncertainties in waste package and cladding degradation models. The uncertainty in the source term associated with these two factors should be discussed in this section.

292 Page 5-39; Section 5.6 - Consequences from Chemically Toxic Materials

Would there be any changes to the discussion in this section based on the change in the waste package design? If so, the Draft EIS should indicate these changes.

293 Page 5-39; Section 5.6.1 - Human Health Impacts From Chromium, and Table 5-17

At the 5 and 20 km locations, the expected chromium concentrations are relatively close to the Maximum Contaminant Level Goal (MCL) and highly subject to uncertainty in waste package failure expectations (and at 20 km, the saturated zone flow model). A slight (but not unreasonable) change in the assumption regarding juvenile waste package failures would result in the MCL Goal being exceeded. The conclusion that, for the high and intermediate thermal load alternatives, "DOE anticipates no detrimental impacts to water quality due to chromium contamination" (Page 5-40) is not justified when reasonable uncertainties are taken into account. The analysis is also somewhat sensitive to the waste package design, which, in the Draft EIS, is not the same as that being currently considered. The current design is likely to permit more rapid mobilization of chromium.

294 Page 5-40; Section 5.6.2 - Human Health Impacts From Molybdenum

The above comments regarding chromium also apply to molybdenum in terms of the amount of metal that could be mobilized if uncertainty due to a single assumption regarding juvenile waste package failure and the current waste package design are taken into account. The lack of a drinking water standard is not a justification for releases of molybdenum into groundwater in amounts similar to chromium, especially when adverse effects of molybdenum in water used by livestock have been documented for years.

295 Page 5-42; Section 5.7 - Consequences From Disruptive Events

Because of the wide range of uncertainty associated with the base case dose calculations and the questionable representativeness of the mean of the model realizations, the base case performance should be represented by the 95th percentile of the calculations rather than the mean.

296 ... Page 5-42; Section 5.7.1 - Drilling Intrusions

This drilling intrusion scenario is unrealistic. Unless there are adequate institutional controls at the site, drilling could occur not long after closure of the repository. Technology could make using a drill bit obsolete. There is no basis given in the Draft EIS for the size of the drill bit or the use of drilling mud, especially when projecting an intrusion more than 10,000 years out. In addition, there is no basis for using just one event. Multiple drill holes are more likely to occur.

The information on doses from the minimal-impact intrusion scenarios does not support the conclusion that the effect would be "small" (Page 5-49). With the larger waste

296 cont. release amount analyzed, it appears that peak doses at the 95th percentile could exceed the existing safe drinking water standard of 4 mrem/year. Scenarios chosen for the analysis are not conservative because they rely on the uncertain condition of waste packages at 10,000 years in the assumption about resistence to intrusion. Also, the larger release analyzed represents less than one third of the contents of one breached container. Overall, it appears that the repository system is not resilient to a realistic human intrusion scenario, contrary to the conclusion of this Draft EIS.

297 Page 5-44; Section 5.7.2 - Volcanic Disturbance

The uncertainty related to the conclusions in this section should be described in the Draft EIS. The description should include assumptions used about the integrity of the waste packages affected in the scenarios. The statement that the peak dose would occur thousands of years after the event based on the time needed for groundwater transport of the radionuclides is vague and not a correct assumption if the uncertainty in the flow and transport models is taken into account.

298 Page 5-45; Section 5.7.3 - Seismic Disturbances

Uncertainty in the rock fall analysis should be discussed in the Draft EIS. This analysis relies heavily on the waste package degradation model. Given the uncertainty associated with the models, the range of potential consequences should be illustrated.

Does the change in the waste package configuration change the analysis used in this section?

299 Page 5-48; Section 5.9 - Consequences to Biological Resources and Soils

The discussion of estimated doses from irrigation water and discharge at Franklin Lake Playa should indicate that the time period considered is 10,000 years. As seen in the referenced Draft EIS sections, peak doses, even at 20 km, could be as high as 1.4 rem/year. None of the peak doses calculated can be considered small and would certainly exceed any standard established for a repository.

300 ... **SECTION 6. ENVIRONMENTAL IMPACTS OF TRANSPORTATION**

As discussed in the comments that follow, DOE has not demonstrated the technical, economic, or environmentally acceptable feasibility of transporting spent nuclear fuel and high-level radioactive waste to the proposed site. Absent this demonstration, DOE violates the National Environmental Policy Act by deferring transportation related decisions. Specifically, if the proposed repository is approved based upon this EIS, DOE

300 cont. will begin to make a substantial commitment of resources to the proposed repository, even though the method of transportation to the site has not been determined. This could force a transportation related decision that results in unacceptable, adverse impacts. This is the scenario that the NEPA process is designed to avoid.

301 ... Section 6 of the Draft EIS purports to address the environmental impacts of transportation without ever specifically describing the radiological characteristics of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) that cause the most serious adverse impacts of repository transportation on public health and safety and the environment.

Nevada believes that the impacts of repository transportation activities cannot be accurately assessed without explicitly acknowledging the deadly nature of SNF and HLW. Nevada's 1995 scoping comments recommended: "The radiological consequences of exposure and contamination associated with each reference fuel type should be presented in terms understandable to the general public, and these consequences should be presented in the Executive Summary as well as in the body of the draft EIS." DOE has chosen to ignore Nevada's recommendation.

Section 6 contains no meaningful discussion of the radiological characteristics of the reference fuel types to be transported to the repository. Indeed, the Draft EIS overall barely discusses the radiological hazards of SNF. The Executive summary states that spent nuclear fuel "consists mostly of uranium, and is usually intensely radioactive because it also contains a high level of radioactive nuclear fission products." (p. S-4) The overview section of Volume 1 states that spent nuclear fuel" is intensely radioactive in comparison to non-irradiated fuel." (p.1-6) Except for identifying Cesium-137 as a major source of SNF preclosure impacts and shielding requirements (p. A-9), Appendices A, F, and J provide little specific information on the hazards of SNF.

DOE has designated a 26 year-old PWR spent fuel assembly with 39,560 MWR/MTHM burn-up and 3.69 percent U-235 initial enrichment as the "typical fuel type" for transportation impact analysis in Section 6 of the Draft EIS. (p. A-14) All other factors being equal, cooling time is the single most important determinant of transportation radiological risk. The 26 year-old SNF assumed in the Draft EIS is considerably less dangerous than the 10 year-old SNF assumed in past DOE program documents, and much less dangerous than the 5 year-old SNF that could be shipped to the repository in casks currently licensed by the NRC.

The typical PWR assembly described in the Draft EIS contains 31,000 curies of Cesium-137 and 21,000 curies of Strontium-90, and is a powerful source of penetrating gamma and neutron radiation. A person standing next to a single, unshielded 26 year-old SNF assembly for a few minutes would receive a radiation exposure sufficient to cause death

301 cont. in 50 percent of the population. Extend the time to ten minutes, and death from classic radiation sickness replaces concern about latent cancer fatalities.

302 In the Draft EIS Summary document (p. S-21), DOE states that legal-weight vehicles would not require special state-issued permits to transport HLW or SNF. This statement is not correct. These vehicles would still need valid hazardous materials transport permits to enter and traverse Nevada with such loads.

303 Also in the Summary document (p. S-53) and later in Section 6, DOE fails to address the potential shipping alternative of repackaging spent fuel and HLW at a potential inter-modal transfer site. Under the DOE heavy-haul scenario, HLW and SNF coming to an intermodal facility by rail must be shipped to the repository via heavy-haul trucks and cannot be repackaged or reconfigured for legal-weight truck transport. It is possible that, given the length, geography, and impacts associated with heavy-haul transportation on the scale required to implement the Proposed Action, such shipments may prove to be impossible. In such an event, intermodal alternatives to heavy-haul should be evaluated.

304 On the bottom of page 6-1, the Draft EIS states: "Because the mode of transportation used to ship from each site would depend on several factors that DOE does not control (for example, future capabilities of shipping sites, rail service to shipping sites, and labor agreements), DOE recognizes that it cannot predict the specific transportation mode (truck or rail) of each shipment to the repository." This statement is factually incorrect. The NWPA, as amended, makes DOE the shipper of record for all SNF and HLW shipments to the repository. As shipper of record, DOE is legally entitled to dictate the choice of mode for every shipment. Over the past decade, DOE contractor studies, such as the Near Site Transportation Infrastructure and Facility Interface Capability Assessment, have documented the technical factors which constrain modal choices at each commercial reactor site and estimated the cost of adding rail shipment capability at truck-only sites. DOE's decision to make all transuranic waste shipments to the Waste Isolation Pilot Plant (WIPP) by truck, even though rail transportation to WIPP is feasible from major federal facilities such as Hanford and Savannah River, is a strong precedent for DOE control of repository transportation modal choice decisions. Moreover, DOE recently dictated not only the choice of mode (rail), but also the service option (dedicated trains), the port of entry (Concord), and the preferred route (Feather River Canyon) for the recent foreign research reactor SNF shipments to INEEL.

305 ... Page 6-2; Section 6 - Environmental Impacts of Transportation

Although DOE maintains that the mostly legal-weight truck and mostly rail scenarios adequately bound the analysis for the national transportation scenarios, this is not true for the Nevada Transportation Scenarios. Under the mostly legal weight-truck scenario,

DOE must still deal with more than 300 rail shipments of high-level waste and Naval fuel (references). The Nevada Transportation Scenario fails to describe how DOE will deal with these shipments without either constructing a rail line or operating an intermodal transfer site and heavy-haul truck transport.

305 ... The Draft EIS fails to identify a preferred rail corridor and sets forth no timetable for selection of a preferred rail corridor, despite DOE's assertion that the information presented is sufficient to select a preferred corridor. The Draft EIS states: "Although it is uncertain at this time when DOE would make any transportation-related decisions, DOE believes that the EIS provides the information necessary to make decisions regarding the basic approaches (for example, mostly rail or mostly truck shipments), as well as the choice among alternative transportation corridors." (p. 6-1) Referring specifically to the selection of "implementing alternatives," such as "alternative rail corridors in Nevada," the Draft EIS states: "If and when it is appropriate to make such decisions, DOE believes that the EIS provides the information necessary to make these decisions." (p. 6-2) According to the Draft EIS, additional information, analyses, and consultations would be required "for selection of a specific rail alignment within a corridor." (p. 6-1)

DOE's failure to designate a preferred rail access corridor in the Draft EIS violates the National Environmental Policy Act (NEPA). NEPA procedures are designed to "insure that environmental information [including information on the human environment as well as public health and safety] is available to public officials and citizens before decisions are made and before actions are taken." DOE's approach for the Draft EIS denies the affected public a meaningful opportunity to participate in the rail corridor evaluation process before DOE prepares the Final EIS.

Moreover, DOE's refusal to narrow the choice of corridors extends the region of influence of the Proposed Action to thirteen Nevada counties traversed by the five rail corridors and their existing mainline rail connections. Virtually the entire population of Nevada will be held hostage by DOE's indecision. Coupled with the absence of a timetable, the resulting uncertainty, in and of itself, will cause adverse socioeconomic impacts for individuals, businesses, and communities.

During the scoping process in December, 1995, the State of Nevada recommended the following process to DOE: "The Draft EIS must present a technically credible methodology for comparative evaluation of rail spur route options. The State of Nevada believes that DOE should fully evaluate at least three feasible rail spur routes before selecting a preferred route." Nevada also recommended specific criteria for the Draft EIS comparative route evaluation: 1) impacts on public health and safety; 2) impacts on highly populated areas; 3) engineering feasibility; 4) impacts on surface and groundwater

305 cont. resources, threatened and endangered species, and federal and state parks and refuges; 5) cost of construction, recognizing that predictability of costs may be as important as least cost in ranking alternatives; 6) avoidance of private lands and potential for voluntary acquisition of private lands where necessary; 7) impacts on Native American lands and cultural resources; 8) potential conflicts with U.S. Air Force facilities and operations; and 9) economic development costs and opportunities, addressing both standard and special (risk-induced) socioeconomic impacts.

The Draft EIS does not reveal the process DOE plans to use in selecting a preferred rail corridor. The baseline information provided in Section 3 and the impact analysis provided in Section 6 and Appendix J are particularly deficient regarding impacts on highly populated areas; engineering feasibility; construction costs and cost uncertainties; potential for voluntary acquisition of private lands; impacts on Native American lands and cultural resources; and economic development costs and opportunities, including risk-induced socioeconomic impacts. Nevada believes that DOE's refusal to identify a preferred rail corridor in the Draft EIS makes a legally sufficient assessment of rail transportation risks and impacts impossible.

306 Page 6-2; Section 6.1 - Summary of Impacts of Transportation

The Draft EIS contains no assessment of operational impacts associated with spent fuel and HLW transportation (e.g., impacts to levels of service, queues, highway safety, etc.).

307 ... Pages 6-2 to 6-8; Section 6.1.1 - Overview of National Transportation Impacts

The Draft EIS contain no information about nuclear waste transportation routes, shipment numbers along those routes, and risks to specific states and communities located on or near transportation corridors to a Nevada repository. Furthermore, the Draft EIS contains no analyses of possible spent fuel and HLW transportation impacts on states, cities, and communities along potential shipping routes, despite the fact that, in responding to public comments on the 1985 Draft Environmental Assessment (EA) for the Yucca Mountain site, DOE committed to just such an assessment as part of the Yucca Mountain EIS:

"The DOE believes that the general methods and national average data used [in the EA] are adequate for this stage of the repository-siting process [i.e., the pre-site characterization stage]. Route-specific analyses and an evaluation of the impacts on host

307 cont. States ***and States along transportation corridors will be included in the environmental impact statement***" (emphasis added).[34]

The irony of the situation is that DOE has, in fact, done the analyses needed to reveal specific highway and rail routes that would be used for waste shipments and to conduct required impact assessment along those routes. That information, however, is buried in data used to run computer models and is never made explicit in the Draft EIS. The Draft EIS contains no maps or other information showing which cities and communities along transportation corridors will be affected by this massive and unprecedented radioactive waste shipping campaign. One can only conclude that such an oversight is intentional and designed to suppress public interest in the project and participation in these public hearings.

Nevada believes that DOE has violated the National Environmental Policy Act by concealing crucial information used to support conclusions in the Draft EIS. Absent this information, persons affected by the transportation impacts of the Proposed Action have no way of determining the substantive and legal sufficiency of DOE's analysis. Such concealment of information can only diminish public confidence in DOE's ability to safely transport these highly radioactive materials.

308 Page 6-8 to 6-9; Section 6.1.2.1 - Land Use

DOE has not accurately identified or assessed the land use impacts of the Nevada transportation alternatives. Even where DOE has identified land use impacts, DOE has understated the nature and severity of the impacts. The failure by DOE to accurately describe the Proposed Action also prevents an adequate assessment of land use impacts. For example, the land use impacts associated with the development of ballast and sub-ballast quarries, solid waste disposal facilities, construction lay-down areas, and construction staging areas can not be assessed until these areas are identified.

The conclusions regarding land use impacts in the Draft EIS rely primarily on disturbed acreage. Although this is one measure of land use impacts, it is not the only one. For linear facilities such as a rail line, an assessment of land use impacts should also include an evaluation of the impacts of bisecting current and future land uses. As discussed above in the comment on Section 2.1.3.3.2, Nevada Rail Scenario, splitting an area with a rail line can have significant impacts on the entire area, not just the area within the right-of-

[34] "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Appendix C, Comment-Response Document, p. C.2-37 (May, 1986).

308 .. way. This is particularly true for ranching operations. DOE has not assessed this type of land use impact in the Draft EIS.

DOE has identified a number of land use conflicts with the proposed rail line, but has not accurately characterized the impact of these conflicts. For example, potential rail corridors cross the Simpson Park Habitat Management Area (Carlin), the Old Spanish Trail/Mormon Road special recreation management area (Jean), Wilderness Study Areas (Valley Modified), and the Desert National Wildlife Range (Valley Modified). A rail line through these special land use areas would have significant impact on the purpose of these special areas. The EIS does not even discuss these impacts. It is particularly difficult to understand why DOE has not eliminated the Caliente-Chalk Mountain alternative. The U.S. Air Force has unequivocally stated that this alternative is unacceptable due to its impacts on the Nellis Air Force Range.

Proposed rail line corridors also cross areas of potential future community growth. Although DOE identifies these areas, the Draft EIS does not contain an assessment of the impacts of this conflict on future community growth patterns. The area of particular concern is the impact of the proposed Valley Modified route on growth in the north Las Vegas urban area.

Many of the areas crossed by potential rail corridors are currently remote, undeveloped areas. Much of the area is currently roadless, including Wilderness Study Areas. Regardless of the decision by the land management agency regarding classification as wilderness, construction of a rail line through a remote, roadless area will have land use impacts. These changes in land use should be identified and assessed.

From a land use perspective, the only rail alternative that does not have serious land use conflicts is the Caliente corridor. Even this corridor could impact the Nellis Air Force Range. All other rail alternatives cross or impact areas designated as special purpose land use. These conflicts are summarized below:

Caliente:	Requires use of land on Nellis AF Range. Alternatives cross difficult terrain.
Carlin:	Requires use of land on Nellis AF Range. Alternatives cross difficult terrain.
	Bates Mountain Antelope Release Area
	Simpson Park Habitat Management Area

308 cont.

Caliente/ Chalk Mountain:	Traverses Nellis Air Force Range, which is unacceptable to the Air Force.
Jean:	Impacts Pahrump potential community growth.
	Old Spanish Trail/ Mormon Road special recreation management area
	Adjacent to Statelier Wilderness Area.
Valley Modified:	Encroaches on the Desert National Wildlife Range.
	Impacts community growth in the north Las Vegas urban area.
	Crosses Nellis A, B, & C and Quail Spring WSA.
	Impacts Nellis AFB small arms range.
	Impacts Indian Springs Auxiliary Field facilities.

DOE lists the Caliente/Chalk Mountain corridor as a non-preferred alternative, based upon the Air Force's statement that no route that traverses Nellis Air Force Range is acceptable. Based upon this comment, the route (and the associated heavy-haul route) should have been eliminated from the alternatives included in the Draft EIS and listed in Section 2.3 as an alternative considered but eliminated from detailed study.

309 ...

Page 6-10; Section 6.1.2.3 - Hydrology

With respect to hydrology related to transportation-related impact, the Draft EIS states as follows:

"Surface water impacts during construction would be avoided by implementing good management practices to prevent and mitigate spills of pollutants and would avoid, minimize, or otherwise mitigate possible changes to stream flows. Therefore, DOE does not anticipate impacts to surface waters from the construction of a rail or heavy-haul implementing alternative."

"Potential for groundwater impacts would be limited. There would be the potential for temporary withdrawals of water from groundwater sources during the construction of a

309 cont.

branch rail line or upgrade to highways and construction of an intermodal transfer station."

Page 6-45
"If DOE selected rail to transport spent nuclear fuel and high-level radioactive waste to the Yucca mountain site, it would also select one of the five routes. DOE would then prepare a more detailed floodplain/wetlands assessment of the selected alternative. The assessment in Appendix L presents a comparison of what is known about the floodplains, springs, and riparian areas and at the three alternative intermodal transfer station sites and along their associated heavy-haul routes. In general, wetlands have not been delineated along the alternative intermodal transfer station sites."

Page L-18; L.4.2.1 - Effects along Rail Corridors

"Potential rail routes would cross many small and some large washes."

"Based on current information, springs and riparian areas that may have associated wetlands occur within three of the rail corridors (Caliente, Carlin, and Caliente-Chalk Mountain."

In the Draft EIS, DOE has not adequately studied the potential surface water impacts of either the rail or the heavy-haul alternative. The discussion on wetlands contained in Appendix L for all of the rail alternatives contains the statement, "no field searches or formal delineations of wetlands have been conducted along this route." Wetlands have also not been delineated for the intermodal transfer station sites. Some of the rail corridors are known to cross or be near to significant springs, groups of springs, streams designated as riparian areas, or reservoirs associated with wetlands. Wetlands and riparian areas are a valuable resource in Nevada. Simply stating that impacts will be mitigated is insufficient.

The discussion of groundwater impacts is limited to impacts associated with groundwater withdrawals for construction activities and from infiltration of pollutants from potential spills during construction and operation. Most of the rail corridors cross rugged terrain where significant cuts will be required. These cuts could intercept groundwater flow. DOE has not provided sufficient information on the actual routes and the location and depth of cuts to assess these potential impacts.

310

Page 6-10; Section 6.1.2.3 - Hydrology

The Draft EIS should recognize the fact that an accident during waste transport could result in long term impacts to surface water and groundwater resources.

311. . .

Page 6-10; Section 6.1.2.4 - Biological Resources and Soils

DOE has significantly understated the impact to biological resources. Loss of habitat would not be limited only to the physical loss of habitat due to the construction of the rail line. The operation of the rail line would reduce the value of habitat crossed or near to the line, resulting in significantly greater loss in habitat than just the area physically within the rail line right-of-way.

All of the rail corridors except the Valley Modified cross and are near to critical habitat for many species of wildlife. Critical habitat is absolutely necessary for wildlife. Human activity, such as the operation of a rail line, in or even near critical habitat, can seriously degrade the value of that habitat for wildlife. This is especially true of linear facilities, such as a rail line, that pass through habitat areas. Without undisturbed access to critical habitat, the wildlife using that habitat may abandon large areas of year round habitat. Critical habitat crossed by or near to rail corridors includes bighorn sheep crucial winter range, mule deer crucial winter range, pronghorn winter range, sage grouse strutting areas, sage grouse nesting areas, caulker crucial habitat, and quail crucial habitat.

The Carlin and Jean corridors also cross migration corridors for big game. Linear facilities such as rail lines can significantly impact the movement of big game. This is particularly true in areas where steep cuts or fills are required. The Jean corridor also crosses a potential migration corridor for bighorn sheep from winter range in the Devil's Hole Hills to historic but currently unoccupied habitat at the northwest end of the Spring Mountains. Although currently not used, the disruption of this migration corridor would be a significant impact. Bighorn sheep are particularly susceptible to disease. An unoccupied habitat area represents the potential to establish another herd unit that could provide greater protection for the continued recovery of the bighorn sheep.

The Environmental Baseline File for Biological Resources (TRW 1999k) lists the following crucial habitats within each of the 400 meter wide rail corridors:

Caliente:	Bighorn Sheep Crucial Winter Habitat (Cedar Range), Mule Deer Crucial Winter Range (Cedar Range), Quail Crucial Habitat in Meadow Valley
Carlin:	3 Sage Grouse Strutting Areas (Grass Valley, Rye Patch Canyon, and Monitor Valley), Sage Grouse Nesting Area (Monitor Valley), Pronghorn Winter Range, Ungulate Migration Corridor Between Simpson and Tacoma Ranges, Bates Mountain Antelope Release Area, Simpson Park Habitat Management Area

311 cont.

Caliente B

Chalk Mountain:	Bighorn Sheep Crucial Winter Habitat (Cedar Range), Mule Deer Crucial Winter Range (Cedar Range), Crucial Areas for Quail (Meadow Valley)
Jean:	Crucial Bighorn Sheep Winter Habitat (Wilson Pass) and Winter Habitat (west of Wilson Pass), Bighorn Sheep Migration Corridor and Potential Migration Corridor, Crucial Caulker Habitat (Good springs), Crucial Areas for Quail (Goodsprings, Pahrump, Johnnie), and Mule Deer Winter Habitat

Although the Valley Modified corridor does not contain crucial habitat, it does cross the Desert National Wildlife Refuge (DNWR) in several places, including the Corn Creek Springs area. The DNWR was set aside primarily for desert bighorn sheep. It also provides habitat for mule deer, other desert mammals, and migratory birds. The Corn Creek area contains an environment filled with trees, pasture, and spring-fed ponds which attract a large number of migrating birds not common to the desert environment. The ponds are home to the endangered Pahrump poolfish.

Each of the corridors contain many additional biological resources within the corridor or within 5 kilometers of the corridor. Although these resources are identified in the Environmental Baseline File, the DOE makes no attempt to quantify the impacts of the rail line on most of these resources.

The Draft EIS does not contain an assessment of the impact of fencing on wildlife. This is inexcusable, since the impact of fencing was identified by the Bureau of Land Management as a major issue (TRW 1999k, p 5B1).

Potential transportation impacts to biological resources and soils are only curtly addressed in this section. There is insufficient information and substance for the section to be meaningful.

This section should also include a rigorous analysis of potential impacts from the spread of noxious or invasive plant species as a result of rail spur construction, heavy-haul highway improvement, and other activities that facilitate or promote the proliferation of noxious weeds.

See also comments on Section 6.3.2.1 (Biological Resources and Soils - page 6-46).

312 Page 6-11; Section 6.1.2.4 - Biological Resources and Soils

The Draft EIS states that "the potential impacts from upgrading Nevada highways for heavy-haul truck use would be small because modifications to roads would occur in previously disturbed rights-of-way."

The amount of upgrade required varies significantly between the various heavy-haul route options. Portions of the Caliente-Chalk Mountain route will require significant upgrades, resulting in much more impact than some of the other route segments. Realigning roads to avoid significant grades and to improve curvatures will impact areas outside of current rights-of-way. The impact of the heavy-haul alternative on critical habitat for wildlife will be similar to that discussed above for the rail line alternative.

313 Page 6-11; Section 6.1.2.5 - Cultural Resources

Historic properties should be identified before effects are determined.

314 Page 6-14; Section 6.1.2.9 - Aesthetics

This transportation impacts overview section admits that the Caliente intermodal transfer station site "could cause impacts on the Class II lands of Kershaw-Ryan State Park" in terms of aesthetics. However, it goes on to imply that, because the character of the Meadow Valley Wash has already been modified by the existence of a rail line, the City of Caliente's water treatment facility and agricultural uses, the impact would be slight, if not negligible. No other potential impacts were even acknowledged in the overview. We find this cursory analysis inadequate.

315 No mention is made of the fact that the Apex/Dry Lake intermodal transfer station sites are in close proximity to the Valley of Fire State Park exit off I-15. Furthermore, no attempt is made to analyze any impacts that may occur as a result of this proximity.

316 Page 6-17 to 6-20; Section 6.2 - National Transportation

The Draft EIS itself is substantively and legally deficient in its treatment (or lack of treatment) of key transportation issues that have both national and regional significance. The Draft EIS fails to evaluate the most likely, and potentially heaviest impact, modal mix (i.e., rail/truck/barge) scenario for civilian SNF shipments. The Draft EIS instead uses a bounding scenario approach, comparing a hypothetical mostly truck scenario with a hypothetical mostly rail scenario. The Draft EIS approach might be appropriate for a generic national transportation impact assessment, but it is not sufficient for a site-specific transportation impact analysis under NEPA.

317 The Draft EIS mostly rail scenario significantly misrepresents the extent to which legal-weight truck (LWT) shipments to the repository can be reduced by unrealistically assuming major infrastructure investments at reactor sites and unprecedented use of heavy-haul truck (HHT) and barge transport. Moreover, the Draft EIS implies that all modal-mix scenarios are equally probable.

318 Nevada believes that the Final EIS must evaluate a third transportation scenario based on the current transportation capabilities of reactor and storage sites. Planning Information Corporation (PIC) developed a current capabilities transportation scenario for the State of Nevada in September, 1996 (see Attachment V). Under this scenario, PIC assumed that neither utilities nor DOE transportation contractors would make major investments to upgrade cask loading capabilities or near-site infrastructure at reactor facilities that are currently unable to load rail casks or that currently lack direct rail access. Further, PIC assumed reactor sites without direct rail access would not utilize HHT or barge shipment options. Using these criteria, PIC identified 32 reactor sites that would likely ship by legal-weight truck and 40 sites that would likely ship by rail. PIC assumed major DOE HLW storage sites (Hanford, Idaho, Savannah River, and West Valley) would ship by rail.

Nevada staff and contractors have updated the PIC current capabilities scenario using data consistent with the Draft EIS projections for reactor-specific SNF inventories, cask capacities, and shipment distances to Yucca Mountain. Attachment W, Tables 1 to 6, provide a reactor-by-reactor overview of the updated current capabilities scenario for the Proposed Action and for DOE modules 1 and 2. PIC's 32 truck-only reactors account for 40% of the projected SNF inventory and would make 26,375 shipments over 39 years. The 40 rail-capable reactors account for 60% of the projected SNF inventory and would make 8,232 shipments over 39 years. DOE sites are assumed to make 5,939 shipments (including SPAR and GTCC) over 39 years, as stated in Table J-1 (p. J-10).

When combined with DOE's base case truck and rail routes (TRW1999u, Data, Ch.4, files bt.map.prn and ca.rail.prn), the updated current capabilities scenario provides a realistic basis for evaluating national transportation impacts. The same cannot be said for DOE's mostly truck and mostly rail scenarios. In particular, DOE's purported bounding scenario approach significantly underestimates the likely number of combined truck and rail shipments, the number and milage of truck and rail routes, and the number of states affected by both rail and truck shipments. The number of states affected by both rail and truck shipments is particularly important for route-specific impact assessment, emergency response planning and training, and identification of affected Indian Tribes and local governments. Under DOE's mostly truck scenario, only 3 states are impacted by both rail and truck shipments; under DOE's mostly rail scenario, the number of states impacted by both modes is 22; under the updated current capabilities scenario, the number of states

318 cont. impacted by both rail and truck shipments is 32. On this important measure, DOE's scenarios clearly fail to bound the full range of impacts of possible modal-mix options.

319 Page 6-19; Figure 6-8 - Map of U.S. Interstate Highway System

Figure 6-8 should be replaced with the map of national truck routes distributed by DOE at the Draft EIS Public Hearing in Chicago on February 1, 2000. (See Attachment X)

320 Page 6-21; Figure 6-9 - Map of U.S. Rail System

Figure 6-9 should be replaced with the map of national rail routes distributed by DOE at the Draft EIS Public Hearing in Chicago on February 1, 2000. (See Attachment Y)

321 Page 6-27 to Page 6-30; Section 6.2.4.2 - Transportation Accident Scenarios

The Draft EIS relies heavily upon the Modal Study (Fischer et al., Shipping Container Response to Severe Highway and Railway Accident Conditions, 1987) categories and data for analysis of severe accidents. The Draft EIS uncritically adopts and incorporates the following deficiencies in the Modal Study estimates of accident severities and probabilities of severe accidents.

Use of "mid-lead" temperature as parameter determining accident severity.
Lead (Melting Point 621°F) will stabilize the inner core temperature in the event of a fire until it is completely melted. This has the effect of insulating the inner core from temperature increases for an extended period of time. Uranium and/or steel, with a much higher melting point, will not melt, resulting in an inner core temperature that will rise constantly with heat input. Therefore, inner cores of newer casks are expected to have higher temperatures during a fire of a given intensity.

The use of mid-lead temperature results in grouping of all fires with temperature greater than 1050°F into one consequence category, since lead-nickel alloying occurs here, weakening the integrity of the older casks. Since uranium and/or stainless steel will behave differently under temperature duress, new classifications based on these properties must be used for categorizing fire intensities.

Use of "reference cask" containing a water jacket neutron shield.
The Modal Study models the dead air space resulting from the evaporation of the water jacket neutron shield to reduce heat transfer from a fire to the cask by over 70%. Modern casks use polypropylene, not water jackets; hence, the estimated heat transfer rate in fire events is a significant underestimate of the behavior of modern casks. (Audin states this may result in a reduction in the time it takes to melt the lead cask from 1.09 hours to 20

321 . . . minutes). For the uranium and/or stainless steel shield, this means quicker increases in temperature than those postulated by the Modal Study, resulting in a reduction in the fire severity needed to cause a given accident condition.

"Lead cask bias" used to select most appropriate measurement parameter.
The decision to use strain on the inner cask wall as the primary measure of cask response is based on lead's tendency to "slump" when subjected to high loading, resulting in high strains on the inner cask wall. However, uranium and/or stainless steel are strong and rigid and thus will not slump. Rather, the force from impacts will be transferred to the joints and welds of the cask, likely resulting in a greater force being applied to them than those in a lead cask. The choice of strain as the sole measurement parameter for physical duress will likely lead to an underestimation of the damage caused to newer casks through rupture of welds and seals in the event of an accident. Therefore, new experiments must be performed to model this behavior.

Incorrect use of "distribution" and "frequency" of velocities.
The Draft EIS states that, even though the average speed limit on national interstates has increased since the Modal Study, the distribution of accidents, and the frequency distribution of accidents, on the highways is not likely to change. However, there is no evidence cited to support this statement. The National Highway Safety Traffic Administration (NHTSA 1998), along with numerous other agencies, have provided evidence that increases in speed limit lead to more accidents, more fatalities, and a greater proportion of vehicles traveling at higher speeds. All of these suggest that DOE is incorrect in claiming that increased speed limits will not affect accident severity distributions.

In one study assessing the change in Interstate fatalities in states that raised the speed limit in 1995, the NHSTA discovered that "Interstate fatalities experienced a statistically significant increase in those states that raised their posted speed limits late in 1995 or early in 1996." (NHTSA 1998) Further, the Insurance Institute for Highway Safety reported that distributions of travel velocities do indeed change with increased speed limits, stating that "in general, higher speed limits lead to greater proportions of cars traveling at very high speeds." For example, the Institute cited traffic statistics in New Mexico, finding that "the proportion of motorists exceeding 70mph grew from 5 percent shortly after speed limits were raised (from 55 to 65 mph) to 36 percent."

This shows that the Draft EIS statement that traffic velocity distributions will not be affected is incorrect, which leads to the conclusion that the probabilities of severe accidents used by the Draft EIS are also incorrect and likely to be underestimates. This provides another reason why the Modal Study is not useful or relevant to current transportation conditions.

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Improper assumptions regarding the location of severe accidents.
The Modal Study correlated severe accidents with high velocities, concluding that the most severe accidents will take place, both for rail and truck, in rural environments. However, most severe rail accidents take place at downgrades, which are as likely to be located in suburban areas as rural ones. Further, the probability of a severe truck fire is greater in urban and suburban environments than in rural ones (Resnikoff, 1993).

In determining severe accident scenarios, the Draft EIS assumed that severe accidents had an equal probability of occurring anywhere, with the probability in each population zone being determined by the length of time each truck or train passes through it. Since trucks and trains spend less time in urban zones, some of the most severe accident scenarios are considered "not reasonably foreseeable" in urban areas. Accident data does not support the assumption that severe accidents are randomly distributed (Resnikoff, 1993). Therefore, the Draft EIS needs to assess the consequences of these most severe accidents in urban zones.

Improper exclusion of most severe accident scenarios.
The Modal Study used as its "average highway conditions" a stretch of Interstate 5 in Los Angeles and Orange counties. For example, it tallied the number, height, and geographic conditions of the bridges on this stretch and used these to estimate the number of bridges of a certain height. This was then used to estimate how many tall bridges existed in the entire nation for spent fuel trucks to cross. Using this, it was determined that an accident involving a truck falling off a high bridge was not "reasonably foreseeable" and its consequences were not determined. Since this stretch of highway is dominated by urban areas, the distribution of bridge types is biased in favor of small, short bridges, like the ones that cross over other roads. This is not representative of national conditions and leads to the unnecessary exclusion of a potentially disastrous consequence.

The Modal Study assumes that the probability of train accidents involving falling off of a bridge is the same as that for the highway scenario, with the geographic conditions also taken from the highway estimations. More clearly, the Study used data taken from Interstate 5 to estimate the geographic conditions of national train routes, including bridge heights. Thus, the same argument given for the highway scenario holds here, but more so since there is no proof that highway and rail conditions are similar.

The method of rejecting accidents having a yearly probability less than one in 10 million is arbitrary and incorrect when performing a probabilistic risk assessment. The product of the probability and the likely consequences are what determine significance in a risk assessment.

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DOE consistently offers estimations of health effects due to transportation without giving a range of likely effects in the event of an accident. This is based on the assumption that the effects given are "conservative." However, the points raised here show that the studies are not conservative. Unless new studies are performed, a range of possible health effects should be given.

If DOE insists on using the "reasonably foreseeable" criteria of 1 in 10 million mentioned above, improper accident distribution data, unknown cask response to accident conditions, and improper estimation of accident probabilities (all mentioned above) will make some circumstances deemed not "reasonably foreseeable" in the Modal Study "reasonably foreseeable." These events must be considered in any acceptable consequence analysis.

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Page 6-29; Box - The Modal Study

The entire discussion of the Modal Study must be revised to address the both the technical and procedural implications of the Modal reassessment currently being conducted by the U.S. Nuclear Regulatory Commission (NRC). In November 1999, the NRC began taking public comments on a proposed study assessing the risks of spent nuclear fuel transportation. The proposed study, to be conducted by Sandia National Laboratories, is intended to update the Modal Study with specific reference to the increased number of shipments, changes in shipping cask designs, and changing the transportation environment in which repository shipments would take place. One particular problem with the Draft EIS reliance upon the original Modal Study is the timing of the NRC reassessment. The NRC will not complete its Modal Study update until well after DOE is scheduled to publish the Final EIS for Yucca Mountain. DOE representative Dwight Shelor acknowledged this potential problem at the initial NRC meeting in Bethesda, Maryland, on November 16, 1999.

The Draft EIS acknowledges the State of Nevada's criticisms of the Modal Study, but the criticizes Nevada for not suggesting "the use of alternative analyses or models" and for not offering "differing values for use in estimating consequences or risks of severe accidents." The Draft EIS further criticizes Nevada for not identifying "examples of actual accident conditions and damage to structures that could support different values for release fractions or release probabilities." (p. 6-29) In response, Nevada makes the same recommendations to DOE that Nevada has made to the NRC regarding assumptions and methods of analysis to be used in the Modal Study update. Those recommendations are contained in Attachment Z and are intended to be treated as comments on this section of the Draft EIS.

323 Page 6-30; Box - Transportation Accidents

The Draft EIS incorrectly assumes that simply requiring contractors to comply with ANSI N14.27-1986-1993) will guarantee timely availability of the trained personnel and special equipment necessary for recovery and reshipment of casks damaged in severe accidents. In particular, DOE must demonstrate the economic and technical feasibility of recovering and re-shipping large (125 tons or greater loaded weight) rail casks such as those proposed for transport of civilian and naval reactor SNF. The analysis must consider the possibility of significant loss of shielding and/or containment as a result of a severe accident or terrorist attack. The analysis must further consider the possibility of such incidents occurring in difficult terrain comparable to that found along potential rail routes identified in the Draft EIS, such as the Union Pacific railroad between Uvada and Elgin, and along potential HHT routes identified in the EIS, such as SR375 through Hancock Summit.

324 Page 6-31 to 6-32; Section 6.2.4.2.1 - Impacts from Accidents - National Mostly Legal-Weight Truck Scenario

Impact Issues Specific to Use of GA 4/9 Casks

The Draft EIS mostly legal-weight truck national transportation scenario fails to consider unique circumstances of the transportation system being evaluated. Specifically, the Draft EIS assumes that all shipments will be made in the new General Atomics GA4/9 truck casks, but fails to explicitly address aspects of the design and performance of those casks which may increase the probability and consequences of highway accidents.

Nevada's 1995 scoping comments requested that DOE consider the following issues. In order to achieve a four-fold increase in cask capacity, the GA4/9 casks utilize a number of new design features and materials. Further, the weight of the loaded GA4/9 cask requires that it be used in conjunction with a specially designed trailer, a lower weight cab-over-engine tractor, and a single fuel tank, in order to comply with legal weight limits. To date, there is no operating experience with spent fuel shipments in actual GA 4/9 casks, although DOE contractors have conducted operational tests using mock-ups. To our knowledge, no GA 4/9 casks have yet been manufactured under the recently issued NRC certificate. The validity of the Draft EIS LWT transportation risk assessment therefore rests entirely upon speculative assumptions about the performance of casks which have never been used.

Nevada believes the Draft EIS must demonstrate that the GA4/9 cask, trailer, and tractor system is appropriately designed for use in a decades-long, nationwide shipping campaign to Yucca Mountain. DOE's risk assessment must evaluate issues such as: the

324 cont. power and handling characteristics of the tractor relative to long hauls in mountainous terrain under winter driving conditions; noise and vibration levels within the cab, and the potential impacts on driver fatigue and increased probability of human error; and the constrained fuel capacity of the tractor, requiring refueling every 300 to 400 miles, which could may additional safety and safeguards risks. The performance of GA4/9 cask's depleted uranium gamma shield in high-speed collisions with relatively unyielding structures, and the vulnerability to terrorist attack with armor piercing weapons and commercial shaped charges, must specifically be evaluated.

325 Impacts of Maximum Reasonably Foreseeable Accident

The Draft EIS underestimates the consequences of a maximum reasonably foreseeable accident. The consequence assessment reported in Table 6-11 considered a cask loaded with 26 year-old PWR SNF. The Draft EIS should have evaluated a range of accident scenarios, including a cask loaded with 10 year-old PWR SNF and a range of other critical assumptions, including release height, atmospheric dispersion models, and downwind population densities. Nevada believes that RADTRAN and RISKIND analyses of the same accident involving 10 year-old fuel and other credible alternative assumptions would result in latent cancer fatalities higher by a factor of 2 to a factor of 40 or more, that is, 10 to 200 latent cancer fatalities.

Further, the NRC recently authorized utilities to plan for truck shipments of 5 year-cooled, high enrichment (5 percent),high-burnup (62,000 MWR/MTHM) fuel to Yucca Mountain (Addendum 1 to NUREG-1437), and the discussion at page 6-12 indicates that DOE is not only aware of, but concurs in, the NRC assessment. Therefore, a legally sufficient evaluation of the maximum reasonably foreseeable accident should include a RADTRAN and RISKIND analysis of the same accident involving a GA 4 cask loaded with SNF having the same maximum radiological characteristics approved by the NRC. The human health effects of the same accident could be hundreds of times greater than those reported in Table 6-11

396 Finally, the Draft EIS fails to provide any estimate of the economic impacts of the maximum reasonably foreseeable accident reported in Table 6-11. A release of radioactive materials sufficient to cause a 9,400 person-rem population dose would clearly involve significant damage to the physical environment. Under NEPA, the Draft EIS must estimate the economic cost of remediation. Cleanup activities alone could cost hundreds of millions, or even billions, of dollars.

326 Page 6-32 to 6-33; Section 6.2.4.2 .2– Impacts from Accidents – National Mostly Rail Scenario

The Draft EIS underestimates the radiological consequences of a maximum reasonably foreseeable rail accident by a least a factor 15, and by up to a factor of 40 or more. The number of latent cancer fatalities could be 1,380 or more.

Under contract with the State of Nevada, Radioactive Waste Management Associates (RWMA) prepared a bounding scenario analysis of the a accident reported in Table 6-12, using the RADTRAN and RISKIND models and a range of credible alternative assumptions about SNF age and radiological characteristics, atmospheric dispersion, and population densities. Nevada is submitting the RWMA analysis as Attachment AA.

397 The Draft EIS fails to provide any estimate of the economic impacts of the maximum reasonably foreseeable rail accident reported in Table 6-12. Under contract with the State of Nevada, Radioactive Waste Management Associates (RWMA) prepared an estimate of the economic impacts of the accident reported in Table 6-12, using the RADTRAN and RISKIND models and a range of credible alternative assumptions about cleanup levels, SNF age and radiological characteristics, atmospheric dispersion, and population densities. RWMA concluded that the economic impacts of cleanup and other post-accident costs could range between $3.2 billion and $9.4 billion. Nevada is submitting the RWMA analysis as Attachment BB.

327 ... Page 6-33 to Page 6-34; Section 6.2.4.2.3 - Impacts of Acts of Sabotage

The Draft EIS underestimates the impacts of a successful terrorist attack on a truck cask by at least a factor of 10. The population dose from the postulated attack could be at least 310,000 person-rem, resulting in at least 150 fatal cancers.

The release and resulting consequences could be ten times greater than reported in the Draft EIS, according to the new Sandia study, if the weapon fully perforated the cask.[Luna, Neuhauser, and Vigil, 1999, p.20] Based on the Army Ballistics Research Laboratory 1982 peer review of the original Sandia report [Sandoval, 1982], full perforation of a truck cask by the reference weapon (the M3A1 military demolition device) should have been assumed in the 1999 analysis. At a minimum, the Draft EIS should have used a bounding scenario approach, resulting in a range of estimated impacts between 31,000 and 310,000 person-rem population dose and 15 to 150 latent cancer fatalities.

The Draft EIS failed to conduct a systems analysis of the potential impacts of sabotage and terrorism during all phases of transportation, including planning, storage prior to transport, cask loading, transportation, intermodal transfer, lag storage at the receiving

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facility, and cask unloading. Nevada is particularly concerned that DOE ignored the potential for attacks at intermodal transfer stations and on large rail casks during transport on slow-moving heavy haul trucks.

The Draft EIS also failed to evaluate the full range of potential sabotage and terrorism events, including terrorist attacks on transportation infrastructure used during nuclear waste shipments, attacks involving capture of a shipment and use of high-energy explosive devices against a cask, and direct attacks upon shipping casks using antitank missiles.

The Sandia analysis underestimates sabotage consequences for the following reasons:

1. Sandia used the military definition of man-portability rather than the Commission's definition of the design basis threat in selecting the reference weapons used in the analysis. As a result, Sandia failed to consider weapons such as the TOW and Milan missiles which are capable of completely perforating rail as well as truck casks.

2. Sandia failed to consider credible attack scenarios involving use of more than one penetrating weapon, use of an incendiary device in conjunction with a penetrating weapon, and use of commercial shaped charges which are more efficient metal penetrators than the M3A1 military demolition device.

3. Sandia's "swept volume" method of estimating the release from the cask is subject to alternative interpretations, especially when coupled with consideration of blast temperature effects. Sandia apparently did not consider the potential contribution of fuel oxidation to generation of respirable fines in any instance where the weapon completely perforated the cask.

Attachment CC provides additional critical commentary on the Sandia report and the Draft EIS assessment of sabotage impacts.

The analysis in the Draft EIS only considers impacts of "successful" sabotage attempts on a cask (truck or rail). This analysis does not address impacts that are caused by the need to prepare for and prevent sabotage and terrorist actions. Such impacts will accrue directly to the State of Nevada in terms of additional security and law enforcement costs and requirements.

The Draft EIS fails to address the fact that chances for a terrorist or sabotage incident (successful or otherwise) are increased when these shipments arrive in Nevada and travel a standard route to the repository. Even if "successful" attempts do not breach the

327 cont. integrity of the casks, impacts of any such incident to affected State agencies, highway users, and affected communities are not addressed in the Draft EIS. In other words, regardless of the adequacy or inadequacy of the assessment of impacts associated with a "successful" sabotage or terrorist attack, the Draft EIS should have examined impacts associated with the increased risk that a Yucca Mountain shipping campaign poses for the State of Nevada, its citizens, and communities.

Such impacts should include not only the costs associated with preparation and response, but also costs and impacts on the State's tourism/visitor dependent economy, should there be a terrorist or sabotage incident involving nuclear materials.

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Page 6-34; Section 6.2.5 - Environmental Justice

The Draft EIS refers only to Native Americans affected by national transportation in Idaho. Proper identification of the national highway and rail routes used in the Section 6 analysis would have revealed additional impacts on Native American populations in other states. Analyses prepared for the State of Nevada by Planning Information Corporation identified the following potentially affected Indian Reservations:

Arizona	Hualapai and Navajo (I-10, I-40; BNSF/UPRR);
California	Agua Calientes, Cabazon, Chemehuevi Valley, Ft. Mojave, Ft. Yuma, Morongo, Torres Martinez, and Hoopa Valley (I-10, I-40/I-15; BNSF/UPRR);
Florida	Hollywood (I-95, FECR);
Iowa	Mesquakie(Sac & Fox) (UPRR);
Kansas	Potawotamie (UPRR);
Minnesota	Prairie Island (CP/Soo);
Nebraska	Omaha and Winnebago (UPRR);
New Mexico	Acoma, Canoncito, Isleta, Laguna, Navajo, and Zuni (I-10, I-40; BNSF/UPRR);
New York	Cataraugas and Tonawanda (I-90, Conrail)
North Carolina	Cherokee (I-40)

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Oklahoma	Choctaw, E. Shawnee, Kialegee Creek, Kickapoo, Miami, Modoc, Osage, Ottawa, Peoria, Quapaw, Sac & Fox, and Thlopthlocco Creek (I-35, I-40; BNSF/UPRR);
Oregon	Umatilla (I-84; UPRR);
Utah	Goshute, Ouray, Skull Valley, and Unitah (I-84/I-15/I-80/US93A; UPRR)
Washington	Yakima (I-84; UPRR)
Wisconsin	Oneida (WCRR)

The Draft EIS does not attempt to define transportation-affected and potentially-affected Indian lands and resources. Nevada defines affected lands and resources to include the following: (1) reservations crossed by potential shipping routes; (2) off-reservation ceded lands, where Tribes retain treaty rights or other legally recognized user rights crossed by potential shipping routes; (3) reservation lands and off-reservation lands within transportation emergency evacuation zones along potential shipping routes; (4) reservation and off-reservation lands which could be contaminated by air or water transport of radioactive materials released in a severe transportation accident or terrorist incident (generally within 50 miles down-wind, down-stream, or down-gradient of a potential shipping route); (5) reservations whose highway access would be disrupted by a nuclear waste transportation emergency; and (6) off-reservation lands along potential shipping routes where Tribal personnel would likely be involved in transportation emergency response.

The Draft EIS gives insufficient consideration to the major concerns identified by potentially affected Indian Tribes and by the National Congress of American Indians. These concerns include: (1) Tribal authority to regulate shipments across reservations; (2) emergency response planning and training for Tribal personnel; (3) advance notification of shipments and shipment monitoring; (4) protection of Native American religious and cultural sites, plants, and animals, both on and off reservations; (5) cultural implications of potential radiological contamination of Indian lands and the cultural implications of cleanup activities involving non-tribal personnel; and (6) adverse economic impacts of public perception of risk, especially adverse impacts on tribal tourism and recreation businesses. Moreover, except for tribes in Idaho, DOE failed to identify potential Indian reservations and communities in the Draft EIS and in the public hearing notices, and failed to provide financial assistance to facilitate independent technical review of the Draft EIS by potentially affected Indian Tribes.

329 Page 6-35; Section 6.3 - Nevada Transportation

Implementing Alternatives for Nevada Legal-Weight Truck Transportation Scenarios: The failure of the Draft EIS to evaluate implementing alternatives for LWT transportation in Nevada is a major deficiency. Nevada's 1995 scoping comments stated: "The DOE must address the potential implications of state route designation decisions in the Draft EIS." Nevada specifically urged DOE to evaluate the impacts of use of the potential alternatives identified as NDOT Routes A, B, and E. The Draft EIS identifies the six potential state-designated alternatives in Appendix J, Section J.3.1.3 and Table J-47. The Draft EIS should have fully evaluated the impacts of using these alternative highway routes in Section 6.3.1.

330 Land Use and Ownership: The Draft EIS makes note of land use and ownership impacts to landowners due to the creation and use of a branch rail line or heavy-haul facility. It does not account for impacts to the Nevada Department of Transportation (NDOT) as a landowner. Negative impacts include corridor degradation, loss of pavement structure, and operational disruptions (queues, etc.). DOE has also failed to assess what will happen to facilities, shipments, and operations when the time comes to rebuild or resurface the roadways sustaining this shipping campaign. These roadways will have to be refurbished, since axle loads of the kind proposed for spent fuel and HLW shipments were never anticipated and would accumulate and reduce the service life of affected roadways. The Draft EIS does not consider the fact that during a 24 year shipping campaign, roadways will deteriorate and must be rebuilt. In section 6.3.3.1, the Draft EIS states that resurfacing would occur every eight years. What 'ESAL' calculations are driving this number? What happens to shipments when highway construction closes down roadways for months at a time? In addition, it would appear that field inspections of 'choke points' and areas of operational concern have not been effectively carried out. Areas such as Hancock Summit, for example, may not be able to legally allow a heavy-haul vehicle configuration to pass through the summit and roadway cut. The turning radius may be too small to allow the vehicle to traverse the roadway.

331 Page 6-37; Section 6.3 - Nevada Transportation

The assessment of socioeconomic impacts associated with Nevada transportation fails to address impacts on State and local governments. Specifically, any response to an incident, accident, or even a simple vehicle breakdown will impact a large group of responders. The Draft EIS does not discuss facilities, equipment, and mitigation, etc. that will be required. It refers only to the transporter's responsibilities regarding these issues, not the impact on public safety (response) agencies. Some of the issues are:

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- Availability of equipment to deal with the large (size and weight) transportation casks in the event of vehicle breakdowns, load shifting, accidents, etc.; and

- Response costs for breakdowns and incidents/accidents. Timely responses would require staged equipment, trained and equipped personnel, and the associated infrastructure to support them.

Page 6-38; Section 6.3.1.1 - Impacts to Biological Resources

See comment for Page 6-10.

Page 6-39; Section 6.3.1.2 - Impacts to Occupational and Public Health

See comments on Section 4.1.7.

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Page 6-39 to 6-40; Section 6.3.1.2.1 - Impacts from Incident-Free Transportation

The Draft EIS fails to consider unique local conditions along potential highway routes in Nevada which could result in significantly higher collective doses and significantly higher doses to maximally exposed individuals. The Draft EIS analyses using the RADTRAN and RISKIND models do not reflect unique local conditions.

Individuals in Nevada who reside, work, or are institutionally confined at certain locations within 6 to 40 meters (20 to 130 feet) of a nuclear waste highway route, or within 6 to 50 meters (20 to 160 feet) of a nuclear waste rail route, could potentially receive yearly radiation doses equal to a significant percentage of, or even in excess of, average annual background doses (360 mrem/year). Such exposures could occur under circumstances where: (1) residences, workplaces, or certain institutions (especially schools, prisons, or long-term health care or retirement facilities) are located near route features or segments which would require nuclear waste trucks or trains to stop and start again, or travel at very slow speed; (2) the number of shipments is high enough (one to several casks per day) that opportunities for exposures occur frequently at the same locations, and (3) the individuals residing, working, or confined at near-route locations are regularly present to be exposed to a significant portion (if not all) of the shipments which occur annually.

All three circumstances exist along some of the truck routes identified in the Draft EIS. Route segments of special concern include US 95 from Las Vegas to Lathrop Wells; the so-called NDOT B Route, US 93A, US 93, US 6, and US 95 from West Wendover to Lathrop Wells (especially where vehicle stops and/ or left turns are required in West

332 cont.

Wendover, McGill, Ely, Tonopah, Goldfield, and Beatty); and SR160 from I-15 to US95 (especially where vehicle stops are required in Arden and Pahrump).

For example, there are locations along the NDOT B Route in West Wendover, Ely, Tonopah, Beatty and Goldfield where exposure times at a distance of 6 – 10 meters could average 2 minutes per LWT shipment. Under the proposed action, mostly truck scenario, the maximally exposed individual at these locations in Nevada could potentially receive annual doses ranging from 150 mrem to 260 mrem, equivalent to 42% to 62% of the average annual background radiation dose.

The Draft EIS fails to fully evaluate the impacts of routine exposures to individuals stuck in traffic jams (also referred to as gridlock incidents). The Draft EIS assumption that this would be a one time occurrence for the affected individual is an undocumented speculation. Given the regularity of commuting patterns, the opposite assumption may be more likely. Gridlock is likely to occur on a regular basis on I-15, I-215, and US95 in Las Vegas. Gridlock involving a large number of vehicles could also occur frequently in a rural area, for example, as a result of highway construction.

The Draft EIS fails to address the types of questions frequently asked by members of the public. How many people could be exposed to 40 mrem in a worst case gridlock incident (e.g., cask jammed up against school bus, city bus, tour bus, etc.)? Would the same 40 mrem exposure over 4 hours pose greater health risks to pregnant woman and unborn children, young children, or persons already exposed to higher than average levels of radiation? Should a health effects analysis address possible psychological consequences, or trauma-related illnesses, which might result from a gridlock incident?

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Page 6-41; Box – Maximum Reasonably Foreseeable Accident Scenarios in Nevada

The Draft EIS assumes that the maximum reasonably foreseeable accident scenarios for Nevada are the same as for national transportation. This assumption is absolutely incorrect, and by itself constitutes a strong argument that the Draft EIS is legally insufficient. DOE has completely ignored Nevada's scoping comments regarding unique local conditions in Nevada which require DOE to evaluate certain low-probability, high-consequence accident scenarios which are more likely to occur in Nevada than elsewhere. Nevada's 1995 scoping comments specifically recommended that DOE evaluate a truck cask collision involving another truck loaded with commercial or military explosives, a truck or rail cask involved in a massive infrastructure failure or natural disaster, and a rail or truck cask involved in an accident with a military aircraft. Our comments emphasized that "Nevada is particularly concerned accidents involving trucks and aircraft carrying military explosives."

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The Draft EIS must specifically evaluate Nevada truck accidents involving commercial and military explosives because of the high concentration of mining, munitions storage, and military training activities in Nevada. The Draft EIS must specifically consider the frequency of munitions shipments to and from the Hawthorne military depot and historical experience with truck accidents on US95 involving explosion of military cargoes.

The Draft EIS must specifically evaluate massive infrastructure failure, such as a bridge or overpass collapse, because of the presence of such structures along Nevada highway routes, especially along I-15, I-215, and US95 in the Las Vegas Valley. The Draft EIS must specifically evaluate truck or rail cask performance in infrastructure failures coupled with a natural disaster, such as a severe earthquake or massive flooding, because the risk of such disasters is considerably higher in Nevada than the national average for such occurrences.

The Draft EIS must specifically evaluate nuclear waste transportation accidents involving military aircraft carrying live munitions because of routine activities at Nellis Air Force Base and other military aviation facilities in Central and Southern Nevada. All of the rail and highway routes to Yucca Mountain identified in the Draft EIS cross flight paths routinely used for military training and testing. The Draft EIS discussion of aircraft accidents in Appendix J completely ignores the potential for cask damage by military explosives. Nevada reminds DOE that the 1986 EA for Yucca Mountain acknowledged that these military activities constitute a unique local condition which might subject shipments to forces beyond those bounded by the NRC cask performance standards.

Finally, there are many locations along Nevada rail and highway routes identified in the Draft EIS where the nonresident population regularly exceeds the resident population, especially in Clark County. Analysis of maximum reasonably foreseeable rail and truck accident impacts in Clark County and other similar locations must include nonresident population density.

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Page 6-43; Section 6.3.2.1 - Impacts Common to Nevada Branch Rail Line Implementing Alternatives

The Draft EIS underestimates the difficulty of constructing a new rail line to Yucca Mountain. The Carlin, Caliente, or Caliente-Chalk Mountain routes would constitute the longest new rail construction project in United States since the World War I era. Construction of the Jean or Valley modified routes would be the second longest U.S. new rail construction project in the past 70 years. The Draft EIS assertion that rail line construction along any of the routes would take an estimated 2.5 years is unjustifiably optimistic considering the difficult terrain, environmental sensitivity, and high probability

334 cont. that previously unidentified Native American cultural resources will be discovered only after construction activities begin. The construction period could be 5 to 7 years.

The Draft EIS further underestimates the difficulty of rail access preconstruction activities, especially environmental reviews and approvals, acquisition of rights of way across both public and private lands, and unresolved Native American rights issues regarding ceded treaty lands. Legal challenges could easily delay construction for 5 to 10 years.

393 The maximum cost estimate of $800 million for Nevada rail transportation, based on an estimate for the Caliente route, is completely unrealistic unless DOE plans to sacrifice safety by constructing a rail line that barely meets the minimum Federal Railroad Administration requirements. Nevada is particularly concerned that DOE contractor studies have recommended operating the line without a state of the art computerized train control system. DOE's cost saving measures include shipping loaded rail casks in general freight trains, which will require switching cars at the connection point. DOE's proposal to routinely park loaded rail cask cars on a side track for up to 48 hours is unprecedented and will result in a separate legal challenge.

394... The Draft EIS provides insufficient information about rail access spur system specifications, construction, and operations to allow the complete assessment of impacts and risks required under the National Environment Policy Act. The Draft EIS provides insufficient information on cut and fill requirements; ballast, rail weight, and tie materials; platform, ditch, and bench dimensions; grade crossing separations (DOE contractors have recommended rail over road), crossing signals and road crossings; administration and maintenance facilities, including remote water supplies and sanitation; seismic and flood hazard standards; and train control signal systems.

The Draft EIS provides incomplete and contradictory information on rail operating assumptions, particularly regarding maximum operating speeds, crew change and way station requirements, and potential shared use of the rail line. The Draft EIS does not contain a meaningful discussion of DOE's assumptions about average and maximum operating speeds on the branch rail line to Yucca Mountain. The Draft EIS summary gives the erroneous impression that even the longest routes can be traversed in one day or less, eliminating the need for crew changes and way stations. (p. S-55) In response to a question at the Crescent Valley public hearing, DOE staff informed the State of Nevada's Transportation Advisor that the travel times reported in the Draft EIS Summary were calculated on the assumption that trains would travel at speeds up to 50 miles per hour or more. Additionally, the Draft EIS fails to address the safety and environmental implications of potential shared use of the rail line for shipments of commercial explosives, military weapons and munitions, petroleum products, and other hazardous

394 cont. materials. These Draft EIS deficiencies, combined with DOE's failure to designate a preferred rail route, result in a legally insufficient assessment of rail transportation risks and impacts.

335 ... Land Use and Ownership: The Draft EIS fails to adequately evaluate potential land use impacts for the various rail spur alternatives. Table 1 below shows the land use conflicts that should have been fully studied:

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TABLE 1 Comparison of Rail Spur Corridors Land Use and Biological Resources Impacts				
Caliente	Carlin	Caliente–Chalk Mtn.	Jean	Valley Modified
Land Use Impacts				
Requires use of land on Nellis AF Range. Alternatives cross difficult terrain.	Requires use of land on Nellis AF Range. Alternatives cross difficult terrain.	Traverses Nellis AF Range, which is unacceptable to AF.	Impacts Pahrump potential community growth	Impacts community growth in the north Las Vegas urban area.
	Bates Mountain Antelope Release Area		Old Spanish Trail/ Mormon Road special recreation management area	Crosses Nellis ABC and Quail Spring WSA.
	Simpson Park Habitat Management Area		Adjacent to Statelier Wilderness Area	Impacts Nellis AFB small arms range.
				Impacts Indian Springs Auxiliary Field facilities.
				Encroaches on the Desert National Wildlife Range.
Biological Resources Impacts				
Biological Resources Within Corridor: 32 Within 5 KM: 77	Biological Resources Within Corridor: 39 Within 5 KM: 171	Biological Resources Within Corridor: 23 Within 5 KM: 79	Biological Resources Within Corridor: 16 Within 5 KM: 67	Biological Resources Within Corridor: 6 Within 5 KM: 29

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TABLE 1 Comparison of Rail Spur Corridors Land Use and Biological Resources Impacts				
Caliente	Carlin	Caliente–Chalk Mtn.	Jean	Valley Modified
Bighorn Sheep Crucial Winter Habitat (Cedar Range)	3 Sage Grouse Strutting Areas (Grass Valley, Rye Patch Canyon, and Monitor Valley)	Bighorn Sheep Crucial Winter Habitat (Cedar Range)	Crucial Bighorn Sheep Winter Habitat (Wilson Pass) and Winter Habitat (west of Wilson Pass)	Desert National Wildlife Range
Quail Crucial Habitat in Meadow Valley	Pronghorn Winter Range	Crucial Areas for Quail (Meadow Valley)	Crucial Caulker Habitat (Good springs)	
Habitat Areas for Bighorn Sheep, Deer, Pronghorn, and Waterfowl	Ungulate Migration Corridor Between Simpson and Tacoma Ranges	Habitat for Mule Deer, Pronghorn, and Waterfowl	Crucial Areas for Quail (Goodsprings, Pahrump, Johnnie)	
8 Wild Horse and Burro Herd Management Areas	Habitat Areas for Bighorn Sheep, Elk, Pronghorn and Mule Deer	2 Wild Horse and Burro Herd Management Areas	Mule Deer Winter Habitat	
			3 Wild Horse and Burro Herd Management Areas	
			Mesquite Bosques Important to Migratory Birds	

336 Page 6-84; Section 6.3.3 - Impacts of Nevada Heavy-Haul Truck Transportation Implementing Alternatives

The Draft EIS fails to demonstrate the feasibility of heavy-haul truck (HHT) transportation from an intermodal transfer station in Nevada to the proposed repository. In the United States there is no experience with long-distance HHT transportation of SNF or HLW, and only limited experience moving smaller rail casks (70 tons loaded weight) short distances by truck. There is only limited experience in Europe with short HHT movements of large rail casks. There is no experience anywhere moving SNF hundreds of miles by HHT through mountainous terrain. According to the Nevada Department of Transportation (NDOT), Nevada has permitted only two comparable HHT movements of any cargo during the past three years, both large mining autoclaves.

Three of the proposed "Heavy-Haul" routes involve an intermodal transfer station near Caliente, opposite the mouth of Kershaw Canyon and the entrance to Kershaw-Ryan State Park. A fourth alternative "Heavy-Haul" route involves an intermodal transfer station near the exit off I-15 to Valley of Fire State Park.

An intermodal transfer station is designed to facilitate the transfer of nuclear waste and spent nuclear fuel from rail cars to heavy-haul transport trucks. Consisting of approximately 50 acres, the transfer station will include "rail tracks, two shipping cask transfer cranes (one on a gantry rail and a backup rubber-tired vehicle), an office building and a maintenance and security building. It would also have connecting tracks to an existing mainline railroad and storage and transfer trucks inside the station boundary. The maintenance building would provide space for routine service and minor repairs to the heavy-haul trailers and tractors. The station would have power, water, and other services. Diesel generators would provide a backup electric power source. The station would have the capacity to allow an intermodal transfer rate of 22 rail casks per week (11 loaded casks to the repository, 11 empty casks returned to the commercial and DOE sites)."

Section 6.3.3.2 fails to address aesthetic impacts. This section ignores potential impacts of other categories, especially noise, on Kershaw-Ryan State Park and fails to evaluate possible impacts to Valley of Fire State Park or its visitors as a result of the Apex/Dry Lake intermodal transfer station proposed location. Accordingly, Sections 6.3.3.2.1 through 6.3.3.2.3, as well as 6.3.3.2.5, are deficient.

337 Page 6-86; Section 6.3.3.1 - Impacts Common to Nevada Heavy-Haul Truck Implementing Alternative

The Draft EIS discussion of HHT operations is deficient. Preliminary analysis by NDOT suggests that the total length of an HHT convoy including escort vehicles will be about 350 feet, and escorts will also be required for return shipments. On any given day of operations, there could be two to four HHTs traveling both ways along any route. No evidence is offered to support the 20 to 30 miles per hour average speed assumption. If actual average speeds are 10 to 15 miles per hour, traffic impacts would be exacerbated and overnight parking areas could be required on all identified routes. Even at 20 to 30 miles per hour, the Draft EIS has severely underestimated the adverse impact on normal traffic flows along HHT routes, considering convoy length and frequency. No evidence is offered on HHT turning radius requirements, which may necessitate shutting down certain intersections and road segments to allow HHT passage. There is no discussion of HHT in-transit refueling requirements and no meaningful discussion of the safety, security, and perceived risk aspects of HHT overnight parking.

390 The Draft EIS generally fails to identify and evaluate credible HHT routing options. Nevada acknowledges that DOE has accurately classified the Caliente-Chalk River HHT route as a "non-preferred alternative" in response to national security issues raised by the Air Force. (p. 6-110) Since concurrence by the Secretary of the Air Force would be required, DOE should eliminate this route from further consideration. DOE's other HHT route options are unrealistic and unwise. The Draft EIS continues to consider HHT routes using I-15, the Las Vegas Beltway, and U.S. 95 through Las Vegas, in spite of repeated advice from Clark County and state agencies that these routes are not even acceptable for LWT shipments. In 1994, NDOT notified the California Highway Patrol that: "Because I-15 goes through the heart of Las Vegas, Nevada is interested in selecting a preferred route ... bypassing Las Vegas." Absent action by California to designate SR 127 or other routes avoiding I-15 into Las Vegas, NDOT stated its intention to "recommend to the State Transportation Board the designation of Nevada SR-160 as the preferred route and to un-designate I-15 between the Utah-Nevada Statelier and Las Vegas as a preferred route." DOE should eliminate HHT routes through Las Vegas from further consideration.

391... The HHT routes identified in the Draft EIS do not meet NRC safeguards criteria. A curious deficiency in the Draft EIS HHT routing analysis is DOE's apparent ignorance of the NRC safeguards route approval process and criteria. Advance route approvals are part of a safeguards system designed to "[m]inimize the possibilities for radiological sabotage of spent fuel shipments, especially within heavily populated areas..." [10CFR 73.37(a)(1)(i)] In 1980, NRC issued a regulatory guidance document (NUREG-0561,

391 cont.

Rev. 1) which identified five types of route characteristics that receive special consideration when Commission staff review requests for route approval: (1) routes through highly populated areas; (2) routes which would place the shipment or the escort vehicle in a significantly tactically disadvantageous position (for example, tunnels which would prevent the escort vehicle from maintaining continuous surveillance of the shipment vehicle); (3) routes with marginal safety design features (for example, two-lane routes, absence of guard rails, etc.); (4) routes with limited rest and refueling locations; and (5) routes where responses by local law enforcement agencies, when requested, would not be swift or timely. None of the HHT routes identified in the Draft EIS meet the safeguards routing criteria established by the NRC. NRC has accepted Nevada's petition for rulemaking, which requests a further strengthening of the advance route approval requirements.

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The conclusions regarding changes in level-of-service are not supported by any analysis. The extreme length of the heavy-haul vehicle and its slow speed will undoubtedly result in a significant impact to traffic flow on all the highways considered. This is particularly true in the Las Vegas metropolitan area. The EIS does not include any analysis of accident rates for this type of vehicle, or of accident rates for other vehicles caused by the traffic delays created by the heavy-haul vehicle.

Heavy-haul shipments would be dispatched from the intermodal transfer station during early-morning hours (p. 2-53). For the Apex/Dry Lake and the Jean/Sloan routes, this will result in heavy-haul vehicles traversing the Las Vegas urban area during morning rush hour. If the level-of-service for the Las Vegas Beltway during non-rush-hour traffic is Class C or lower, then it is reasonable to assume that the level-of-service during rush hour would be D or F. Putting the heavy-haul vehicle in traffic experiencing this level-of-service is unacceptable.

338 ...

Page 6-96; Section 6.3.3.1 - Impacts Common to Nevada Heavy-Haul Truck Implementing Alternative

Incident-Free Transportation

The Draft EIS does not adequately evaluate the radiological impacts of routine HHT transportation. The Draft EIS appears to significantly underestimate HHT routine radiation exposures to the general public, especially in Tonopah, Goldfield, Beatty, and other locations where residences and businesses are located within 25 to 200 feet of the U.S. 95 road shoulder. The RADTRAN model is not sufficiently sensitive to local conditions and probable HHT operating characteristics. DOE must recalculate the annual and cumulative collective dose and maximum individual dose, assuming a range of HHT

338 cont. speeds and stop-times. The analysis must consider the actual location of all occupied buildings within ¼ mile of the route. The analysis must accurately reflect the actual population within ¼ mile of the route during daylight hours on week days, including children in schools and nonresidents in hotels and commercial establishments. Nevada believes that numerous individuals could receive annual doses from HHT operations equal to ten to thirty percent or more of annual background radiation exposures.

339 Accidents

The Draft EIS discussion of HHT accidents is deficient. Because of the lack of actual experience with long distance HHT shipments, no meaningful empirical data is available to support the Draft EIS assertion that accident risks "are low for all five [route] alternatives."(p. 6-96) HHT operations on the routes identified in the Draft EIS may experience substantially higher accident frequencies and consequences. For example, using Nevada average accident rates and projected shipment-miles for DOE's Module 2 scenario, the expected number of HHT accidents on the Caliente route would be about 24 (12 loaded, 12 empty) over 39 years. The severity and consequences of accidents could be greater because of unique local hazards. Steep upgrades and downgrades (especially in combination with horizontal curves less than 800 feet radius) and critical side slopes and steep drop-offs (common near the summits of mountain passes) could subject casks to extreme accident impact forces and make emergency response, cask recovery, and post-accident cleanup difficult. Such conditions appear to exist near Oak Springs Summit on U.S. 93, near Hancock Summit on SR 375, and at several other locations along the Caliente HHT route.

340 ... Page 6-105; Section 6.3..3.2.1 - Caliente Route Implementing Alternative

Occupational and Public Health and Safety

The Draft EIS does not adequately evaluate the radiological impacts of routine HHT transportation using the Caliente route. The Draft EIS states that HHT shipments could routinely use existing roadways through Tonopah and Goldfield. (pp. 6-100, J-84, and J-88) The State of Nevada challenges this assertion, but if we accept it for purposes of analysis, the Draft EIS appears to significantly underestimate HHT routine radiation exposures to the general public in Tonopah, in Goldfield, and possibly in Beatty. The RADTRAN model, using the assumptions described in the Draft EIS, (pp. J-39 to J-42) is not sufficiently sensitive to local conditions and probable HHT operating characteristics. DOE must recalculate the annual and cumulative collective dose and maximum individual dose, assuming that each HHT shipment stops for 2 -5 minutes at the intersection of U.S. 6 and U.S. 95, and travels through Tonopah and Goldfield at an

340 cont. average speed of 5 miles per hour. Numerous residences and businesses are located within 25 to 250 feet of the U.S. 95 road shoulder. The analysis must consider the actual location of all occupied buildings within ¼ mile of the route. The analysis must accurately reflect the actual population within ¼ mile of the route during daylight hours on week days, including children in schools and nonresidents in hotels and commercial establishments.

341 Socioeconomics

Cost figures shown for upgrading the Caliente route are significant understatements. It is likely that the State of Nevada will require extensive lane additions and widening along most of the route in both directions between Caliente and Yucca Mountain. Without such additions, the presence of daily heavy-haul trucks coming and going along the narrow, rural highways would create hazards and cause major disruption along impacted highways. Costs for upgrading the Caliente route alone are likely to be upwards of $800 million.

The Draft EIS also fails to assess costs and impacts of upgrading an alternative to the Caliente heavy-haul truck route that can be used when the primary route is unavailable (due to weather, construction, accidents, etc.). To be functional, a heavy-haul transportation system must have at least two functional routes. Both routes will require extensive upgrades and improvements. Costs and impacts for both must be assessed in the EIS.

342 ... Page 6-137; Section 6.3.4 - Environmental Justice Impacts in Nevada

The Draft EIS fails to acknowledge the full range of nuclear waste transportation impacts on Native American communities, lands, and cultural resources in Nevada.

The State of Nevada considers the following Indian Reservations and Colonies in Nevada to be potentially affected by rail and truck routes identified in the Draft EIS:

-Moapa Reservation (UPRR, I-15)

-Las Vegas Reservation (Valley Rail Spur, US95)

-Ely Colony (US93)

-Duckwater Reservation (US6)

342 ...

-Walker River Reservation (UPRR)

-Pyramid Lake Reservation (UPRR)

-Reno-Sparks Colony (UPRR)

-Lovelock Colony (UPRR)

-Winnemucca Colony (UPRR)

-Te-Moak Reservations [Battle Mountain, Elko, South Fork, Te-Moak, Wells] (Carlin Rail Spur, UPRR)

The Draft EIS does not define transportation-affected and potentially-affected Indian lands and resources. Nevada defines affected lands and resources to included the following: (1) reservations crossed by potential shipping routes; (2) off-reservation ceded lands, where Tribes retain treaty rights or other legally-recognized user rights, crossed by potential shipping routes; (3) reservation lands and off-reservation lands within transportation emergency evacuation zones along potential shipping routes; (4) reservation and off-reservation lands which could be contaminated by air or water transport of radioactive materials released in a severe transportation accident or terrorist incident (generally within 50 miles down-wind, down-stream, or down-gradient of a potential shipping route); (5)reservations whose highway access would be disrupted by a nuclear waste transportation emergency; and (6) off-reservation lands along potential shipping routes where Tribal personnel would likely be involved in transportation emergency response.

The Draft EIS gives insufficient consideration to the major concerns identified by potentially affected Indian Tribes in Nevada, the Western Shoshone National Council, and organizations such as the Nevada Indian Environmental Coalition and the Inter-Tribal Council of Nevada. These concerns include: (1) Tribal authority to regulate shipments across reservations; (2) emergency response planning and training for Tribal personnel; (3) advance notification of shipments and shipment monitoring; (4) protection of Native American religious and cultural sites, plants, and animals, both on and off reservations; (5) cultural implications of potential radiological contamination of Indian lands, and the cultural implications of cleanup activities involving non-tribal personnel; and (6) adverse economic impacts of public perception of risk, especially adverse impacts on tribal tourism and recreation businesses. DOE's proposal to construct a rail spur to Yucca Mountain creates special concerns about right-of-way acquisition implications for Western Shoshone land claims (Ruby Valley Treaty) and about protection of graves,

342 cont. religious sites, and other cultural resources within the potential rail corridors identified in the Draft EIS. Moreover, DOE failed to provide financial assistance to facilitate independent technical review of the Draft EIS by potentially affected Indian Tribes in Nevada.

SECTION 7. ENVIRONMENTAL IMPACTS OF THE NO-ACTION ALTERNATIVE

343 Page 7-1; Section 7 - Environmental Impacts of the No-Action Alternative

This section lacks substance because of the large uncertainties and lack of information regarding the No-Action Alternative. Weaknesses of this kind are discussed by Salk and others (1998) and by Westman (1985).

SECTION 8. CUMULATIVE IMPACTS

344 Page 8-12; Section 8.1.2.2 - Federal Actions - DOE Waste Management Activities

The statement in paragraph 2 of this section regarding potential short and long-term cumulative impacts of waste management activities is not consistent with information in Table 8-1 (page 8-4) that indicates no short-term cumulative impacts from future potential waste management activities.

345 Page 8-22; Table 8-5 - Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region.

Utilities: Table 8-5 states that peak electric power demand would require an upgrade of the transmission and distribution system. In order for this EIS to be complete, it should include an evaluation of impacts of a specific proposed upgrade since it is acknowledged that an upgrade would be required as part of the Proposed Action. Section 8.2.11 does not provide an evaluation of the impacts of the necessary upgrade.

346 Waste Management: There is no existing authority that would permit low-level radioactive waste from the repository operation to be disposed at the NTS low-level waste disposal facility. This assumption is inconsistent with other statements regarding low-level waste disposal in this Draft EIS.

347 Page 8-31; Section 8.2.2.2.2 - Radiological Air Quality

This section incorrectly states that the 2.5 mrem per year cumulative dose is "about 40 percent" of the 10 mrem annual dose regulatory limit.

348 Page 8-36; Section 8.2.4 - Biological Resources

This section is deficient in two major respects. First, an ecosystem approach was not adopted for the Draft EIS and second, thermal loading impacts are not factored into cumulative effects. Therefore, this section is inadequate.

349 Page 8-37; Section 8.2.5 - Cultural Resources

DOE should make provisions for identifying, evaluating, and treating historic properties if Inventory Module 1 or 2 is authorized.

Page 8-39; Section 8.2.7 - Occupational and Public Health and Safety

See comments on Section 4.1.7 above.

350 Page 8-59; Section 8.3 - Cumulative Long-Term Impacts in the Proposed Yucca Mountain Repository Vicinity

The performance assessment results shown in tables for this section are based on a Total System Performance Assessment (TSPA) code and supporting analyses developed prior to those that will be used in the site suitability evaluation for site recommendation. The Draft EIS must include a description of the current TSPA and include its results and analyses rather than relying on an acknowledged incomplete and obsolete TSPA. In order to meet the need for a complete and accurate evaluation of the long-term impacts of the Proposed Action, DOE should issue a new Draft EIS for public review and comment that includes information and analyses consistent with the Site Recommendation Report.

351 Page 8-74; Section 8.3.2.1 - Past, Present, and Reasonably Foreseeable Future Actions at the Nevada Test Site - Item Number 5. Shallow Land Radioactive Waste Disposal

There has been no demonstration of the "absence of a groundwater pathway." Section 8.3.2.1.3 does not provide any basis for this assertion.

352 Pages 8-74 to 8-76; Section 8.3.2.1.1 - Underground Nuclear Testing

The discussion in this section of the Draft EIS addresses cumulative impacts associated with groundwater contamination within the Yucca Mountain region. The discussion covers contamination beneath the Nevada Test Site (NTS).

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352 Between 1951 and 1992, DOE conducted more than 1,000 nuclear tests at the NTS. Nearly one third of these tests were conducted in or near the groundwater. State officials contend that as much as 300 square miles of surface and subsurface area on and off the NTS are contaminated with radionuclides. The Draft EIS states that the estimated radionuclides source term for all subsurface tests was 300 million curies.

This section of the Draft EIS concludes by stating that "... the maximum potential dose from the underground testing inventory is calculated to be 0.2 millirem per year ... ." The document further states that the maximum cumulative impact of the Proposed Action in 10,000 years (i.e., radionuclides released from Yucca Mountain at the proposed point of compliance (20 kilometers from the repository) would be 0.22 millirem per year. Adding this to the NTS release of 0.2 millirem per year produces a cumulative release of 0.42 millirem per year.

The State of Nevada believes it is not yet possible, with any reasonable level of confidence, to estimate the release of radionuclides through the groundwater to the biosphere in the region of influence beneath the NTS and offsite locations. In fact, DOE does not have the data required to calculate a base case scenario for determining groundwater travel time in the region, let alone to make an estimate of hydraulic conductivity (important for determining the rate of movement of contaminants in the groundwater). The State of Nevada has repeatedly documented these facts as part of the State's ongoing regulatory review of DOE's Underground Test Area program for the NTS. The State's detailed comments are available on the World Wide Web at the following addresses:

http://www.state.nv.us./ndep/boff/ndep13.htm
http://www.state.nv.us./ndep/boff/ndep11.htm

It should also be noted that DOE's current program for assessing groundwater contamination beneath the NTS was recently criticized by an independent external peer review group commissioned by DOE. Overall, the reviewers found inadequate data to support groundwater flow modeling at NTS. They noted that available groundwater level and permeability data were inadequate for the assessment of groundwater flow directions, rates, and travel times in the vicinity of the contaminated areas.[35]

[35] "External Peer Review Group Report on Frenchman Flat Data Analysis and Modeling Task, Underground Test Area Project," (ITLV/13052-077A0), prepared for U.S. Department of Energy, Nevada Operations Office under contract No DE-AC08-97NV13052 (September, 1999).

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352 cont.

nuclear testing at the NTS is simply not possible. Moreover, estimates of hydraulic conductivity contained in the Draft EIS rely on only one data set obtained from only one well in a period of fifty years. Using this limited information and then extrapolating the data over a 10,000 year period to produce the estimated 0.2 millirem per year dose figure is pure fiction.

Current estimates suggest the geographic scope of existing groundwater contamination in the region may exceed 300 square miles and extend to depths ranging from 500 to 5,000 feet.

Developing believable and reasonable estimates of the potential cumulative impacts to groundwater from existing contamination beneath the NTS and future contamination that would escape from a proposed repository at Yucca Mountain is mandatory for assessing the degree to which the Proposed Action would affect public health and safety. The Draft EIS fails to make this basic, rudimentary assessment and is, therefore, deficient. The Draft EIS fails to meet the basic requirement of NEPA as defined by the Council of Environmental Quality implementing regulations, Sec. 1500.1(b).

Groundwater contamination attributable to underground nuclear weapons testing has been found off the NTS on the Nellis Air Force Range. Also, contamination has been detected within the NTS boundaries as far as 0.8 miles from a nuclear test location known to be the source of the contamination.

353

Page 8-77; Section 8.3.2.1.3 - Future Nevada Test Site Low-Level Waste Disposal

Paragraph 3 under this section of the Draft EIS states that "DOE proposes to locate the Mixed Waste Disposal unit, which will be a landfill, on about 0.18 squares kilometers (45 acres) of the Area 5 site, immediately north of the developed Radioactive Waste Management Site landfill area. The design has been completed, the unit has been included in the Resource Conservation and Recovery Act permit application, and the environmental assessment is being updated."

Virtually all of the information stated above is outdated and incorrect. DOE's permit application related to the Area 5 site is at least five years out of date. DOE's current RCRA permit re-application was submitted to the State in October 1999. This re-submittal only requests authorization to use an existing mixed waste trench (pit 3) for disposal of defense low-level mixed waste generated on NTS.

354 Page 8-89; Section 8.4.2.4 - Biological Resources and Soils

The section concerning Nevada transportation impacts appears to address only the intermodal transfer stations and not the routes to be followed through the state. For these reasons, the section is inadequate. Guidance such as that provided by Clark and Cantor (1997) should have been followed to supplement CEQ's 1997, "Considering Cumulative Effects Under the NEPA."

SECTION 9. MANAGEMENT ACTIONS TO MITIGATE THE POTENTIAL FOR ENVIRONMENTAL IMPACTS

355 Page 9-5; Section 9.2.2.2 - Groundwater

The Proposed Action, as spelled out by this Draft EIS, does not meet the stated purpose of a geologic repository. If the "detailed study" of Yucca Mountain by DOE showed a good geologic site, as required by the NWPA, there would be little need for "many engineered barrier elements to complement the site's natural characteristics...." (emphasis added)

356 Page 9-6; Section 9.2.3 - Biological Resources and Soils

In this section, the focus is almost exclusively on the desert tortoise and not on other components of the ecosystem or on the ecosystem itself. Additionally, there is no consideration of risks associated with mitigation. For these and other reasons (Attachments D, G, M; Clark and Canter, 1997; Ortolano, 1997; Westman, 1985), the section is inadequate.

357 Page 9-8; Section 9.2.3.2 - General Biological Resources and Soils

This section should include efforts to prevent the spread of noxious or invasive plant species.

358 Page 9-9; Section 9.2.4 - Cultural Resources

The text of this section states that the Programmatic Agreement (PA) contains the requirements and general procedures for mitigation of adverse effects at important archaeological and historic sites in the Yucca Mountain region. This is incorrect; the PA deals strictly with identification, evaluation, and treatment of historic properties in advance of site characterization activities.

359 Page 9-18; Section 9.3.3.2 - Groundwater

The Draft EIS does not discuss potential impacts to groundwater from an accident occurring during transport.

Page 9-19; Section 9.3.4 - Biological Resources and Soils

See comment for Page 9-6.

SECTION 10. UNAVOIDABLE ADVERSE IMPACTS; SHORT-TERM USES AND LONG-TERM PRODUCTIVITY; AND IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

360 Page 10-2; Section 10.1.1.3 - Hydrology

This section of the Draft EIS should point out that the resultant peak doses expected from releases of radionuclides to the groundwater are much larger than considered acceptable under any reasonable standard. To illustrate the extent of expected contamination, reference should be made to Table 8-41 on page 8-63, which provides peak dose calculations at various distances from the waste emplacement area. It must also be recognized that the Proposed Action results in an irreversible commitment of groundwater in Amargosa Valley, Franklin Lake Playa, and springs in Death Valley to contamination by radionuclides at a level that makes the water unfit for human use and a significant danger to the environment.

361 Page 10-3; Section 10.1.1.4 - Biological Resources and Soils

This section addresses biological and soil resources for Yucca Mountain. No meaningful or substantive information is given and addressed, so the short section is meaningless.

362 Page 10-4; Section 10.1.1.5 - Cultural Resources

Provisions to deal with unavoidable adverse impacts need to be part of any new Programmatic Agreement drafted by DOE.

363 Page 10-6; Section 10.1.2.1 - Land Use

The Draft EIS assumes that 0.04 square kilometers could be needed to construct a bypass near Beatty. The Draft EIS ignores the fact that at least two other locations will also require bypasses - Tonopah and Goldfield.

364 Page 10-6; Section 10.1.2.4 - Cultural Resources

Provisions to deal with unavoidable adverse impacts need to be part of any new Programmatic Agreement drafted by DOE.

365 Page 10-9; Section 10.2.1.2 - Hydrology

The last statement in this section is specious, at best. Yucca Mountain will result in contamination of a large aquifer and surface water expressions, and the shipping campaign could cause the contamination of many major and minor water bodies throughout the U.S. The perception given by this statement is that it is acceptable to contaminate water in Nevada, but not anywhere else.

SECTION 11. STATUTORY AND OTHER APPLICABLE REGULATIONS

366 Page 11-1; Section 11 - Statutory and Other Applicable Requirements

This section describes the Department of Energy Orders and Potentially Applicable Federal Regulations. However, there is only a cursory effort at discussing applicable State of Nevada Regulations. This section should be expanded to discuss these regulations in more detail, especially those dealing with the operations of a repository.

367 The Draft EIS also fails to identify the laws that will be violated by the repository. This includes NRS 445A.575, which reads as follows:

> "*It is unlawful to discharge any radiological, chemical or biological warfare agent or high-level radioactive waste into any waters of the state.*"

The Proposed Action contained in the Draft EIS indicates that leakage of high-level radioactive wastes to the groundwater of the State will occur. Therefore, when any such waste from the repository reaches the groundwater, DOE will be in violation of State law. This has not been identified in the Draft EIS.

368 A new Executive Order (Executive Order 13132 - Federalism) has been issued since the preparation of this Draft EIS. This order should be added to this section and fully incorporated, where applicable, into the Draft EIS.

369 Because the Draft EIS considers transportation, DOE should identify the regulatory requirements for the storage, shipment, and transportation for <u>all</u> States affected by the transportation of nuclear waste.

370 Page 11-6; Section 11.2.2 - Water Quality

This section fails to discuss requirements under NRS 445A (Water Pollution Control) for the protection of the waters of the State of Nevada as it applies to the long-term operation and life of the repository. The Draft EIS discusses only requirements for support facilities and ignores long-term repository performance.

371 Page 11-11; Section 11.2.4 - Control of Pollution

The discussion of the Resource Conservation and Recovery Act (RCRA) in this section of the Draft EIS states that DOE does not expect to need a RCRA permit for Yucca Mountain. However, the table in Appendix I (Table I-10) lists elements that are to be part of defense high-level waste stored in the repository. These elements include barium, cadmium, lead, mercury, and selenium. These elements are controlled under RCRA with set regulatory levels. The Draft EIS should indicate how these RCRA-controlled elements are exempt from permit requirements. The Draft EIS should include a discussion of the permitting process that will be used or an in-depth explanation of why a permit would not be required.

Other DOE documents that discuss the composition of high-level nuclear waste show that toxic heavy metals, organic solvents, and hazardous chemicals are usually contained in high-level defense waste. The Draft EIS should show the breakdown between RCRA-controlled high-level waste and non-RCRA-controlled high-level waste. The Draft EIS should also provide an analysis of how these two waste categories will be handled for Yucca Mountain.

The waste stored at Hanford, WA is currently regulated according to RCRA. The proposed BFNL vitrification plant will be RCRA-permitted, and the INEEL vitrification plant will also be permitted. The statement that DOE will not need a RCRA permit for Yucca Mountain is inconsistent with these facts, and the Draft EIS should clarify this statement.

DOE should also be required to comply with the Toxic Substances Control Act, if applicable. There is no discussion in the Draft EIS about DOE waste that is contaminated by such substances as PCBs. Currently, DOE manages approximately 22,000 cubic meters of radioactive PCBs. DOE currently manages about 14,000 cubic meters of radioactive asbestos. The Draft EIS should contain a discussion of whether or not these waste types will be disposed of at Yucca Mountain.

372 Page 11-12; Section 11.2.5 - Cultural Resources

Reference is made to the existing Programmatic Agreement dealing with site characterization activities. DOE states it would prefer to modify the existing document. However, based on changes in the Preservation Act regulations and the widened scope of the project, the Nevada State Historic Preservation Office requests a new document be negotiated.

373 **SECTION 12. REFERENCES**

There were twenty-seven important references regarding biological, ecological, and soil resources cited in the Draft EIS. Of these, three were professional publications reflecting work of the State of Nevada. There are other State of Nevada professional publications not included among the references cited in the Draft EIS. Among DOE's twenty-four other references are ten reports issued by TRW regarding environmental information for the Yucca Mountain Project. Of these, four are Environmental Baseline Files that draw upon additional sources of information. A key DOE citation in the Draft EIS is "TRW 1999k, Environmental Baseline File for Biological Resources." Section 4 (Opposing Views) and Section 5 (Major Issues and Data Needs) of TRW 1999k are attached to these comments. Section 4 identifies six opposing views to DOE's field studies raised by the State of Nevada and the NWTRB. These are key issues regarding Yucca Mountain biological and ecological programs, which are not disputed in the Draft EIS. This is consistent with the earlier comment on the Draft EIS for page 3-59 that DOE failed to use an integrated ecosystem approach, thereby negating many of its field studies for the biological and ecological resource aspects of the Draft EIS. As noted in the comments on Section 1.5 of the Draft EIS, there are many publications concerning EIA and NEPA processes that should have been used as guidance by the DOE, cited, and referenced in the Draft EIS.

374 **APPENDIX H. POTENTIAL REPOSITORY ACCIDENT SCENARIOS: ANALYTICAL METHODS AND RESULTS**

In the Draft EIS, DOE analyzes the likelihood and consequences of potential air crashes at the repository. The formula used to estimate crash frequency is standard. Primary factors that must be taken into account is the crash rate for small aircraft (F-15, F-16) and the effective area of the target. The crash rate for small aircraft (page H-11) is provided by the Air Force and is standard; it is the long-term crash rate rather than the crash rate from the last 5 or 10 years.

The effective target area is greatly underestimated. It assumes a major accident would

374 ... only affect the roof of the waste handling building, since the walls of the waste handling building are five feet thick. The analysis also assumes a jet engine will not penetrate a shipping cask. This is discussed further in Appendix K. Thus, the rail yard is not considered an area that is subject to radiological consequences. Conclusions regarding the consequences of a jet crash into a rail cask are based on assumptions about the air speed of an F-15 and the cross-section of a jet engine. The penetration depth is inversely proportional to the diameter of the penetrating object.

If the object impacting the facility is not a jet engine but a hanging bomb, this assertion by DOE can be disputed. Since Nellis is a bombing range, one must consider hanging bombs, either armed or dummy. Dummies weigh one ton, are made of concrete, and are conical-shaped. They could easily penetrate a cask at speeds of 500 fps. For example, inert bombs were used in Iraq to penetrate fortified bunkers, without "collateral damage." In addition, we do not know whether Cruise missiles are flown at Nellis. For these reasons, the entire waste handling building and repository freight yard, which would have a large number of shipping casks awaiting processing, must be included in the effective target area, A_{eff}. This dramatically alters the likelihood of an air crash accident.

According to DOE, the effective roof area of the waste handling building is 27,000 m^2, whereas the rail yard plus waste handling building is 0.6 km^2. (Fig. 2-11) Just considering the footprint, the probability of an air crash increases by a factor of 22, from 5.6×10^{-8}/y to 1.2×10^{-6}/y. If one expands the effective area to include the skid zone and the height of horizontal casks on rail cars, the effective area and probability would increase further. Since the probability is greater than 10^{-6}, under DOE regulations, the rail yard must be redesigned to bring the probability down to 10^{-6}/yr.

Potential source terms

The EIS considers a "typical" Pressurized Water Reactor (PWR) assembly as one that has cooled for 25.9 years. (page H-17) The State believes this could be an underestimate. However, even if one accepts this average age of 25.9 years, it is quite likely that fuels cooled both less than and more than 25 years would be transported to the proposed repository. Therefore, the accident consequences would be greater than estimated by DOE simply because radionuclides decay exponentially. Co-60, one of the bad actors, since it is located on the outside of fuel cladding, has a half-life of 5.25 years and decays exponentially. The EIS states that the **average** age of shipped fuel is used for estimates of Co-60 crud. (page H-19)

Consider the following scenario. PFS, a proposed private nuclear waste storage facility in Utah, operates until the repository begins operation (supposedly the year 2010) with

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much of the older spent fuel in the U.S. being shipped first to PFS or being stored at reactor sites in storage casks. For reactors still operating in the year 2010, it is likely that more recent spent fuel would be shipped directly to the repository. The entire cost of loading and shipping this fresher fuel would be borne by DOE, whereas for fuel already stored in casks, costs are already sunk and the incremental cost to the utility is small. Thus, contrary to DOE's view that oldest fuel will be shipped first, it is more likely that older fuel would first be shipped to PFS and newer fuel would be shipped first to the proposed repository, followed at a later time by very old spent fuel. In the end, the average age of fuel shipped might be 25.9 years, but in terms of accident impacts, one cannot take the average age of fuel, since it is not a linear, but exponential, decay.

As an example of the inherent error in considering only the characteristics of an "average age" fuel shipment, consider a dichotomous distribution of fuel ages, with ½ of the spent fuel being shipped after cooling for five years (the minimum cooling time required by law) and the other half being shipped after cooling for forty-seven years (perhaps cooling at the PFS facility while the newer fuel is shipped to the geologic repository). The average age of the spent fuel shipments is twenty-six years. If we assume there were two curies of Co-60 initially in the spent fuel, we obtain the following estimates for activity using: (1) only the average age of the fuel shipments (26 years); and (2) five years of decay for one curie of Co-60 and forty-seven years of decay for 1 curie of Co-60.

(1): half-life = 5.25 years
decay coefficient = ln(2)/5.25 = .13203 years^{-1}
$[\text{Co-60}]_{t=26\ \text{years}}$= (2 Curies)$e^{-.13203 \times 26}$ = .065 Curies

(2): $[\text{Co-60}] = [\text{Co-60}]_{t=5\ \text{years}} + [\text{Co-60}]_{t=47\ \text{years}}$
$[\text{Co-60}]_{t=5\ \text{years}}$ = (1 Curie)$e^{-.13203 \times 5}$ = .517 Curies
$[\text{Co-60}]_{t=47\ \text{years}}$ (1 Curie)$e^{-.13203 \times 47}$ = .002 Curies
[Co-60] = .517 +.002 = .519 Curies

This simple calculation shows that using only the "average" fuel characteristics results in a gross underestimate of the impact of this short-lived radionuclide. Under the scenario involving PFS operation, waste characteristics will likely conform more to the dichotomous distribution used above than to a normal distribution. This leads to underestimates of the impacts of releases from these containers.

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APPENDIX I. ENVIRONMENTAL CONSEQUENCES OF LONG-TERM REPOSITORY PERFORMANCE

Page I-31; Section I.4.2.4 - Hydrology and Climate Regime

The accumulation of greenhouse gases is anticipated to alter not just global climate, but regional climates as well. It is not clear in this section whether state of the science technology (regarding climate change) was used to predict future climate and hydrologic conditions for the performance assessment modeling.

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Additional Radionuclides Should Be Included in Dose Assessment

In order to reduce the time to calculate environmental consequences of long-term repository performance, DOE reduced the full complement of radionuclides down to a manageable number. Specific radionuclides were selected for the dose assessment. The inventory of remaining radionuclides was increased to account for neglecting many radionuclides that are important to a dose assessment.

The radionuclides selected for dose assessment are: carbon-14, technetium-99 and iodine-129 (may be in gas phase and subsequently dissolved in water); selenium-79, protactinium-231, uranium-234 and neptunium-237; plutonium-239 and plutonium-242. (page I-7) Curium isotopes were not included because they were similar to plutonium. Americium isotopes were not directly included – Am-243 was included with Pu-239 and Am-241 was included with Np-237. Pu-240 was not included because it is highly sorbing (but could move more rapidly in colloidal form). U-238 was not included, but its decay product, U-234, was included. Ra-226, with a relatively short half-life (if 1600 years can be considered "short") also was not included.

The estimated activities of Np-237 and U-234 were increased by 58 % and 13%, respectively. (p. I-8) Np-237 activity included Cf-249, Cm-245, Pu-241, and Am-241. U-234 activity included Cf-250, Cm-246, Pu-242, Am-242, Cm-242, U-238, and Pu-238.

DOE took the following as Ci/waste package for commercial spent fuel (page I-9):

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Radionuclide	Curies/waste package
C-14	12
I-129	0.29
Np-237	11
Pa-231	5.1
Pu-239	3,100
Pu-242	17
Se-79	3.7
Tc-99	120
U-234	21

For the period around 10,000 years and earlier, DOE's substitutions underestimate the health impacts concerning long-term repository performance, resulting in a non-conservative estimation of impacts.

To understand the potential ingestion hazard posed by radionuclides in spent fuel, we constructed Table 1 (below). For selected radionuclides, the table lists the number of curies in a PWR fuel assembly for the present, 1,000 years from now, and 10,000 years from now. The table also contains columns for dose conversion factors for effective dose equivalents (EDE) and thyroid. The hazard index is defined as the product of the radioactive inventory and the dose conversion factor. This is a rough measure of the ingestion hazard. The hazard index does not account for transport of specific radionuclides through the environment, which is an important consideration.

The greatest potential hazard through the first 1,000 years arises from Am-241 and Am-243 (see Table 1 below). Through the year 10,000, the greatest hazard arises from Am-243 and Pu-239. Neither Am-241 nor Am-243 are represented in the DOE calculations (page I-9).

Table 2 (below) compares the radioactivity in one canister of spent PWR fuel with the inventory actually employed by DOE. As seen, except for Pa-231, the DOE inventory is always less than that for PWR fuel. Since the DOE analysis also includes lower burnup BWR fuel, it is not surprising to have a lower inventory in the DOE canister. However, note that the radionuclides Am-241, Cf-249, Cm-245, and Pu-241 are not simply added to the Np-237 inventory. DOE has assumed these other radionuclides are added to Np-237 at some future time period, closer to the 10,000-year time frame when computer analysis shows that canisters open up and radioactive leachate moves out of the proposed repository and into the accessible environment. Clearly, if the DOE estimates on package degradation are in error and waste materials move into the aquifer and the accessible environment within a time period less than 10,000 years, then the impact of these neglected radionuclides must be included in order to provide a realistic assessment of consequences. Possible causes of more rapid container degradation may include

376 construction defects, container damage during emplacement, and chemical interactions. Several surprises have already occurred during dry storage, including chemical interactions with zinc coating leading to the production of hydrogen gas in the VSC-24 cask, causing explosion hazards and QA problems. The effect on cladding integrity for extended storage at high temperatures is untested. Over a 10,000-year period, additional surprises should be expected. Inclusion of Am-241 and Am-243, among other radionuclides, would yield a more realistic dose assessment.

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Table 1. Potential Ingestion Hazard of Spent Fuel

Hazard Index Today

Radionuclide	Half-Life (Years)	Ci/PWR assembly	EDE DCF (Sv/Bq)	Thyroid DCF (Sv/Bq)	Hazard Index EDE	Hazard Index Thyroid
C-14	5.73E+03	6.40E-01	5.64E-10	5.64E-10	3.61E-10	3.61E-10
Cl-36	3.01E+05	5.40E-03	8.18E-10	7.99E-10	4.42E-12	4.31E-12
I-129	1.59E+07	1.80E-02	7.46E-08	2.48E-06	1.34E-09	4.46E-08
Tc-99	2.13E+05	7.1	3.95E-10	1.62E-09	2.80E-09	1.15E-08
Pu-239	2.44E+04	1.80E+02	1.40E-08	7.50E-14	2.52E-06	1.35E-11
Am-241	4.33E+02	1.70E+03	9.84E-07	1.32E-11	1.67E-03	2.24E-08
Am-243	7.37E+03	1.30E+01	9.79E-07	6.80E-11	1.27E-05	8.84E-10
Np-237	2.14E+06	2.30E-01	1.20E-06	1.10E-10	2.76E-07	2.53E-11
Pa-231	3.25E+04	1.60E-05	2.86E-06	6.33E-11	4.58E-11	1.01E-15
Pu-242	3.87E+05	9.90E-01	1.33E-08	7.38E-14	1.32E-08	7.31E-14
Se-79	6.50E+04	2.30E-01	3.51E-10	5.66E-11	8.07E-11	1.30E-11
U-234	2.44E+05	6.60E-01	7.06E-09	1.03E-10	4.66E-09	6.80E-11

Hazard Index T= 1000 years

Radionuclide	Half-Life (Years)	i/PWR assemb	EDE DCF (Sv/Bq)	Thyroid DCF (Sv/Bq)	Hazard Index EDE	Hazard Index Thyroid
C-14	5.73E+03	5.67E-01	5.64E-10	5.64E-10	3.20E-10	3.20E-10
Cl-36	3.01E+05	5.39E-03	8.18E-10	7.99E-10	4.41E-12	4.30E-12
I-129	1.59E+07	1.80E-02	7.46E-08	2.48E-06	1.34E-09	4.46E-08
Tc-99	2.13E+05	7.08E+00	1.62E-09	5.95E-10	1.15E-08	4.21E-09
Pu-239	2.44E+04	1.75E+02	1.40E-08	7.50E-14	2.45E-06	1.31E-11
Am-241	4.33E+02	3.43E+02	9.84E-07	1.32E-11	3.37E-04	4.53E-09
Am-243	7.37E+03	1.18E+01	9.79E-07	6.80E-11	1.16E-05	8.05E-10
Np-237	2.14E+06	2.30E-01	1.20E-06	1.10E-10	2.76E-07	2.53E-11
Pa-231	3.25E+04	1.57E-05	2.86E-06	6.33E-11	4.48E-11	9.91E-16
Pu-242	3.87E+05	9.88E-01	1.33E-08	7.38E-14	1.31E-08	7.29E-14
Se-79	6.50E+04	2.28E-01	3.51E-10	5.66E-11	7.99E-11	1.29E-11
U-234	2.44E+05	6.58E-01	7.06E-09	1.03E-10	4.65E-09	6.78E-11

Hazard Index T= 10000 years

Radionuclide	Half-Life (Years)	i/PWR assemb	EDE DCF (Sv/Bq)	Thyroid DCF (Sv/Bq)	Hazard Index EDE	Hazard Index Thyroid
C-14	5.73E+03	1.91E-01	5.64E-10	5.64E-10	1.08E-10	1.08E-10
Cl-36	3.01E+05	5.28E-03	8.18E-10	7.99E-10	4.32E-12	4.22E-12
I-129	1.59E+07	1.80E-02	7.46E-08	2.48E-06	1.34E-09	4.46E-08
Tc-99	2.13E+05	6.87E+00	1.62E-09	5.95E-10	1.11E-08	4.09E-09
Pu-239	2.44E+04	1.35E+02	1.40E-08	7.50E-14	1.90E-06	1.02E-11
Am-241	4.33E+02	1.90E-04	9.84E-07	1.32E-11	1.87E-10	2.51E-15
Am-243	7.37E+03	5.08E+00	9.79E-07	6.80E-11	4.97E-06	3.45E-10
Np-237	2.14E+06	2.29E-01	1.20E-06	1.10E-10	2.75E-07	2.52E-11
Pa-231	3.25E+04	1.29E-05	2.86E-06	6.33E-11	3.70E-11	8.18E-16
Pu-242	3.87E+05	9.72E-01	1.33E-08	7.38E-14	1.29E-08	7.18E-14
Se-79	6.50E+04	2.07E-01	3.51E-10	5.66E-11	7.26E-11	1.17E-11
U-234	2.44E+05	6.42E-01	7.06E-09	1.03E-10	4.53E-09	6.61E-11

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Table 2. Canister Inventory, PWR Fuel

Radionuclide	Half-Life (Years)	Ci/PWR assembly	Ci/Canister	DOE
C-14	5.73E+03	6.40E-01	1.34E+01	12
Cl-36	3.01E+05	5.40E-03	1.13E-01	
I-129	1.59E+07	1.80E-02	3.78E-01	0.29
Tc-99	2.13E+05	7.1	1.49E+02	120
Pu-239	2.44E+04	1.80E+02	3.78E+03	3100
Am-243	7.37E+03	1.30E+01	2.73E+02	
Np-237	2.14E+06	2.30E-01	4.83E+00	1.10E+01
Am-241	4.33E+02	1.70E+03	3.57E+04	
Cf-249	3.52E+02			
Cm-245	8.50E+03	1.80E-01	3.78E+00	
Pu-241	1.50E+01	2.00E+04	4.20E+05	
U-234	2.44E+05	6.60E-01	1.39E+01	2.10E+01
Cf-250	1.31E+01			
Cm-246	4.76E+03	3.80E-02	7.98E-01	
Pu-242	3.87E+05	9.90E-01	2.08E+01	
Cm-242	4.46E-01	8.70E+00	1.83E+02	
U-238	4.47E+09	1.50E-01	3.15E+00	
Pu-238	8.78E+01	1.70E+03	3.57E+04	
Pa-231	3.25E+04	1.60E-05	3.36E-04	5.1
Pu-242	3.87E+05	9.90E-01	2.08E+01	17
Se-79	6.50E+04	2.30E-01	4.83E+00	1.7

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Multi-Barrier Concept

Contrary to how a permanent geologic repository is intended to perform under the Nuclear Waste Policy Act, the geological formation is not proposed as the primary containment barrier at Yucca Mountain. Instead, the packaging, consisting of the fuel matrix itself, the fuel rod cladding, and the double wall package must function as the primary containment barrier. Once radionuclides move from the fuel matrix and the waste package, the Yucca Mountain geologic setting provides little resistance. Under the Proposed Action, the function of the geologic setting at Yucca Mountain to merely to decrease the likelihood of human intrusion.

The waste package design in the Draft EIS (not the design currently used by DOE) consists of an outer wall, 10-cm thick layer of carbon steel (corrosion-allowance material) and an inner 2-cm layer of chromium-molybdenum Alloy-22 (corrosion-resistant material). (p. I-34) The computer software WAPDEG quantifies the range of expected degradation. The major factors are temperature and moisture. WAPDEG evaluates

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generalized and localized corrosion. Corrosion of carbon steel generally begins when the temperature of water is below the boiling point. (p. I-35)

According to these theoretical models, by 5,000 years, nearly every package has a single corrosion-allowance material breach. (page I-40) By 20,000 to 30,000 years, corrosion-resistant material is also breached. High thermal loads generate the earliest breaches. Spent fuel dissolution depends critically on temperature, carbonate concentration, and pH.

DOE calculates the dose for a reference person in the Amargosa Valley – an adult, who lives year-round on a farm, grows a garden, and raises livestock. (page I-48)

In addition to food, radiation pathways considered by DOE include incidental ingestion of contaminated soil and groundshine. (page I-49) It is not clear that the radiation pathway, dust resuspension, was considered. DOE conducted a survey to determine food consumption habits in Amargosa Valley. To calculate health effects from radioactive input, DOE used ICRP-30 dose conversion factors. It is important to note that the more recent dose conversion factors from ICRP-60 would have allowed DOE to also calculate the dose to children rather than a reference adult, which would likely have resulted in higher dose calculations. Four locations to estimate doses were considered – 5, 20, 30, and 80 kilometers distant. As calculated, the maximum peak dose would occur well after 10,000 years. For 10,000 years, the highest dose would be at 5 km. (page I-51) The first failure for the intermediate thermal load scenario is 9,000 years after repository closure. (page I-52) For the low thermal load case, the first failure occurs at 27,000 years after repository closure.

DOE has high expectations for the containment potential of the cladding. Not taking credit for the cladding increases the mean dose at 20 km from 0.22 mr/y to 5.4 mr/y at 10,000 years. (page I-54) At 1,000,000 years, the doses can be quite high, 260 mr/y at 20 km with cladding credit, and **3,000 mr/y** without cladding credit. These latter doses are extremely high, far above regulatory limits and entirely unacceptable.

Note: Because the performance assessment for long-term repository performance used in this DEIS is not the one that will be used in the FEIS to support site recommendation, no further review of Appendix I was undertaken. For this reason alone, the DEIS is insufficient.

APPENDIX J. TRANSPORTATION

378 Page J-23; Section J.1.2.2.1 - Routes Used in the Analysis

The models used in performing risk analysis rely on obsolete population data. Nevada is the fastest growing area/state in the country. Using population data that are almost a decade old seriously jeopardizes the study results. These data will be over two decades old if the repository opens in 2010. The population residing within one half mile either side of routes analyzed could easily be twice as much as recorded in 1990. The use of outdated or incomplete data is a problem throughout the Draft EIS.

379 Page J-89; Table J-37 – Potential Road Upgrades for Caliente Route

The Draft EIS does not properly evaluate a range of costs for required infrastructure upgrades along the Caliente HHT route. Aside from construction of a short bypass in Beatty, the Draft EIS assumes that the Caliente HHT route will require only moderate pavement upgrade turnouts every 20 miles. (p. J-89) Preliminary analysis by NDOT indicates that the life-cycle costs of such upgrades may be $450-500 million. Additional upgrades may be necessary for safety and traffic control, as well as to reduce routine radiological exposures and perceived risk impacts. The State of Nevada has identified 13 route segments, with a total length of 92 miles, where slow lanes would likely be required on both sides of the road, at a cost of at least $100 million in addition to pavement upgrades. DOE must reexamine its minimum infrastructure upgrade assumptions and costs. A bounding analysis should estimate the cost of constructing slow traffic lanes on both sides of the road for the entire 331 mile route. DOE should also investigate the costs and benefits of constructing bypasses to avoid the U.S. 6 intersection with U.S. 95 in Tonopah and the extreme right turn on U.S. 95 in Goldfield.

380 Page J-95 to J-98; Section J.3.3.1 – Intermodal Transfer Station Accident Methodology

A major deficiency in the Draft EIS safety analysis involves the consequences of transportation and storage accidents involving military aircraft. The Draft EIS only evaluates aircraft accidents relative to intermodal transfer stations and fails to consider the impacts on facilities and shipping casks of military ordinance and practice bombs used in training missions. The Draft EIS analysis is limited to the penetration capability of jet engines and engine shafts as falling projectiles.(p. J-97) DOE's 1986 Yucca Mountain Environmental Assessment (EA) correctly identified the potential vulnerability of rail and truck shipments to military aircraft accidents. All of the LWT, HHT, and rail routes identified in the Draft EIS are potentially vulnerable to military aircraft using the Nellis Air Force Base and Bombing Ranges. The Draft EIS must specifically evaluate

380 cont. the consequences of aircraft accidents involving military ordinance designed to destroy tanks and fortified installations. Further, the Draft EIS should also evaluate the potential impacts of military aircraft accidents involving practice weapons, including steel-tipped concrete dummy bombs weighing up to a ton. Even dummy weapons may have a greater destructive capability than the jet engine projectiles evaluated in the Draft EIS.

381 **APPENDIX K. LONG-TERM RADIOLOGICAL IMPACT ANALYSIS FOR THE NO-ACTION ALTERNATIVE**

Two No-Action Alternatives are considered by DOE, both involving long-term storage at present locations: (1) Long-term storage at present locations with effective institutional control for at least 10,000 years; and (2) Long-term storage at present locations with no effective institutional control after 100 years. Another alternative, perhaps more likely, is storage at a centralized location, such as the proposed PFS facility in Skull Valley, Utah. The environmental impact of this alternative should be seriously investigated by DOE.

While DOE researchers have attempted to construct the impact analysis of the No-Action Alternative in parallel to the analysis conducted for the proposed Yucca Mountain repository, in several respects, researchers have not been successful.

For decentralized storage at reactor sites where spent fuel is presently stored, a major concern over the long-term is the freeze-thaw cycle. As DOE researchers note, freeze-thaw cycles lead to concrete spalling and weakening of the concrete overpacks around spent fuel canisters (page K-4). In addition, storage canisters can degrade due to corrosion caused by acidity and chloride concentration. This can be followed by water infiltration (page K-8). The final barriers to radionuclide release are the fuel cladding and the fuel matrix (page K-9).

According to DOE, degradation appears to begin at about 7,000 to 8,000 years. In year 10,000, less than 1% of the cladding has degraded. This is primarily the stainless steel clad fuel. For zirconium, degradation begins about 10,000 years (page K-11).

Table K-4 lists radionuclides important to dose for this decentralized storage scenario: Am-241, Am-243, Np-237, Pu-238, Pu-239, Pu-240 and Tc-99. (p. K-14) These radionuclides are important, but they are not the radionuclides considered in the repository analysis. Of these, only Np-237 is directly considered in the repository analysis. Pu-239 (49%) and Pu-240 (47%) contribute most of the dose, followed by Am-241 (3.2%).

387 DOE assumed the crash of a mid-size twin engine commercial jet into a dry storage facility. (page K-25) An aircraft could crash into the top, or side of canisters, or could strike in front and skid into the canisters. The estimated crash frequency is 3.2 in 1 million. DOE assumed the crash occurred 1000 years after termination of institutional control. DOE also assumed a fire would heat fuel pins to the point of cladding rupture. UO_2 would oxidize to U_3O_8. The amount of fuel of respirable size was estimated to be 0.12% of the canister inventory. (page K-26) The State agrees that the environmental impact of an aircraft crash should be evaluated. Similarly, an aircraft crash in the rail yard of the proposed repository should also be evaluated. Given the speed and type of payload (i.e., hanging bombs) represented by F-15 and F-16 fighter jets, shipping casks can release their contents. This environmental impact must be seriously considered by DOE.

382 **APPENDIX L. FLOODPLAIN/WETLANDS ASSESSMENT**

Page L-18; Section L.4.2.1 - Effects along Rail Corridors

In the Draft EIS, DOE has not adequately studied the potential surface water impacts of either the rail or the heavy-haul alternative. The discussion on wetlands contained in Appendix L for all of the rail alternatives contains the statement, "no field searches or formal delineations of wetlands have been conducted along this route." Also, wetlands have also not been delineated for the intermodal transfer station sites. Some of the rail corridors are known to cross or be near to significant springs, groups of springs, streams designated as riparian areas, or reservoirs associated with wetlands. Wetlands and riparian areas are a valuable resource in Nevada. Simply stating that impacts will be mitigated is insufficient.

REFERENCES

Bartlett, R. and C. Malone. 1993. Science and the National Environmental Policy Act. *The Environmental Professional* 15(1): 1-160.

Caldwell, K. 1998. *The National Environmental Policy Act.* Indiana University Press, Bloomington.

Clark, R. And L. Canter. 1997. *Environmental Policy and NEPA.* St. Lucie Press, Boca Raton, FL.

Gilpin, A. 1995. *Environmental Impact Assessment.* Cambridge University Press, New York, NY.

Ortolano, L. 1997. *Environmental Regulation and Impact Assessment.* John Wiley & Sons, Inc., New York, NY.

Salk, M. and others. 1998. Guidelines and techniques for improving the NEPA process. *Environmental Management* 23(4): 467-476.

Westman, W. 1985. *Ecology, Impact Assessment, and Environmental Planning.* Wiley-Interscience Publications, New York, NY.

Wiesner, D. 1995. *The EIA Process.* Prism Press, Bridport, Dorset, GB.

APPENDIX I

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APPENDIX I

RADIOACTIVITY, STIGMA, AND SOCIOECONOMIC IMPACTS THE NEED FOR AN ASSESSMENT OF IMPACTS ON NEVADA'S PRINCIPAL ECONOMIC SECTORS IN THE U.S. DEPARTMENT OF ENERGY'S YUCCA MOUNTAIN DRAFT ENVIRONMENTAL IMPACT STATEMENT

Introduction

The U.S. Department of Energy's (DOE) Yucca Mountain Draft Environmental Impact Statement (EIS) contains no analysis of the impacts the Yucca Mountain high-level radioactive waste repository (HLRW) program will have on the State of Nevada's principal economic sector and on other areas of the Nevada socioeconomic context vulnerable to stigma effects of the Proposed Action. Nevada is unique among all of the states in its heavy reliance on tourism for its economic well-being. A repository at Yucca Mountain, just 100 miles from Las Vegas, and the transportation of spent nuclear fuel and high-level radioactive waste (HLW) to such a facility have the potential to significantly and negatively impact the State's economy. This Appendix is provided to demonstrate the substantial body of research and information available for conducting a credible Socioeconomic Impact Assessment (SIA) that fully addresses the potential effects of the Yucca Mountain project, including the most important and potentially most damaging economic stigma impacts.

Impacts associated with stigma attached to nuclear and/or hazardous facilities and activities are not psychological effects. They are real, definitive, quantifiable impacts that are directly manifested in economic indicators such as reduced property values, reductions in tourism and conventions, suppressed economic development, and reduced business investment. A substantial body of information and research exists, some of it generated through DOE and DOE-sponsored research, that can and should be used in any assessment of impacts related to the federal HLRW program.

The attached bibliography provides references for the basic social science literature that should be consulted and utilized in preparing an EIS. These references are shown in three categories: 1) Background and socioeconomic responses to managing and siting high-level radioactive waste facilities; 2) Basic literature on perceptions of risk from HLRW materials, programs, and projects, the conceptual framework of the social amplification of risk, and technological stigma including the special stigma associated with nuclear facilities and radioactive conditions; and 3) An annotated bibliography of reports and data produced by the State of Nevada's socioeconomic studies of Yucca Mountain. Most of the Nevada materials are publicly available and have been provided to DOE over the years.

383 **Understanding Public Responses to High-Level Radioactive Waste**

Public responses to facilities and programs designed to store or dispose of radioactive wastes have a long history. They have been expressed in every area of the country and have served to initiate important political, social, and economic behaviors. The details of opposition and aversion as responses to radioactive wastes have been recorded by journalists, economists, sociologists, social geographers, social psychologists, historians, anthropologists, risk analysts, planners, regulators, legislators, physical scientists, social scientists, politicians, business leaders, and local, state, and federal officials. Opposition and aversion are so prevalent that they dominate the range of responses. Failure to recognize this fact and address the implications of such aversion and opposition is a failure to address the most basic and important socioeconomic impacts from the proposed repository at Yucca Mountain.

Over the past two decades, social scientists have developed the theories, methods, data, and analytic capabilities to describe, understand, and project the range of potential socioeconomic impacts. These developments have been presented to DOE's Office of Civilian Radioactive Waste Management (OCRWM) in many ways and on numerous occasions. Reports have been submitted to DOE. Papers have been presented at conferences attended by DOE personnel and their contractors. Testimony has been presented in venues attended by, and in some cases even organized by, DOE. Major publishers have issued books on these subjects, and peer-reviewed articles have appeared in leading journals and magazines. The information on the public's responses to the repository program and how people's behaviors produce important, concrete, and quantifiable socioeconomic impacts has long been available to DOE and contractor personnel assigned duties of impact assessment, even to those with only rudimentary social science backgrounds.

The Nuclear Waste Policy Act of 1982 (NWPA)

After two decades of failure on the part of the Atomic Energy Commission and its successor agencies to solve the HLRW problem, Congress spent five years considering the problem and eventually passed the Nuclear Waste Policy Act of 1982 (NWPA). The fact of public resistance and aversion to HLRW facilities was clear. In response, the NWPA of 1982 incorporated a number of unique provisions to obtain congressional approval and to address the concerns of state and local communities.

Several provisions addressed concerns about an equitable outcome from the program. Two repositories were mandated, one in the West where some potential sites had been looked at, and one in the East where most of the wastes are created. The principle was

383 established that generators of the wastes would pay for the program, and a fee was imposed on nuclear-generated electricity to create the Nuclear Waste Fund. Compensation was authorized for states and communities that experienced adverse economic impacts.

Provisions of the Act were specifically directed at important process issues in site selection. DOE was required to report to affected stakeholders (state governments, Indian tribes, public, etc.) on all activities. The selection process was to be based upon technical criteria, and this was to be subject to outside scrutiny and review. DOE was directed to consult and cooperate with affected states and tribes before making key decisions. Participation by the affected states and tribes to oversee the repository program and conduct socioeconomic studies was to be funded through the Nuclear Waste Fund. Host states were provided with the right to file a notice of disapproval, essentially a veto of the site, which could only be overturned by Congress.

The NWPA assigned the U.S. Environmental Protection Agency (EPA) the duty to set radiation exposure standards and gave the U.S. Nuclear Regulatory Commission (NRC) the authority to permit and license construction and operation of a repository facility. The provisions for fairness and public safety were designed to make the eventual choice of a site acceptable to those directly affected. This attempt was successful to the extent that, in December, 1982 there was support for this Act even from congressional representatives from states identified as potential repository host sites.

The OCRWM and the Site Selection Process, 1983-1987

Key issues, concerns, and problems that produce social and economic impacts and limit public acceptance and support were clarified during the early years of the OCRWM program (1983-1987). Public concerns about human and environmental exposure to radiation were clearly articulated in the context of widespread references to past DOE activities with the nation's weapons program. Expressions of distrust of DOE were raised at the federal, state, and local levels. The ability of DOE to properly manage the program mandated by Congress was called into question on several levels as the schedule for performance slipped, key program process goals were ignored, adversarial legal actions were initiated, and costs escalated.

State and local governments raised important questions. In addition to the exposure risks and the questions about DOE management, concerns were expressed that the public would respond adversely to places that hosted HLRW facilities. Tennessee argued that a Monitored Retrievable Storage (MRS) Facility would stigmatize local communities and the state, adversely impacting attempts at economic development. Along the same lines, the

383 State of Texas and farmers near the Deaf Smith County candidate repository site were concerned that their agricultural crops would be stigmatized. This was also a concern of farmers in Washington State near the proposed facility site on the Hanford weapons complex reservation. In Maine, there was concern that a potential second-round site would ruin the tourist and recreation economy of the area, a potential adverse impact that was also raised in more than a quarter of the statements at public hearings held in Wisconsin and North Carolina (Kraft and Clary, p. 105).

This early history of public responses throughout the nation in response to the NWPA (1982) program served to identify important areas of socioeconomic impact for DOE, state, and local officials responsible for administration and oversight of HLRW programs. In terms of socioeconomic impacts, it became clear during this period that HLRW possessed the potential to induce a wide range of impacts at all levels of society and to produce "special effects" as a direct result of the nuclear and hazardous nature of the program. In order to evaluate the potential socioeconomic impacts of a repository program, it was clear that these special effects would have to be taken into account.

As one of several sites being considered, the State of Nevada outlined the requirements for socioeconomic assessment of the proposed facility site at Yucca Mountain in 1985 and issued a Request for Proposals (RFP) to conduct research and provide needed reports. This RFP required work to assess standard economic-demographic-fiscal impacts based on tried and true methods developed over the preceding decade of experience with the National Environmental Policy Act of 1969. The RFP also specified new basic research to address "special effects" that were so obviously important determinants of public responses to HLRW facilities and the economic and related impacts stemming from such responses.

The purpose of Nevada research on special effects was to devise methods for characterizing and estimating the potential for this unique class of impacts. A contractor was selected and the study team began work in March 1986. Mountain West Research, Inc. of Phoenix, Arizona headed the study team. This firm had extensive experience in socioeconomic impact assessment of energy facilities in the west and included researchers with experience in developing methods for the Nuclear Regulatory Commission, the Bureau of Land Management, and other agencies, as well as doing EIS work for federal, state, and industry clients. The effort also involved Planning Information Corporation of Denver, Colorado whose principals specialized in regional economics, fiscal, and transportation studies. Other team members included participants from Decision Research and the University of Oregon, the University of Nevada, Reno, the University of Nevada, Las Vegas, Clark University, Arizona State University, The Wharton School at the University of Pennsylvania, and Utah State University. Provisions were made to include other individuals

383 and groups to address specific problems and to provide technical and professional assistance when needed.

To provide an objective review, the State established a Technical Review Committee (TRC) made up of distinguished social science researchers and professionals. At periodic meetings, State, county, and local representatives, together with the TRC, examined research plans and issues, provided rigorous peer review of study results, and gave the study team guidance. These reviewers supported state-of-the-art efforts to address the standard effects including economic, demographic, public service, fiscal, social, and cultural impacts that would be expected from a major project of this size, cost, and timeline. They also encouraged a research program to investigate and describe the unique, highly significant "special" socioeconomic impacts.

The effort to understand special effects focused on the characteristics of the Nevada economy, especially tourism, gaming, conventions, recreation, outside business investments, and the inmigration of workers and retired people. The purpose was to develop methods to evaluate the potential effects of the HLRW repository within the Nevada socioeconomic context.

The Historical Case for Assessing Impacts to Nevada's Principal Economic Sector

As early as 1986, DOE's final Environmental Assessment (EA) for the Yucca Mountain site acknowledged the potential for impacts to Nevada's tourism-dependent economy and the need for additional research:

> "... the potential for adverse public perception of a repository and its associated waste transportation could adversely affect the tourism industry. The importance of public perception lies in the attractiveness of the image of Las Vegas to potential visitors. Concerns have been expressed that this image could be affected by the visibility of the repository and waste shipments and by safety concerns regarding the high-level radioactive waste-disposal system, particularly when accompanied by extensive media attention. Preliminary research to date concerning the potential effect of a repository on tourism is inconclusive; ***therefore further studies will be conducted***" (emphasis added).[1]

[1] "Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," (May, 1986), p. 5-110.

383 Additional commitments to address tourism and so-called risk perception impacts are contained throughout the final EA.[2] Nevertheless, no subsequent work in this crucial impact area by DOE's Yucca Mountain Project was ever carried out - or, if it was, the work was never disclosed.

When Congress redirected the federal HLRW program in 1987, it implicitly acknowledged the unique and special nature of the program, the intense public responses to it, and the need for a complete and exhaustive assessment of impacts. The Nuclear Waste Policy Amendments Act of 1987 directed DOE to report to Congress on potential socioeconomic impacts that could be occur as a result of locating a repository at the Yucca Mountain site. DOE was directed to report on fourteen (14) specific areas of potential impacts covering the gamut from education to public health to public lands, emergency response, and transportation, among others. Specifically singled out by Congress was the directive (number 13 on the list) that DOE report on potential impacts to "tourism and economic development, including the potential loss of revenue and future economic growth."[3]

The "Section 175 Report" was released in December, 1988. While the treatment of tourism and economic development impacts in the document was cursory at best, the report did conclude that a repository at Yucca Mountain could have negative effects on these important economic areas. With respect to economic development, the report found that, "[b]ecause the repository may be defined by some as a hazardous activity, some limitations on the prospects for economic development in Nevada may result."[4]

In evaluating the potential for impacts on tourism and economic development later in the report, DOE concluded that "[p]ossible changes in economic development patterns, generally, and in the tourism industry specifically, in southern Nevada may result from the repository program."[5] Such impacts were to be identified and quantified in subsequent impact assessments.

Following the publication of the Section 175 Report, a June 1992 policy directive was issued by DOE headquarters to OCRWM Associate Directors and Office Directors

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[2] Ibib., p. 5-111, p. 6-87, p. C.7-6.

[3] Public Law 97-425 [42 U.S.C. 10174(a)]

[4] "Section 175 Report: Secretary of Energy's Report to Congress Pursuant to Section 175 of the Nuclear Waste Policy Act, As Amended," by the U.S. Department of Energy Office of Civilian Radioactive Waste Management, December, 1988 (DOE/RW-0205), page 46.

[5] Ibid, page 64.

383 .. stipulating that "... perception-based impacts [i.e., stigma impacts] are of potential concern to affected governments, interested parties and the public and should be appropriately addressed by OCRWM."[6] The memorandum was in response to an earlier memo that sought to limit research in this area. The new directive superceded the prior guidance and specifically noted that "[the previous memorandum] is not viewed as limiting OCRWM-supported research in this area [i.e., stigma and perception impacts on tourism and economic development]."

The June 1992 memorandum was followed in July 1992 with a "Socioeconomic Policy Management Directive" from OCRWM. This directive was intended to serve as "... the program-level policy document that will guide the conduct of all OCRWM socioeconomic activities. Project-level socioeconomic plans for all OCRWM components will be prepared in accordance with the guidance provided in this document, and will serve as the primary source of information about each project's socioeconomic activities" (page 1).

To guide the OCRWM socioeconomic program, the Policy Directive set forth a list of specific objectives "designed to help OCRWM realize its mission." Two of these objectives are especially relevant to the draft EIS:

- Address "standard" impacts arising primarily from program-related employment and population growth as well as expenditures for materials, equipment, and services.

- Address developments, as necessary, in the area of "special" impact assessment arising primarily from the various components of the high-level radioactive waste program (page 2)[7]

In addition to DOE's policy pronouncements regarding the need to assess "special" impacts, there is evidence that DOE considered the State of Nevada's extensive work in

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[6]Memorandum from Jerome Saltzman, Director, OCRWM Office of External Relations, dated June 3, 1992.

[7] The terms "standard"impacts and "special" impacts are terms of art in socioeconomic assessment. The former refers to the impacts of the range of specific economic indicators used routinely in such assessments. The later refers specifically to those impacts that occur as a direct result of the nuclear or hazardous nature of the project and are synonymous with "stigma" impacts. In practice, "standard" and "special" effects are interrelated. Stigma effects of the project will be manifested as "standard" economic, fiscal, and impacts that can be characterized in the same units of measure as standard effects.

383 .. identifying potential stigma impacts associated with the high-level radioactive waste program to be credible and appropriate. In 1993, DOE commissioned Argonne National Laboratory to evaluate research on risk perception and stigma impacts carried out by the State of Nevada. Since much of the State's work involved survey research, Argonne contracted with the National Opinion Research Center (NORC) at the University of Chicago to undertake a technical evaluation of the methodologies used in the State's "special" impact assessment activities. The NORC report is instructive as to the high quality and appropriateness of the Nevada stigma research. The report concluded:

> "... the [State of Nevada] surveys could provide valuable data about risk perceptions and potential behavioral responses. NORC identified a few minor problems with a number of questions and calculated response rates but claimed these problems would probably not have any major biasing effects."[8]

The report went on to praise the creativity and robustness of the survey research, noting that the State surveys "exhibit some considerable creativity in approaching a difficult measurement problem." The report expressed "confidence that the conclusions [of the State's stigma research] are not highly dependent on the measurement technique, that is they are robust across measurement methods," noting that "... such robustness is a very important attribute in assessing the validity of the surveys."

DOE has, in fact, sponsored its own "stigma" research that is not included in the socioeconomic analyses contained in the draft EIS. An excellent example of this research is the work done by the University of New Mexico under contract with DOE. Of particular interest is a study by Drs. Gawande and Jenkins-Smith on the effects of stigma on property values along routes in South Carolina that were used to transport spent nuclear fuel from foreign research reactors. The Gawande and Jenkins-Smith findings are extraordinarily important and relevant to the potential for stigma effects stemming from the Yucca Mountain program and related nuclear waste transportation. Specifically, the researchers found that the hazardous, nuclear nature of these shipments and peoples' responses to them directly caused property values in urban Charleston to be "lowered in a substantive manner":

> "... we are convinced by the results for Charleston County [South Carolina] that real price effects can occur when shipments like those involved in the [foreign spent

[8] "Technical Evaluation of Available State of Nevada Survey Instruments," by Argonne National Laboratory, Environmental Assessment and Information Sciences Division, February, 1993 (ANL/EAIS/TM-93), page 1.

383 ..

nuclear fuel] FSNF return program take place. Despite systematic and extensive search for alternative explanations, the onset of the shipments appears to be the best explanation for the drop in housing values close to the route. Moreover, the results are consistent with research regarding the effects of other disamenities (e.g., polluted water, air and Superfund sites), with the self-reports of perceived risk of spent nuclear fuel shipments obtained in public opinion surveys, and with surveys of expected effects of nuclear waste shipments on housing values (Flynn et al, 1997)."[9]

Argonne National Laboratory, under contract to DOE, undertook an evaluation of the need for studies into potential stigma-related impacts on business location decisions and economic development in Nevada. In 1991, the issue of possible impacts of stigma and risk perceptions on small firms' location decisions was addressed:

> "Stigmatization and perceived risk can influence the location decisions of small firms, because of the importance personal preferences play in their location decision-making behavior. Although the impact of changes in behavior as a result of stigma and changes in risk perception is likely to be smaller in terms of total employment and income effects than it would be if a large manufacturing or service firm were forced to move, the effect on the competitiveness of a location can still be substantial. ...Consideration of the location decision-making behavior of small firms would be of great value in assessing the special effects associated with a repository or other hazardous facilities, given the importance of personal preferences in location decisions. ... Systematic consideration of these influences on entrepreneurs of small firms would be important in determining if and how stigmatization and perceived risk will affect the location decisions of small businesses."[10]

It is clear from the historical record that DOE, as early as 1988, recognized the potential for "special" or stigma effects of the Yucca Mountain program to result in significant impacts to Nevada. DOE took steps to evaluate the extensive body of research on this matter produced by the State of Nevada and found that work to be sound. And, finally, DOE undertook its own research on stigma impacts associated with the

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[9] "Nuclear Waste Transportation and Residential Property Values: Estimating the Effects of Transient Perceived Risks," by Kishore Gawande and Hank Jenkins-Smith, University of New Mexico (June 1999), page 28.

[10] "Socioeconomic Assessment Guidance Report: Determining the Effects of Amenity Characteristics on Business Location Decisions," by T. Allison, Argonne National Laboratory, ANL/EAIS/TM-85 (April, 1991), p. 40.

383 transportation of spent nuclear fuel and obtained confirmation that such impacts can and do occur and are potentially significant.

The fact that no assessment of "special" impacts to Nevada's uniquely vulnerable tourism-dependent economy was conducted in the draft EIS, despite DOE's prior knowledge of the potential for and legitimacy of such impacts, renders the socioeconomic impacts assessment in the draft document both legally and substantively deficient.

The following sections describe in some detail the research approaches, information, and findings that were available to DOE and should have been used in conducting the impact assessment contained in the Draft EIS.

Perceptions of Risk and Trust

Understanding how the public constructs its attitudes, opinions, and behaviors toward high-level radioactive wastes utilizes research on perceptions of risks and research on public trust of the program and the project managers. These efforts examine how members of the public view the risks from radioactive materials, from the science and technologies applied to HLRW disposal, and from the performance capabilities of the managers. The process by which perceptions influence the construction of attitudes and opinions underlies subsequent behaviors (see Kraus, 1995, for a review of the literature on attitudes and behaviors).

Research on perceptions of risk from technological hazards, including various nuclear technologies, advanced significantly in the 1970s and 1980s. The article in *Science* by Slovic (1987) serves as the basic statement of the findings from those years and as the starting point for subsequent work to understand the social dynamics of public response to HLRW. A subsequent 1991 article in *Science* by Slovic, et al. focused specifically on HLRW and demonstrated how data collection and analysis could address some of the public's key questions about the Yucca Mountain project. Other areas of inquiry, as discussed in the following sections, addressed broader social factors (such as the role played by the media and the influence of expanded public awareness) that create conditions of stigma.

Two factors, waste materials and trust in waste managers, are often separated in formal assessments and evaluations. However, the public views both these factors as significant sources of risk. The safeguards provided by engineering and other techniques for containing the radiation from HLRW are routinely subjected to risk assessments and various levels of testing. The contributions of program and project management to risks from

383 HLRW are seldom afforded any similar level of scrutiny. This appears to be the case because the proposed management itself defines and performs the required risk assessments. The existing regulatory evaluation of management schemes seldom goes beyond acquiescence to assurances that new levels of performance will be achieved on a consistent basis in the future. Nonetheless, the history of DOE (and its predecessor agencies) provides extensive evidence that shortcomings and failures in management of facilities and materials are major, perhaps dominant, sources of radiation exposure. Public opinion on this matter is expressed in terms of trust or distrust of radiation waste management agencies, since this is the terminology provided. Thus, studies of public risk perceptions and trust-distrust must be examined to understand public responses to HLRW. Understanding the full range of public responses is, in turn, necessary to evaluate potential socioeconomic impacts from a repository program.

Risk Perception and the Social Amplification of Risk

The public's knowledge of hazards and risks is based on information from many sources. At a basic level, personal experiences and interpersonal communications are involved. In the contemporary world, however, the speed and influence of the news media plays a dominant role. News of risk events is transmitted quickly and widely to a receptive public. These messages contain information about conditions that create the hazards and, in the case of technological dangers, there is both implied and specific identification of the responsible parties. Taken together, a hazard with inherent danger (e.g., radioactivity) and reports of mismanagement create serious public concern. The taxonomy used to explain the complex social processes that tie together these causal relationships was developed by Kasperson, et al. (1988) in "The Social Amplification of Risk: A Conceptual Framework." In the following decade this framework became an essential conceptual tool for social scientists who study issues of public responses to technological hazards. ***More than thirty peer-reviewed articles have directly dealt with this framework, and it has been widely accepted by and cited in the social science literature.***

Development of the Social Amplification of Risk (SAR) framework addressed a full range of public responses - from those relating to major accidents to those cases where some relatively minor risks or risk events, as assessed by technical experts, elicit strong public responses and produce substantial social and economic impacts. The main thesis of the SAR research is that hazards interact with psychological, social, economic, institutional, and cultural processes in ways that amplify or attenuate public responses, with consequent economic effects (Kasperson, et al., 1988). This research found, among other things, that a key determinant of amplification is public belief that an event is caused by managerial

383 incompetence and that it is a signal of increased future risk (Burns, et al., 1993). Concern about dangers from hazardous materials, especially when associated with evidence of poor organizational control, leads to the stigmatization of places, products, and even whole technologies (Gregory, et al., 1995). The history of America's nuclear facilities provides ample evidence of stigmatization associated with the nation's nuclear technologies (Flynn, 1999).

Specific examples of stigma responses are found in public responses to the transport of nuclear wastes with associated impacts on property values. Adverse impacts on property located near nuclear facilities were found in the case of the weapons plant at Rocky Flats, Colorado (Flynn, et al., 1998). The public response to potential danger from radioactivity is characterized by strongly negative images and negative affective evaluations.

Tourist and Visitor Studies

In their work on images of place and of a high-level radioactive waste facility, Slovic and his colleagues provided a research design and outlined a set of related propositions to examine possible connections between images and stigma. The research was designed to test the following three propositions:

1. Images associated with environments have diverse positive and negative affective meanings that influence preferences (e.g., in this case, preferences for sites in which to vacation, retire, find a job, or start a new business).

2. A nuclear waste repository evokes a wide variety of strongly negative images, consistent with extreme perceptions of risk and stigmatization.

3. The repository at Yucca Mountain and the negative images it evokes will, over time, become increasingly salient in the images of Nevada and of Las Vegas. (Slovic, et al., 1991, pp. 686-687)

Support for these propositions demonstrate a mechanism whereby the HLRW repository could adversely affect tourism, migration, and business development in Nevada. This demonstration is based upon established patterns people use to evaluate and characterize information about places as a prelude to making behavioral decisions. As such, the results from these studies do not rely upon introspective statements about future behaviors but reveal the underlying rationale for choices about places. The basis for evaluating places as revealed by images applies equally to places with or without radioactive

383 waste facilities and includes the full range of amenities and disamenities as perceived by respondents.

This was clearly demonstrated in a test-retest study of Phoenix, AZ survey respondents. In the retest interviews conducted 16-18 months after the first image elicitation, respondents were asked in which cities or states they had vacationed since the original interviews were conducted. The data show that the affective quality of the respondent's original image ratings were clearly related to the probability that person would subsequently vacation at places with the highest positive image ratings with the relationship being stronger for states than for cities.

A class of socioeconomic impacts of a HLRW facility at Yucca Mountain, therefore, will depend upon the nature of the repository images (positive or negative) as held by key economic actors (i.e., potential visitors, investors, and inmigrants), as well as the degree of association of these images with Nevada or Las Vegas. Both these conditions are subject to change and development over time. The existing images of a high-level radioactive waste repository have been collected from thousands of survey respondents. These data provide a baseline for answering the first part of the question about the nature of repository images. At present, it is known with a high degree of certainty that repository images are overwhelmingly negative.

Four surveys that interviewed 3,334 respondents produced a total of 10,000 images in response to a question about an "underground nuclear waste repository." The respondents also rated the effect associated with these images. The most arresting and important finding was the extreme negative quality of the images. More than 56 percent of the total images could be classified as negative consequences and negative concepts. These images included danger, toxic, death, sickness, environmental damage, bad, scary, decay, slime, and darkness. There were 232 images pertaining to war, annihilation, weapons, and things military. Positive imagery was less than a quarter of the total. The response "safe" was given only 37 times out of the 10,000 images (0.37 percent). Other concepts generally considered positive – "necessary," "employment," and "money/income" combined to total only 2.5 percent of the images.

The results of these image-based studies support and extend other methods of eliciting responses to HLRW programs and projects. Respondents in surveys were asked direct questions about whether a repository would reduce the desirability of a community located within 100 miles of the site. The activities measured were the attraction of the community as a place to attend a convention, vacation, raise a family, retire, or locate a new

383 business. In a national survey, between 41% (attend a convention) and 73% (raise a family) said a repository would reduce the desirability of the area.

Convention Impact Studies

Easterling and Kunreuther (1993) undertook a study of potential impacts to the Las Vegas convention industry from association with a repository at Yucca Mountain. They defined the industry at risk in two ways: the transfer of conventions from Las Vegas to other cities, and the decrease in the number of people who would attend meetings still held in Las Vegas. These possibilities were examined by studying the convention location process and the role of convention planners and by interviewing convention attendees. In this way the two important decision levels (planners and attendees) that determine attendance at conventions were addressed.

The research scenarios used in these studies included a variety of conditions that were defined within the social amplification of risk framework. That is, events as they might be treated in the news media, both amplified and attenuated, were evaluated by respondent-planners. Even the least adverse scenarios (a benign ten-year history of repository operation with dampened media attention) prompted 13 percent to 35 percent of the planners to say they would hold meetings somewhere else if a repository were located in the area. For the more dramatic scenarios (multiple mishap events with amplified media attention), 47 percent to 80 percent of the planners said they would go elsewhere.

Interviews with convention attendees were conducted with respondents who belonged to organizations that had held at least one meeting in Las Vegas during the preceding four years (1986-1989). This study found that images of places predicted attendance at the cities covered during the four years under review. The location of a HLRW repository near a convention city was compared to other conditions and resulted in the most negative evaluations, with 23 percent of the respondents reporting they "probably" or "definitely" would not attend.

Economic Development

Studies of economic development issues were conducted by Mountain West Research and its subcontractor Growth Strategy Organization to provide a baseline for potential economic impacts and to examine the role of stigma effects among business decision-makers (Mountain West Research, 1989). This research demonstrated that Las Vegas has significant strengths in competing for business development. These advantages

383 ... have been widely recognized since the early 1980s. Its location in the rapidly growing southwest is augmented by excellent surface and air transportation to the region. There is an abundance of land, cheap electric energy, excellent telecommunications, good climate, low taxes, and excellent recreational and entertainment opportunities. There are limitations in education, lack of a critical mass in manufacturing, and limitations on transportation to national markets to the east. Overall, the economic development potential for the Las Vegas area was judged to be excellent.

In the 1988 national survey of randomly selected citizens, two-thirds of the respondents felt that Las Vegas would be a desirable location for a new business, but this dropped to only 20 percent when respondents were aware of the repository possibility. In that case, 77 percent rated Las Vegas as an undesirable business location. The Mountain West study team followed up on these public responses by conducting a survey focusing on corporate decision-makers with expertise in business development and business site evaluation.

A survey of corporate decision-makers was conducted with a sample selected from *Who's Who in Corporate Real Estate*, published by the National Association of Corporate Real Estate Executives (NACORE). Five hundred and sixty-nine business people were contacted; 400 interviews were completed. Respondents were interviewed about four cities: Phoenix, Las Vegas, Denver, and Albuquerque. The interviews utilized the methods of image elicitation developed with public samples and also asked about the desirability of these cities as business locations in terms of five factors: work force availability, image of the city, availability and cost of space, quality of life, and accessibility to markets. Finally, the respondents were asked about a series of LULU's (locally unwanted land uses). These inquiries included proximity to a sanitary landfill, chemical manufacturing plant, oil refinery, and highways used for radioactive waste and nuclear materials transport. Additional questions asked about environmental conditions of poor air quality, flood plain location, and earthquake hazards.

These image responses, like those the public provided for vacation choices, produced a strong correlation between the image scores and the ranking of the cities as places to do business. In responding to the LULU conditions, 52 percent said a site next to a highway leading to an underground facility for disposing of radioactive wastes would be very influential (negatively so) in a location decision. This level of influence was greater than location on a highway leading to a "nuclear weapons testing site" (38 percent) or a "nuclear power plant" (26 percent). The siting of an underground radioactive waste storage facility at Yucca Mountain was found to affect the opinion of these decision-makers in terms of the physical security of their employees, their perception of the environment, and the area's

383 ... public image. Concerns were greatest for the location of administrative offices, business and professional services, and firms that serve the tourism/hospitality industry, an area of crucial importance to the Nevada economy.

The potential impacts from HLRW stigmatization of Nevada and/or Las Vegas could be very large, especially if the entertainment and visitor sectors were involved. The State of Nevada research estimated that a one percent decline in visitor spending from the 17 million visitors that came to the Las Vegas area in 1988 would reduce visitor spending by almost $100 million, lead to a drop in employment of about 7,000 jobs, and cut public revenues by $7,000,000 (Mountain West, Interim Report, 1989, pp. 4-26 to 4-28). As visitors and tourists in the year 2000 number around 30 million, potential impacts of a one-percent downturn would be even larger and more dramatic. Given the power of messages forwarded to the public through the social amplification of risk process, a significant decline in visitation trips to Las Vegas resulting from a spent fuel or HLW incident or accident should be expected.

The history of public responses to technological stigma supports a conclusion that sudden and serious economic impacts can result from accidents, incidents, or reports of mismanagement. Major accidents are obviously capable of provoking costly impacts. It is also true that seemingly minor events can produce major economic impacts. This phenomenon was addressed in the work on the social amplification of risk initiated with the conceptual framework article by Kasperson and his colleagues (1988). In the more than ten years since the publication of that article, dozens of studies have demonstrated the validity of the observation that widespread dissemination of news about potentially dangerous events through the news media, and now including the internet, is central to this stigma impact process.

Potential losses from hosting HLRW facilities as a result of economic stigmatization have been intuitively recognized by states and communities for many years. This widespread recognition was verified through the social science research outlined in this appendix. The mechanisms and the potential for serious social and economic impacts have been demonstrated. The implication for the Yucca Mountain Draft EIS is that these impacts must be considered if the final EIS is meet its mandated purposes.

The Overall Conclusion of the Nevada Research

The State's research has demonstrated that the Yucca Mountain repository program will result in significant socioeconomic impacts at all levels within the state, from the local

383 ... communities to the state government. The research has developed a convincing body of evidence that indicates the greatest potential socioeconomic threat from the proposed repository stems from what has been termed the "special effects" of the project. These are impacts related to intense negative perceptions and stigma associated by the public with a high-level radioactive waste repository, combined with the unique vulnerability of Nevada's economy to changes in its public image. Because of the high profile nature of the high-level nuclear waste disposal program, the potential exists for Nevada to become associated with these negative perceptions to the detriment of its ability to attract tourists, conventions, migrants, and diversified new industry to the state. This would be especially troublesome in the event of a nuclear waste accident in or near Las Vegas that might stigmatize the area and cause visitors to stay away in significant numbers. The work to date demonstrates clearly that Nevada is uniquely vulnerable to such stigmatizing effects because of its tourism-dependent economy and State revenue structure.

Summary: The Scope of Stigma Effects

The studies summarized in this appendix provide a guide to understanding nuclear stigma. The Social Amplification of Risk defines the conceptual framework, while the image studies provide a means to estimate potential impacts and monitor ongoing events. A report from Planning Information Corporation (1995) to the Clark County Nuclear Waste Division provides the theoretical and applied interface with existing economic-demographic modeling, such as the REMI model available to DOE personnel and contractors.

The importance of considering the economic impacts of technological stigma can be gauged by the important role they play in a wide range of economic activities. This includes economic development, investments in existing properties, potential declines in property values (relative to healthy economic conditions), increased unemployment with downturns in the Nevada visitor economy, and resulting negative impacts on public sector revenues leading to reduced public services (public safety, schools, transportation, public health, etc.). It is also highly probable that these stigma effects underlie social and political impacts at several levels of society. These same effects play an important but largely unexamined role in the history of tensions between communities, counties, the State of Nevada, and key entities of the federal government. One example of this is the introduction of potential economic stigma effects into adjudicatory proceedings between the State and DOE, as was the case in the recent water permit hearings before the State Water Engineer. Another area where stigma effects can clearly be seen is in the responses of states and communities along proposed transportation corridors. The conflict between the Mescalero Apaches in New Mexico and the State of New Mexico on the issue of a possible monitored retrievable storage

383 facility on the Indian reservation was largely based upon stigma concerns. Stigma impacts were also the basis for claims and court-awarded damages against the City of Santa Fe in regard to the transportation of transuranic wastes to DOE's Waste Isolation Pilot Plant facility in southern New Mexico.

The development of the methods to examine perceptions of risk, the Social Amplification of Risk framework, and the concept of Technological Stigma provide the means for understanding the long and difficult history of the nation's attempt to locate and develop radioactive waste facilities. This, in turn, allows researchers the means to evaluate the full range of potential socioeconomic impacts that a repository imposes on a host state and its communities and that spent fuel and HLW waste transportation imposes on states and communities along shipping routes. Research in these areas has been ongoing for a quarter of a century, and the methods and findings are well established in the peer-reviewed social science literature. A full and honest examination of the potential socioeconomic impacts resulting from stigma effects and public aversion to places associated with HLRW is possible, given the substantial social science resources now available. Such an examination is clearly called for to meet the standards of impact assessment mandated by federal law and regulation.

REFERENCES

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References A:

Carter, L. C. (1987). *Nuclear imperatives and public trust: Dealing with radioactive waste.* Washington, DC: Resources for the Future.

Clary, B. (1992). Enactment of the Nuclear Waste Policy Act of 1982: A multiple perspectives explanation. *Policy Studies Review, 10*(4), 90-102.

Colglazier, E. (1982). *The politics of nuclear waste.* Elmsford, NY: Pergamon.

Dunlap, R. E., Kraft, M. E., & Rosa, E. A. (1993). *Public reactions to nuclear waste: Citizens' views of repository siting.* Durham, NC: Duke University Press.

Easterling, D., & Kunreuther, H. (1995). *The dilemma of siting a high-level nuclear waste repository.* Boston: Kluwer Academic.

Flynn, J., Chalmers, J., Easterling, D., Kasperson, R., Kunreuther, Mertz, C. K., Mushkatel, A., Pijawka, K. D., Slovic, P., & with Lydia Dotto. (1995). *One hundred centuries of solitude: Redirecting America's high-level nuclear waste policy.* Boulder: Westview.

Flynn, J., & Slovic, P. (1995). Yucca Mountain: A crisis for policy: Prospects for America's high-level nuclear waste program. In *Annual review of energy and the environment* (Vol. 20, pp. 83-118). Palo Alto, CA: Annual Reviews Inc.

Holdren, J. P. (1992). Radioactive-waste management in the United States: Evolving policy prospects and dilemmas. In *Annual review of energy and the environment* (Vol. 17, pp. 235-259). Palo Alto, CA: Annual Reviews Inc.

Jacob, G. (1990). *Site unseen: The politics of siting a nuclear waste repository.* Pittsburgh, PA: University of Pittsburgh.

Nuclear Waste Policy Act of 1982 [Public Law 425. 97th Cong., 2nd sess., 7 January 1983].

References B:

Burns, W. J., Slovic, P., Kasperson, R. E., Kasperson, J. X., Renn, O., & Emani, S. (1993). Incorporating structural models into research on the social amplification of risk: Implications for theory construction and decision making. *Risk Analysis, 13,* 611-623.

Desvousges, W. H., Kunreuther, H., Slovic, P., & Rosa, E. A. (1993). Perceived risk and attitudes toward nuclear wastes: National and Nevada perspectives. In R. E. Dunlap, M. E. Kraft & E. A. Rosa (Eds.), *Public reactions to nuclear waste: Citizens' views of repository siting* (pp. 175-208). Durham, NC: Duke University.

383 ...

Dunlap, R. E., Kraft, M. E., & Rosa, E. A. (1993). *Public reactions to nuclear waste: Citizens' views of repository siting.* Durham, NC: Duke University Press.

Fischhoff, B. (1989). Risk: A guide to controversy. In *Improving risk communication* (pp. 211-319). Washington, DC: National Academy Press.

Flynn, J. (1999, September). *Nuclear stigma.* Paper presented at the Workshop on the Social Amplification of Risk, London.

Flynn, J., Burns, W., Mertz, C. K., & Slovic, P. (1992). Trust as a determinant of opposition to a high-level radioactive waste repository: Analysis of a structural model. *Risk Analysis, 12*(3), 417-429.

Flynn, J., Kasperson, R. E., Kunreuther, H., & Slovic, P. (1997). Overcoming tunnel vision: Redirecting the U.S. high-level nuclear waste program. *Environment, 39*(3), 6-11, 25-30.

Flynn, J., Peters, E., Mertz, C. K., & Slovic, P. (1998). Risk, media, and stigma at Rocky Flats. *Risk Analysis, 18*(6), 715-727.

Flynn, J., & Slovic, P. (1993). Nuclear wastes and public trust. *Forum for Applied Research and Public Policy, 8,* 92-100.

Flynn, J., & Slovic, P. (in press). Expert and public evaluations of technological risks: Searching for common ground. *Risk: Health, Safety & Environment.*

Gregory, R., Flynn, J., & Slovic, P. (1995). Technological stigma. *American Scientist, 83,* 220-223.

Hunsperger, W. (1997, March). *The effects of the Rocky Flats nuclear weapons plant on neighboring property values.* Paper presented at the Conference on Risk, Media, and Stigma, Philadelphia.

Jenkins-Smith, H. (1991, June). Alternative theories of the policy process: Reflections on research strategy for the study of nuclear waste policy. *PS: Political Science & Politics,* pp. 157-166.

Jenkins-Smith, H. C. (1993). *Nuclear imagery and regional stigma: Testing hypotheses of image acquisition and valuation regarding Nevada* [Technical report]. Albuquerque, NM: University of New Mexico, Institute for Public Policy.

Kasperson, R. E. (1992). The social amplification of risk: Progress in developing an integrative framework of risk. In S. Krimsky & D. Golding (Eds.), *Social theories of risk* (pp. 153-178). New York: Praeger.

Kasperson, R., Golding, D., & Tuler, S. (1992, Winter). Social distrust as a factor in siting hazardous facilities and communicating risks (Individual and collective responses to risk). *Journal of Social Issues, 48*(4), 161-188.

383 ...

Kasperson, R. E., & Kasperson, J. X. (1996, May). The social amplification and attenuation of risk. *The Annals of the American Academy of Political and Social Science, 545,* 95-105.

Kasperson, J. X., Kasperson, R. E., Perkins, B. J., Renn, O., & White, A. L. (1992). *Information content, signals, and sources concerning the proposed repository at Yucca Mountain: An analysis of newspaper coverage and social-group activities in Lincoln County, Nevada* [RP0136/MRDB]. Worcester, MA: Clark University, CENTED.

Kasperson, R. E., Renn, O., Slovic, P., Brown, H., Emel, J., Goble, R., Kasperson, J. X., & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis, 8,* 177-187.

Kraus, S.J., (1995) Attitudes and the Prediction of Behavior: A Meta-Analysis of the Empirical Literature. *Personality and Social Psychology Bulletin, 10 (1):58-75.*

Kunreuther, H., Easterling, D., Desvousges, W., & Slovic, P. (1990). Public attitudes toward siting a high-level nuclear waste repository in Nevada. *Risk Analysis, 10,* 469-484.

Kunreuther, H., & Slovic, P. (1996). Science, values, and risk. *The Annals of the American Academy of Political and Social Science [special issue on risk assessment and risk management], 545,* 116-125.

Kunreuther, H., Desvousges, W. H., & Slovic, P. (1988). Nevada's predicament: Public perceptions of risk from the proposed nuclear waste repository. *Environment, 30*(8), 16-20, 30-33.

National Research Council (NRC). Committee on Risk Characterization. (1996). *Understanding risk: Informing decisions in a democratic society* (P. C. Stern. & H. V. Fineberg, Eds.). Washington, DC: National Academy Press.

National Research Council. National Academy of Science. Board on Radioactive Waste Management. (1990). *Rethinking high-level radioactive waste disposal: A position statement of the Board on Radioactive Waste Management.* Washington, DC: National Academy Press.

Peters, E., & Slovic, P. (1996). The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology, 26,* 1427-1453.

Planning Information Corporation. (1995). The Clark County/Las Vegas Visitor Profile and Visitor-Gaming Economy. Report to the Clark County Nuclear Waste Division, Comprehensive Planning, 500 S. Grand Central Pkwy, P.O. Box 551751, Las Vegas, Nevada 89155-1751.

383 ...

Renn, O., Burns, W., Kasperson, J. X., Kasperson, R. E., & Slovic, P. (1992). The social amplification of risk: Theoretical foundations and empirical applications. *Journal of Social Issues, 48*(4), 137-160.

Secretary of Energy Advisory Board. Task Force on Radioactive Waste Management. (1993, November). *Earning public trust and confidence: Requisites for managing radioactive waste.* Washington, DC: Author.

Slovic, P., Flynn, J., & Gregory, R. (1994). Stigma happens: Social problems in the siting of nuclear waste facilities. *Risk Analysis, 14*(5), 773-777.

Slovic, P., Layman, M., & Flynn, J. (1991). Risk perception, trust, and nuclear waste: Lessons from Yucca Mountain. *Environment, 33,* 6-11, 28-30.

Slovic, P., Layman, M., Kraus, N., Flynn, J., Chalmers, J., & Gesell, G. (1991). Perceived risk, stigma, and potential economic impacts of a high-level nuclear waste repository in Nevada. *Risk Analysis, 11,* 683-696.

Slovic, P. (1987). Perception of risk. *Science, 236,* 280-285.

Slovic, P. (1990). The legitimacy of public perceptions of risk. *Journal of Pesticide Reform, 10*(1), 13-15.

Slovic, P. (1990). Perception of risk from radiation. In W. K. Sinclair (Ed.), *Proceedings of the Twenty-fifth Annual Meeting of the National Council on Radiation Protection and Measurements, Vol. 11: Radiation protection today: The NCRP at sixty years* (pp. 73-97). Bethesda, MD: NCRP.

Slovic, P. (1992). Perception of risk: Reflections on the psychometric paradigm. In S. Krimsky & D. Golding (Eds.), *Social theories of risk* (pp. 117-152). New York: Praeger.

Slovic, P. (1993). Perceived risk, trust, and democracy. *Risk Analysis, 13,* 675-682.

Slovic, P. (1997). Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. In M. H. Bazerman, D. M. Messick, A. E. Tenbrunsel & K. A. Wade-Benzoni (Eds.), *Environment, ethics, and behavior* (pp. 277-313). San Francisco: New Lexington.

Slovic, P., Flynn, J. H., & Layman, M. (1991). Perceived risk, trust, and the politics of nuclear waste. *Science, 254,* 1603-1607.

Slovic, P., Layman, M., & Flynn, J. (1990, September). *What comes to mind when you hear the words "Nuclear waste repository"? A study of 10,000 images* (Report No. NWPO-SE-028-90). Carson City, NV: Nevada Agency for Nuclear Projects.

Slovic, P., & Peters, E. (1998). The importance of worldviews in risk perception. *Risk Decision and Policy, 3*(2), 165-170.

383 cont.

U.S. Department of Energy. Advisory Panel on Alternative Means of Financing and Managing Radioactive Waste Facilities. (1984, December). *Managing nuclear waste—A better idea* [A report to the U.S. Secretary of Energy]. Portland, OR: Author.

U.S. Department of Energy (USDOE). (1992, December). *Draft final report of the Secretary of Energy Advisory Board Task Force on radioactive waste management.* Washington, DC: Author.

U.S. Office of Technological Assessment. (1985). *Managing the nation's commercial high-level radioactive waste* (OTA-O-171). Washington, DC: Author.

Weart, S. (1988). *Nuclear fear: A history of images.* Cambridge, MA: Harvard University.

White, A. L., Edwards, S., & Emani, S. (1990). *Risk perceptions of the Yucca Mountain repository: A comparative assessment of Caliente and other southern Nevada communities.* Worcester, MA: Clark University, CENTED.

References C:

Reports and Data from the Nevada Socioeconomic Studies - Summaries attached to this Appendix.

YUCCA MOUNTAIN SOCIOECONOMIC PROJECT
DELIVERABLES

- MRDB -
12/16/99

MRDB #	AUTHOR	TITLE	PUBLICATION DATE
ED0020	Anderson, E.	REMI Policy Simulation Interface: Overview Yucca Mountain Socioeconomic Project	01/31/90

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase IV-B, Task 2.0) describes the REMI Policy Simulation Interface Program written to simplify the data management aspects of handling regular and translator policy variables for the REMI FS-53 modelling system. Policy and translator policy variables are used in the REMI model to alter the baseline (or control) forecasts for a region and to simulate the economic and demographic effects of specific exogenous events. Such events could include such things as in increase in hotel and resort employment, tax changes, energy costs, income, or sales.

First, this Overview describes the two ways the REMI model can incorporate changes in policy variables: (1) through an interactive batch program that queries the user through a series of steps to input the policy variable changes; or (2) through the use of Lotus print files. Secondly, the Overview describes the two major components of the Interface program: (1) the Data Management component, which serves as a database manager for the storage, retrieval, and modification of policy variables; and (2) the Simulation Management component that serves as an audit trail for REMI simulations and performs a number of calculations and formatting functions. Finally, instructions on how to use the Interface Program are provided.

IG0002	Atkinson, G.	The Department of Taxation: State-Level Economic-Demographic and Fiscal Costs Yucca Mountain Socioeconomic Project	04/14/88

This document, prepared for NWPO's Yucca Mountian Socioeconomic Project (Phase III, Task 4.2), examines the organizational structure and functions of the Nevada Department of Taxation. The oversight roles of the Tax Commision and the State Board of Equalization in the operation of the Department of Taxation are discussed. The functions and responsibilities of the various divisions within the Department are also described including the following divisions: Administrative, Local Government, Compliance, Assessment Standards, Executive, Revenue and Audit. This report contains a brief description of the revenue collection and distribution system including the state's role in collecting and distributing taxes back to the local governments. Taxes discussed in the report include: sales and use, excise, and ad valorem including centrally assessed property. Tables are included showing: staffing, salary expenditures and appropriations, and expenditures for the Department. The impact of the repository on the Department is expected to result from economic and demographic factors and the anticipated increased number of accounts; the repository's potential impact on the Department's workload is examined. The two divisions expected to be most impacted are the Compliance Division and the Division of Assessment Standards.

IG0004	Atkinson, G.	Employment Security Department: State-Level Economic-Development and Fiscal Costs Yucca Mountain Socioeconomic Project	06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 4.2; Phase III), descibes the organization, functions and funding of the Nevada Employment Security Department (ESD) and potential impacts on the agency from the repository. The ESD is the major public labor market intermediary in the State of Nevada; its goals are to promote economic growth through the effective administration of a labor exchange, and to provide economic and labor force stability through the administration of an unemployment compensation system. The funding discussion includes: funding sources, funding mechanisms and funding trends from 1985 to 1988. The influx of workers seeking employment was considered to be the principal source of impact on the agency - primarily affecting the Employment Services Division of the ESD. Since the current funding mechanism of the ESD was not expected to be able to meet future demands due to the inmigrants, the author proposes an idealized funding mechanism for the ESD that would recognize the repository's impact.

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This document also contains tables demonstrating agency trends in: staffing, number of offices, budget and staff salaries. Appendix A shows detailed organizational charts of all the divisions of the ESD and how they relate to one another and to the state government;the duties of the ESD's various offices are also outlined. Appendix B shows example documents used by the ESD's Unemployment Insurance Division for federal funding. This document is one of a series of reports of this type discussing potential impacts of the repository on Nevada state agencies (see documents IG0002 through IG0008). The methodology for assessing state agency impacts is discussed in document IG0001.

IG0005 Atkinson, G. Department of Education: State-Level Economic-Demographic and Fiscal Costs Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 4.2, Phase III), describes the organizational structure and functions of the Nevada Department of Education, its two major divisions (the Instructional, Research and Evaluative Division and the Administrative and Fiscal Division) and the specialized branches of these divisions. The author also discusses the Distributive School Account, the funding mechanism for providing direct financial aid to local school districts, which is administered by the Department of Education. The budget and staff of the department are outlined including charts showing trends in appropriations and expenditures for 1982/83 to 1986/87. Lastly, preliminary estimates of the impact of the Yucca Mountain repository on the Nevada Department of Education are made.

Attached with this document are two appendixes containing a series of reports. Included in Appendix A are: the 1985-86 Biennial Report to the Governor, a report on state and federal funding for occupational education, a report on funding the occupational education in Nevada, and finally a sequence of charts with data on student enrollment and licensed personnel. Appendix B contains: an explanation of the Nevada Plan (to finance public education), a memo explaining 1988-89 basic support statistics, and an update of the 1987-88 estimates of school statistics. This document is one of a series of reports of this type discussing Nevada state agencies and the possible impact of the repository on these agencies (see documents IG0002 through IG0008). The methodology for assessing state agency impacts is discussed in document IG0001.

RA0043 Audin, L. Comments on the Preliminary Design Report for the BR-100 Rail Cask Yucca Mountain Socioeconomic Project 07/31/90

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 13.0) reviews the DOE preliminary design report for the BR-100 rail cask. The author felt that the DOE report addressed the basic requirements of 10CFR71, but only minimally, and left many important items for resolution in the the final design. Since some of these interact with items seemingly "settled" at the preliminary design stage, there is some question concerning the completeness of the preliminary design. When compared to the often robust work by General Atomics on the GA-4 and 9 design, the BR-100 report appeared to the author to be quite lean. He was especially concerned with the use of non-standard materials (e.g., aluminum and concrete) and the somewhat simplistic and shallow treatment of hypothetical accident conditions.

Four general areas of concern were mentioned with the design and its supporting document: (1) choice of materials; (2) lack of sophistication; (3) analysis of interactions; and (4) human error handling. This commentary primarily focused on these items; since so much of the preliminary design remained unfulfilled, a more detailed critique must await the final design report. In conclusion, the BR-100 preliminary report was found to be surprisingly incomplete, despite its claims. The author felt it read more like a secretive overview, keeping the reader in the dark whenever a controversial issue might arise. While some of its trade-off analyses provided interesting results, the main body of the report did not supply the necessary background to accept the BR-100 design, even in a preliminary form. For other reports reviewing DOE preliminary design reports, see MRDB ID#'s RA0039, RA0041, and RA0042.

RA0042 Audin, L. Comments on the Preliminary Design Report for the GA-4 and GA-9 Casks Yucca Mountain Socioeconomic Project 07/31/90

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 13.0) reviews the DOE preliminary design report for the GA-4 and GA-9 casks. In the author's opinion, the DOE report addressed the basic requirements of 10CFR71 and, in some ways, was more complete than some final design reports for spent fuel casks certified in the past. Like those past reports, however, it was felt to leave many unanswered (or at least unclarified) questions, and proffers a design that works better on paper than would be likely in real life. Four general areas of concern were identified with the design and its supporting document: (1) fabrication and quality assurance requirements will be difficult to acheive and maintain; (2) some safety margins are quite narrow; (3) unexamined vulnerabilities exist; and (4) questions exist regarding supporting data.

While some of these problems might be ameliorated in the final report, others were felt to be endemic to the design and could not be resolved by additional documentation. In many ways, innovative and better than their predecessors, the GA-4 and GA-9 designs were not considered acceptable as portrayed in the preliminary report. This commentary first elaborates on these general concerns, and then lists examples and questions that relate to one or more of these problems. For other reports reviewing DOE's preliminary cask design reports, see MRDB ID#'s: RA0039, RA0041, and RA0043.

TR0040 Ballard, J.D. An Assessment of Transportation Risks: Sabotage and Terrorism as Risk Factors for the Shipment of Materials to the Proposed Yucca Mountain Facility 07/01/96

This preliminary study (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies, Phase V, Task 13.7) begins the process of identifying the potential risk of terrorism against shipments of HLNW to the proposed Yucca Mountain repository. The report examines Rand Corp. records of international terrorist activity to help extablish that a risk exists. The author finds that the Rand data combined with other sources (FBI, ATF, etc.) indicate that a potential risk of terrorist attack exists for the transportation of nuclear waste.

The author analyzes some consequences of a successful or attempted attack. In particular the report focuses on the economic, environmental, social, and moral consequences of a terrorist attack. In addition to the problems one could reasonably expect from an accident scenario, a terrorist attack may generate significant impacts with regard to public perceptions of the risk of nuclear waste transportation. The author also discusses some of the various methodologies that exist, or that could be designed, to reduce the risks for transportation of HLNW. Finally, the report offers a series of suggestions for additional research.

TR0038 Bentz, E. J. Technical & Institutional Considerations Regarding Near-Term (1998) Spent Fuel Transportation To An Interim Storage Facility (NWPO Yucca Mountain Socioeconomic Project 09/01/95

This document (prepared as part of the Nevada Yucca Mountain Socioeconomic Studies, Phase V, Task 13.8) discusses issues involved in transporting spent nuclear fuel to an interim facility. The following three areas are addressed: (1) at-reactor and near-site facility interface, transportation, infrastructure, and institutional issues; (2) transportation equipment availability, including currently-licensed casks and new cask designs; and (3) rail transportation issues.

CF0013 Boutte, M. Community Health Information Project (CHIP): Preliminary Framework for a Health Studies Program Yucca Mountain Socioeconomic Project 09/01/96

The Nevada Nuclear Waste Project Office plans to incrementally develop and implement a community-based program for generating baseline health effects data, monitoring health effects indicators, and identifying potential impacts that may result from Yucca Mountain activities. The first phase of this project involved a review of the literature, design of a pilot health effects study, and identification of a community for implementing the pilot effort. The next step is to design a community health effects monitoring and impact assessment component that can be implemented in targeted, potentially vulnerable communities. The end goal is a workable framework for a Nevada health studies program that can be implemented in collaboration with affected communities and appropriate State agencies. This report (prepared as part of the NWPO Yucca Mountain Studies: Phase V, Task 15.1) presents a general and preliminary environmental epidemiological framework for guiding the initial steps in constructing a formal study protocol for health assessment and monitoring.

CF0015 Boutte, M. Health Effects Studies: Epidemiology at Nevada Test Site: Thyroid Cohort Study Yucca Mountain Socioeconomic Project 01/31/97

This report (prepared as part of the Nevada Yucca Mountain Socioeconomic Studies, Phase VI, Task 3.1) reviews the epidemiological studies of the NTS. Two major health studies were conducted: the Utah Thyroid Cohort Study (UTCS) and the Utah Leukemia Case-Control Study. This document focuses on the UTCS; another report reviews the leukemia studies (see MRDB# CF0016). The objectives of the UTCS were to assess the association, if any, between exposure to iodine-131 from fallout from the NTS and the incidence of thyroid disease among selected downwind populations, and to estimate the absorbed dose of I-131 to the thyroid gland of cohort members. These studies were essentially completed in the early 1990's and publication of results continue to appear in scientific journals. The author provides a review of these journal articles including a description of the methodology of epidemiologic and dosimetry components of the study and discusses the limitations and biases of these studies. The dosimetry results with regard to Lincoln County, Nevada are also discussed. Even though the UTCS received criticism, especially in terms of methodology, results eventually showed that exposure to radioiodines from weapons testing at the NTS was associated with an excess of thyroid neoplasms in residents downwind from the test site.

CF0016 Boutte, M. Health Effects Studies: Epidemiology at Nevada Test Site: Leukemia Yucca Mountain Socioeconomic Project 04/30/97

This report (prepared as part of the Nevada Yucca Mountain Socioeconomic Studies, Phase VI, Task 3.1) reviews epidemiological studies of the NTS. Two major health studies were conducted: the Utah Thyroid Cohort Study (UTCS) and the Utah Leukemia Case-Control Study. This document provides a review of a series of studies of childhood leukemias and other cancers; another report reviews the UTCS (see MRDB# CF0015). As early as 1965, an increase in leukemia mortality in southwestern Utah (1950 through 1964) was reported by several studies. Subsequent investigations both supported and refuted these findings. As in the thyroid studies, however, the addition of dosimetry studies to epidemiological findings helped to clarify the association between leukemia and radioactive fallout.

ED0014 Boyle, R. Assessment of the Impact of a Nuclear Waste Repository at Yucca Mt on the Econ. Dev. Potential of Las Vegas, Clark County, and the Surrounding Area 01/01/89

This document, prepared as part of the NWPO Socioeconomic Project (Phase IVA, Task 8.1.6), discusses the potential impacts of the proposed Yucca Mountain repository on Clark County's competitiveness as a business facility location in the mid- to late-1990's. The author projects negative impacts on Clark County's economic development competitiveness for manufacturing and distribution facilities, information processing centers, and administrative office operations and business and professional services firms should the repository be located at Yucca Mountain. The analysis is based on previous research conducted by the author (see MRDB ID#s ED0007 and ED0008).

ED0007 Boyle, R. Business Profile of Metropolitan Las Vegas Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 2.1.6, Phase III), describes the present makeup of the Las Vegas Metropolitan Statistical Area (MSA) economy and analyzes the climate for business expenditures in 1988. This document is the first of two reports (ED0007 and ED0008) which, together, provide a baseline for an assessment of likely effects of the Yucca Mountain repository on Las Vegas MSA economic development potential. This report is the product of information collected and analyzed by Growth Strategies Organization and Mountain West. It consists of two parts. The first part describes the current local economy by comparing population trends and eonomic patterns locally, with other nearby market places, and with national figures.

The second part documents the area's overall capacity to respond to each of 40 business locational factors, factors which influence a business' investment decision on where to locate. These 40 business locational factors are sorted and analyzed in eight broad factors: access to markets, access to resources consumed in producing a product or providing a service, labor force characteristics, access to financal capital, access to and cost of space, public sector investment in the business climate, government-imposed business costs and quality of life considerations. This business climate profiles serves as a foundation of an analysis of industries for which the Las Vegas MSA is a competitive location for new capital investment. This report also provides a baseline for assessing the economic impacts of future actions which could affect the area's potential for attracting and retaining business investment.

ED0008 Boyle, R. Current Target Industry Analysis: Las Vegas Metropolitan Area Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 2.1.6, Phase III), presents an analysis of potential baseline target industries for the Las Vegas Metropolitan Statistical Area (MSA). This document is the second of two reports dealing with the Las Vegas MSA's economic and socioeconomic impact statement for the repository at Yucca Mountain. This report draws on the business climate assessment posture in pursuing business investment in the "primary" sector of the economy--businesses which sell their products or services outside the local marketplace and businesses serving local customers who would otherwise import these products or services from suppliers outside the area.

The authors of this report have attempted to model the decision-making process used by businesses in selecting locations for new or expanded business investment. Each of the 40 business locational factors, identified by Growth Strategies Organization (see document ED0007), are coded numerically in terms of "relative importance" and "community response". These numbers are then compared with the needs of 600 different types of manufacturer and producer industries (defined at or beyond the 4-digit SIC system level). Those industries most suited for the Las Vegas MSA are identified and examined in greater detail in the latter part of this report.

RP0108 Burns, W., *Kasperson, R., *Kasperson, J., *Renn, O., *Emani, S., and Slovic, P. Social Amplification of Risk: An Empirical Study Yucca Mountain Socioeconomic Project 09/01/90

This paper reports on a theoretical framework called "the social amplification of risk." The research that went into this framework was funded in part through the NWPO Yucca Mountain Socioeconomic Project (Phase IVA, Task 7.0). According to this theory, the societal impact of an unfortunate event (e.g., an accident, discovery of pollution, product sabotage, etc.) is determined not only by the event's direct harmful consequences but by media coverage, perceived risk, and public response. Analysis of the impacts of 108 adverse events supported the theory by demonstrating that the behavior of the media and the public play crucial roles in determining the impact of a hazard event. Perceptions of managerial incompetence and perceptions of the degree to which people might be at risk from future events of this kind also were found to be important predictors of the public's response to an accident. These findings suggest that ignoring the reactions of the media and public may lead to gross underestimation of the risk that a hazard poses for a firm, an industry, or a society.

SE0014	Carter, L. and Willard, W.	Scope, Stakeholder Groups, and Impact Issues Raised by the Proposed Hanford Washington HLNW Repository Site Yucca Mountain Socioeconomic Project	05/01/92

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies: Phase IV-C, Task 9.3.1) identifies the diverse publics concerned with development of the Hanford Nuclear Reservation as a potential site for a HLNW repository and explores reasons for inclusion or exclusion of certain publics and inclusion or omission of issues important to each of these groups. Special attention is given to delimiting: (1) the diverse "publics," (2) the issues of interest to these publics, (3) the reasons why some publics and issues received attention early in the selection process, while others did not, and (4) some of the longer-tern consequences that followed from these exlusionary choices.

The study suggests that artificial narrowing of scope conditions is not a site specific phenomenon. Rather, some special characteristics of the nuclear industry as its representatives interact with diverse publics, and as these publics form perceptions of the industry, seem to raise recurrent issues. To the extent permitted by observations, the report identifies lessons from the Hanford experience that appear to have relevance for anticipating and managing the impacts that might be associated with development and operation of a repository for HLNW at the Yucca Mountain site. The authors conclude that more inclusive definitions of impacted areas, impact variables, and affected publics, while more cumbersome in the short run, pose fewer risks of awkward oversights. Field verification of suspected impact areas and groups becomes especially important in contexts where an adversarial model of multiple parallel studies, responsive to different interested "publics," is employed.

SE0015	Chalmers, Easterling, Flynn, Fowler, Gervers, Halstead, Kasperson, Krannich, Kunreuther, Little, et al.	State of Nevada Socioeconomic Studies of Yucca Mountain 1986-1992: An Annotated Guide and Research Summary Yucca Mountain Socioeconomic Project	06/01/93

This volume is the summary report for the State of Nevada Yucca Mountain Socioeconomic Studies conducted between 1986 and 1992. The unique nature of a repository facility, the uncertain schedules, public risk perceptions and potential behaviors, the highly charged political atmosphere, and the need to develop new and innovative reserach approaches were addressed in the study design and the subsequent study efforts. Each chapter, which begins with a short introduction followed by an explanation of the objectives of the research, the general methods used, an annotated bibliography of reports submitted to the NWPO, the major findings, and the implications for further research, present a detailed description of the research effort that resulted.

Table of Contents: Introduction, 1) Study Design, 2) Project Description, 3) Economic-Demographic, 4) Government Systems, 5) Fiscal, 6) State Agencies, State Government, and Intergovernmental Relations, 7) National, Regional, and Nevada State Surveys, 8) Social-Cultural: Rural Communities, 9) Urban Area Impacts, 10) Socio-Cultural: Native Americans, 11) Case Studies, 12) Risk Assessment, 13) Risk Perception and Behavior, 14) Equity, 15) Trust and the Repository Program, 16) Management and Policy, 17) Transportation, 18) An Overview.

NU0039	Cook, B., Emel, J. and Kasperson, R.	Clashing Judgment, Common Fears: Solving the Nuclear Waste Disposal Problem (DRAFT) Yucca Mountain Socioeconomic Project	08/24/91

No abstract.

ED0023	Coopers & Lybrand (C&L)	Las Vegas Business Climate Assessment Yucca Mountain Socioeconomic Project	10/04/90

The purpose of this document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 2.4) is to assess Las Vegas' business operating costs and conditions in comparison to the Southern California market. The report reviews the local locational characteristics that influence various forms of business investment. These factors include: access to markets, access to resources, space availability and cost, work force, public sector influence, and quality of life. The business climate assessment serves as a baseline from which to measure and compare Las Vegas' position as a "product" in the market place. The city's strengths and weaknesses are discussed. The contents of this report are to assist the City of Las Vegas in focusing marketing efforts on Southern California firms likely to expand or relocate to Las Vegas. The Southern California cities of Alhambra, Irvine, and Glendale were selected as likely sources of prospects seeking to expand or relocate.

The report analyzes the significant factors which determine Las Vegas' competitive position. Each section begins with a short discussion of the relevance of the site location criteria for the needs of business, then presents a profile of the Las Vegas situation, and concludes with an assessment of competitive market areas in Southern California. The report presents sections on: information on access to markets by examining the area's transportation systems; access to resources; access to labor resources; real estate in terms of access to commercial and industrial space and nonresidential development costs as well as the cost and availability of residential property; impact of the public sector on the business climate of Las Vegas (i.e., taxes, business incentives, etc.); quality of life factors such as climate, recreation/culture, and personal safety in Las Vegas; and conclusions in a matrix format about Las Vegas' competitiveness relative to the target Southern California markets.

ED0024	Coopers & Lybrand (C&L)	Las Vegas Target Industry Update Yucca Mountain Socioeconomic Project	10/04/90

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 2.4) examines Las Vegas' competitiveness for new and expanding business investment from Southern California. The purpose of this report was to update the target industry analysis completed in 1988 by Mountain West (see MRDB ID#s ED0007 & ED0008). The development of a HLNW repository in southern Nevada would likely have direct and indirect implications for the future economic base of the Las Vegas urban area. In order to better understand the possible effects of a repository, it is essential that economic development baseline information be developed. This involves the analysis of the potential for future economic develoment in the Las Vegas area together with an analysis of the business climate which governs the scope and direction of such economic development.

Based on the analysis, Las Vegas was found to be locationally competitive for 34 target industries in southern California. These industries have site location needs for which Las Vegas is competitive, have better-than-average employment growth, and have "strong" or "medium" regional presence in southern California. Las Vegas' southern California target industries can be characterized in the following industry groups: office users, information processors, distributors, hospitality/retailers, printing and publishing, computer and instruments, wood products, and furniture manufacturers. A companion report to this document is MRDB ID# ED0023.

NA0005	Cultural Resources Consultants (UNR)	Native American Visit to Yucca Mountain: October 16-17, 1987 Yucca Mountain Socioeconomic Project	03/30/88

This document is an account of a two-day site visit of ten Native American consultants to Yucca Mountain; this visit was conducted as part of the State's Yucca Mountain Socioeconomic Project (Phase III, Task 6.0). The visit was designed as part of an ongoing assessment of Native American (particularly the Southern Paiute and Western Shoshone) concerns regarding siting within their aboriginal territories. The visit was also designed to acquaint the consultants with the features of the region and possible impacts on it. The visit consisted of inspections of nine archeological sites at or around Yucca Mountain, an area that has been closed to the public since 1941. This document transcribes the activities and comments of the consultants as they visited each site as well as lists Native words for plants, animals and places whenever they were identified by the Native American consultants.

RP0016 Cummings, R. New Mexico's Waste Isolation Pilot Project (WIPP): A Historical Overview Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 7.5, Phase III), is a historical overview of the Waste Isolation Pilot Project (WIPP) in New Mexico. As the nation's first HLNW repository, many aspects of WIPP's evolution and development may be applicable to Yucca Mountain. Thus, this report focuses on those aspects which relate to the socioeconomic impacts (anticipated and realized) of the WIPP. Major technical issues, and issues related to public confidence in DOE, which have been raised to date during the site characterization and construction phases of the WIPP are discussed.

The patterns of public reactions to the WIPP project and the successes and failures of the state and the DOE in dealing with these reactions are described. The promise of economic benefits projected for the WIPP and the WIPP's performance in generating such benefits are compared. The issue of impact/risk management and the relative successes and failures of community involvement in such management are also highlighted. Community involvement in the management of impacts from the nuclear waste storage facility are then evaluated in the concluding section.

RP0009 Desvousges, W., Dunford, R., Frey, J., Kunreuther, H., Kasperson, R., and Slovic, P. High-Level Nuclear Waste Risks Surveys: Integrated Survey Plan Yucca Mountain Socioeconomic Project 12/23/86

An important part of the NWPO Yucca Mountain Socioeconomic Study is to assess the impacts to Nevada resulting from people's risk perceptions of a HLNW repository. A number of activities and surveys will be undertaken over a period of time. This document (prepared as part of Phase II, Task 6.3.1) describes the integrated survey plan that will guide the research activities for the risk team during Phase II. As this is a new area of research in impact assessment this document is viewed by the authors as a working draft that will be revised as the study proceeds. This plan brings together the research design for measuring risk impacts, the sampling plan for drawing a representative sample, and the survey plan for ensuring the quality of the interviews. Chapter 1 provides an overview of the plan and its objectives, including some background material on risk surveys. The research design that underpins both the survey questionnaires and planned empirical analyses is described in Chapter 2. Chapter 3 highlights the important sampling issues and presents a plan for addressing them. Chapter 4 summarizes the planned survey activities that will provide the essential quality assurances. The final chapter presents a list of key items requiring further discussion.

A number of activities were subsequently undertaken by the risk team during Phase II and are reported on in separate documents. An inventory of concerns and issues to Nevada is presented in MRDB ID# RP0002. Focus group meetings were held prior to design of the risk perception survey questionnaire. The plan for the meetings can be found in MRDB ID# RP0007, while the findings are summarized in ID# RP0006. MRDB ID# RP0003 summarizes the results of the telephone surveys. Finally, another document (ID# RP0001) discusses the potential for the perceived risks associates with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy.

RP0006 Desvousges, W., Dunford, R., Frey, J., Kunreuther, H., Kasperson, R., and Slovic, P. High-Level Nuclear Waste Repository Risks: Focus Group Findings and Implications for Surveys Yucca Mountain Socioeconomic Project 01/15/87

This document summarizes the HLNW repository risk focus groups activities conducted as part of Task 6.2 of the Yucca Mountain Socioeconomic Study (Phase II). The primary goal of the focus groups was to find ways to elicit people's perceptions of the potential risks of siting a HLNW repository at Yucca Mountain. These insights were used in developing the questionnaire for the telephone surveys conducted later during Phase II (document ID# RP0003 summarizes the results of the telephone surveys). Three focus group meetings were conducted in late Fall of 1986 in the communities of Pahrump, Las Vegas and Caliente. Summaries of each meeting are contained in the Appendix of this document. The report summarizes the three meetings noting differneces among the perceptions of the different communities. Some of the issues discussed at the meetings include: perceived likelihood of siting the repository at Yucca Mountain; evaluation of mitigation and compensation alternatives; attitudes or confidence in the government's abilitiy to safely manage a HLNW repository; and risk perceptions associated with the repository, including a comparison with other types of risks.

Chapter 4 discusses the implications of the focus group findings for the risk perception telephone survey questionnaire. The main themes that emerged from the focus groups include: characteristics of risk are important in risk perceptions; people perceive various sources of risk with transporation as the most prominent source; a complex mix of factors influences the risks people perceive from the repository; urban/rural differences are likely to be significant in explaining risk perceptions; compensation and mitigation are important areas but may be difficult for telephone surveys; and the amount of information and knowledge about the repository differs significantly among people. Also on file are videotape of the Las Vegas and Pahrump focus groups. The insights developed through the focus groups were also incorporated into the integrated survey plan developed to guide the integrations of the risk perception activities (see ID# RP0009).

RP0007 Desvousges, W., Frey, J., Kunreuther, H., Kasperson, R., Slovic, P., and Pijawka, D. — Nuclear Waste Repository Risks: Revised Focus Group Plan Yucca Mountain Socioeconomic Project — 10/16/86

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase II, Task 6.2) discusses the role of the focus groups in the HLNW repository risk perception surveys, which were conducted as part of the NWPO project. The two main objectives of the focus groups were: to provide ideas for developing the risk perception and compensation-mitigation survey questionnaires; and to learn about people's perceptions of risks from the nuclear waste repository. The authors discuss the advantages and limitations of the use of focus groups and the planning group and design issues to be dealt with in setting up and conducting the focus group.

Three important parts of the focus groups design are: the location of the meetings; the composition of each group; and the content of each group. These three aspects are each discussed in turn. The three sites selected were: Las Vegas, Pahrump and Caliente. A later report summarizes the findings of each of the focus group meetings (see MRDB ID# RP0006) and a videotape of the Las Vegas focus group meeting is also on file (ID# RP0008). A summary of the risk perception telephone surveys is contained in another document (ID# RP0003).

NA0027 Dufort, M. — Native Americans and Yucca Mountain: 1994 Perceptions and Involvement Yucca Mountain Socioeconomic Project — 12/01/94

Since 1986, Cultural Resources Consultants, Ltd. have been assessing the vulnerabilities of Native Americans to the effects of the Yucca Mountain project. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase V, Task 6.1) summarizes the information collected during 1994, specifically focusing on current Native American opinions and attitudes toward the Yucca Mountain project, and the level of tribal involvement with the DOE and with local governments in any ongoing studies. Native Americans continue to be strongly opposed to the siting of the nuclear waste repository at Yucca Mountain and to believe that the overall effects of the project will be harmful.

The issue regarding the level of involvement of tribes with the DOE or local governments is viewed as very significant by the tribal administrative-level respondents. The tribes are very interested in obtaining "affected status" designation, and some of the tribes are moving toward applying or reapplying for that status. It appears that, unified through the Nevada Indian Environmental Coalition, the Nevada tribes may well bring legal action against the DOE over the transportation and non-representation issues. The issues raised by the tribal representatives need to be explored by the Secretary of Interior and DOE in order for tribes to have an "official" voice on this major issue in their communities.

NA0029 Dufort, M. — Community Health Information Project Moapa Band of Paiute Indians Moapa, Nevada Yucca Mountain Socioeconomic Project — 09/01/96

This report summarizes community health data from field research conducted in the Southern Paiute community of the Moapa Band of Paiute Indians, located in southern Nevada. This medical ethnography was conducted by a medical anthropologist and undertaken as part of the NWPO Yucca Mountain Socioeconomic Studies (Phase V, Task 6.2). The goal of this research was to gather information on a variety of health-related topics at the community level, rather than at a household or individual level, in order to provide a framework for a comprehensive community health information study which the tribe and/or the NWPO may want to initiate in the future.

Information was gathered on the following topics: the kinds of medical services currently available to Moapa tribal members, health care needs as seen by community members and health-care professionals, the kinds of medical services available in the past fifty years, types and availability of health records, current and past sources of environmental exposures, general demographic characteristics of the community, general lifestyle activities of community members, community perceptions about the health of the community and Native treatments and healing practices.

NA0028	Dufort, M. and Abel, H.	Nuclear Waste Storage and the Fort McDermitt Paiute-Shoshone Tribe: Community Perceptions Yucca Mountain Socioeconomic Project	12/01/94

This report summarizes data from field research conducted between January and December, 1994 on the Fort McDermitt Reservation regarding perceptions of tribal members toward the potential siting of an MRS facility on their reservation. This research was funded as part of the NWPO Yucca Mountain Socioeconmic Study, Phase V, Task 6.1. The goal of this research was to study the process of the Ft. McDermitt tribe's involvement in feasibility studies of the MRS siting, funded by DOE. The major question guiding the research was: What factors are potentially influencing decisions by tribal memebers as to whether to accept the MRS? Two major areas of concern were found: a focus on safety issues and the perceptions of risk associated with the transportation of and storage of nuclear waste, and the need for clear and accessible information about the MRS process.

The authors found that an overwhelming majority of tribal members were not actively in support of the MRS, and that they felt that they were not prepared to make a firm decision about the MRS until they had much more information. Factors which appear to be potentially influencing a majority of the tribal members to refrain from actively supporting the MRS include: 1) perceptions of risk and safety issues appear to outweigh the potential for economic gain, 2) information sources were seen as highly inadequate, and extremely biased in favor of the MRS, 3) employment opportunities for tribal memebers are perceived to be very limited, 4) cultural beliefs regarding the care of the land prohibit the storage of nuclear waste, and 5) there is a high level of distrust in the federal government.

RP0106	Easterling, D. and Kunreuther, H.	The Vulnerability of the Convention Industry to the Siting of a High-Level Nuclear Waste Repository Yucca Mountain Socioeconomic Project	09/01/90

Yucca Mountain, Nevada has been proposed as the site for the nation's first HLNW repository, barring discovery of any factors that make the site technically unsuitable. The State of Nevada is concerned that a repository will lead to major dislocations of the state's visitor economy, of which conventions and trade shows constitute a major source of revenue. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 8.9) summarizes two studies investigating the sensitivity of convention planners and convention attendees to a HLNW repository when deciding either to hold or to attend a meeting in Las Vegas. This paper explores the question as to whether or not a repository has the potential to produce convention losses, and if so, to provide a rough estimate of the size of the effect that could occur. (Also see MRDB ID#s RP0038 and RP0101 for other information on the convention planners and convention attendees surveys.) Data from the convention attendees survey suggest that many noxious facilities are largely ignored by the public in deciding whether to attend a convention. However, the survey also suggests that a HLNW repository is not viewed as a typical noxious facility.

A number of individuals are apt to take deliberate actions to avoid such a facility due to both its perceived level of risk and its general negative image. This finding implies that some planners are likely to reject Las Vegas as a location for a future meeting if the city becomes associated with a repository. Based on the surveys, the authors argue that there certainly exists the potential for a repository at Yucca Mountain to become psychologically linked with Las Vegas, and for this affiliation to trigger major dislocations of the city's convention industry. An open question still needing to be explored is whether a link between the repository and Las Vegas will, in fact, develop within the public's mind if and when the facility is built. To a large extent, this will be determined by the degree of scientific and institutional integrity that comes to surround the program, as well as whether a need for the facility is convincingly demonstrated. In the absence of such developments, one can expect a repository to impose a stigma on cities unfortunate enough to be linked with the facility.

RP0095 Easterling, D., Morwitz, V. and Kunreuther, H. — Estimating the Economic Impact of a Repository from Scenario-Based Surveys: Models of the Relation of Stated Intent to Actual Behavior (Yucca Mountain Socioeconomic Project) — 12/01/90

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVB, Task 7.2) presents a model that has been developed to examine the relationship between people's stated intention of behavior with their actual behavior (e.g., can we believe what people report they would do in a hypothetical situation?). Data gathered from a survey of convention planners, which included scenario-based intention reporting, is utilized to forecast the impacts of a HLNW repository on the Las Vegas convention industry. Two strategies for forecasting propensity to actual behavior from stated intent are discussed. The first forecasting strategy is denoted as "mapping intent into propensity." Section 3 presents the logic of this strategy, and then considers what the mapping between stated intent and actual propensity might look like in the case of the convention planner survey. A host of empirical research is reviewed to address this question. However, many of the more relevant studies report only the correlation between intent and behavior, which renders these studies inadequate to the task of estimating the mapping for repository-induced behaviors.

Section 4 presents the alternative forecasting strategy, under which the mean propensity to act score is estimated more theoretically. This section includes the assumptions surrounding true intent, the method for estimating true intent from stated intent, and a list of biasing factors that can be used to estimate reasonable values for the deviation between the average respondent's true intent and his or her actual propensity. The "average-propensity" forecasting model is then applied to the convention planner survey in Section 5. Planners' statements of intent to avoid Las Vegas following repository scenarios are used to generate forecasts of the proportion of planners who would actually avoid Las Vegas following different repository-related events. Finally, in Section 6, the authors discuss methods for applying the analytic model to other data sets. They also reconsider the more general problem of estimating the public's response to a facility whose image is as volatile as a HLNW repository. See MRDB ID# RP0111 for an extracted paper describing the model.

RP0121 Edelstein, M. — Mitigating Environmental Stigma and Loss of Trust in the Siting of Hazardous Facilities Yucca Mountain Socioeconomic Project — 05/01/92

Contaminated communities may be defined around the perceived boundaries or "risk shadows" of a discovered contamination or proposed hazardous facility. In either case, the events surrounding contamination (or the imposed threat of contamination through hazardous facility siting), rather than contamination per se, cause the predominant stresses in contaminated communities. These events take their meaning in light of the "eco-historical context" of the community. This context is useful for understanding both the extent to which the facility serves as a cause for environmental stigma and the atmosphere of trust or distrust that surrounds the facility plan and lifecycle. Such an understanding can be used to explain outcomes of stigma and distrust or to project into the future scenarious related to these effects.

In this paper (prepared as part of the NWPO Yucca Mountain socioeconomic analogous case studies: Phase IVC, Task 9.3.6), the constructs of trust and environmental stigma are analyzed and the potential for their mitigation is assessed. Three case studies are briefly reviewed for their potential relevance to theory affecting hazardous waste siting. The first case study, involving the potential psychosocial impacts of the proposed sixth CECOS hazardous waste site in Niagara Falls, NY, illustrates how environmental stigma and distrust are embedded in a community's eco-historical context. An important issue in this case study was the prospect for mitigating such impacts. Further understanding of the problems involved in mitigating environmental stigma and distrust are explored through two additional case studies, involving so-called "sanitary landfill" facilities in the states of New York and Washington.

RA0012 Emel, J., Cook, B., and Kasperson, R. — Risk Management and Organizational Systems for High-Level Radioactive Disposal: Issues and Priorities Yucca Mountain Socioeconomic Project — 09/01/88

This report, prepared for the Yucca Mountain Socioeconomic Project (Task 7.3, Phase III), explores the nature of HLNW disposal tasks and their implications for the design and organizational structure of effective risk management systems. The authors have organized this discussion into a set of interrelated tasks that draw upon both relevant theory and accumulated experience. Specifically these tasks are: 1) to assess the management implications of high levels of technical and social uncertainty that characterize the technology and mission; 2) to identify the elements of organizational theory that bear upon risk management system design; 3) to explore these theoretical issues in the context of two hypothetical risk scenarios associated with radioactive waste disposal; 4) to consider the appropriate role of engineered and geologic barriers; 5) to examine briefly issues implicit in DOE's past waste management performance, with special attention to the Hanford facility; and 6) to suggest findings and recommendations that require further attention.

RA0031 Emel, J., Cook, B., Kasperson, R. and Renn, O. — Nuclear Waste Management: A Comparative Analysis of Six Countries Yucca Mountain Socioeconomic Project — 11/01/90

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase IV-B, Task 7.3) analyzes the approaches taken in different countries with regard to the management of radioactive waste disposal. There currently appears to be wide agreement on deep geological disposal of HLNW either on land or under the sea. Each country appears to be developing independent disposal options rather than considering out-of-country disposal. Furthermore, ocean dumping is out of the question for the time being, except for possible decommissioning wastes and small volumes of low-level wastes. No country has yet licensed a site for the final disposal of HLNW and because of the long lead times necessary for the requisite research and approval of a repository, more countries are giving serious attention to interim storage facilities.

This report focuses on three areas of international and comparative national approach. These are: (1) comparative review and analysis of waste disposal policies, including siting, interim storage, and reprocessing; (2) comparative review and analysis of organizational structure relative to nuclear waste disposal; and (3) analysis of public health and safety criteria proposed by international groups and nations for licensing or siting repositories. The authors chose to study the six countries with the largest nuclear power industries apart from the U.S. and the U.S.S.R. These are: Canada, France, Japan, Sweden, the United Kingdom, and West Germany. Because these counties have different social, political, economic, and cultural histories, they have given rise to a variety of experiences with waste policy and are at different stages in research and development, and in repository siting. However, some major areas of agreement in approach have been ascertained and contrasted with the U.S. approach.

RA0009 Emel, J., Kasperson, R., Goble, R. and Renn, O. — Post Closure Risks at the Proposed Yucca Mountain Repository: A Review of Methodological and Technical Issues Yucca Mountain Socioeconomic Project — 06/15/88

This document, prepared during Phase III (Task 7.1) of the NWPO Yucca Mountain Socioeconomic Project assesses potential post-closure risks associated with the Yucca Mountain repository. The first section of the report provides an overview and critique of the risk analysis methodology proposed by the DOE (1988) in the Draft Site Characterization Plan (SCP) and related documents. The second section addresses specific technical problems associated with the site. Both sections considers the significance or implications of the issues for the successful long-term isolation of radioactive wastes from the biosphere.

The authors discuss the characteristics and regulations concerning radioactive isotopes associated with high-level nuclear waste and examine possible scenarios involving disruptive phenomena which could threaten the viability of the Yucca Mountain repository including some which are rejected by the DOE because of uncertainty. The report concludes with overall observations on the adequacy of current understandings and approaches in the waste disposal program and implications for the State of Nevada. This document is one of a series of reports prepared by CENTED concerning risk issues of critical aspects of the project (see documents RA0001-RA0005, RA0010 and RA0011).

RP0019 Ericksen, E. Power Calculations for Estimates Under Four Scenarios in Las Vegas Survey Yucca Mountain Socioeconomic Project 06/01/88

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project - Phase III, Task 8.4.2) presents power calculations for a survey conducted in the Las Vegas area concerning residents' reactions and risk perceptions to the proposed HLNW repository. The report discusses both sampling and measurement errors involved in the study design.

RP0018 Ericksen, E. and Bunkle, B. Evaluation of Two Surveys Concerning the Risks of High-Level Nuclear Waste Repositories Yucca Mountain Socioeconomic Project 03/01/88

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase III, Task 8.6) evaluates two surveys undertaken in 1987 for Phase II of the project. These surveys were conducted to provide data on public perceptions of the risks of HLNW repositories. The first was a national survey conducted by Gordon Black, Inc., Rochester, New York, and the second was a survey of Nevada residents conducted by the Survey Research Center of the University of Nevada at Las Vegas (UNLV). Both surveys were conducted by telephone and the samples of telephone numbers were selected by Survey Sampling, Inc., Fairfield, Connecticut.

In this report, the evaluation of the sampling plan focuses on biases that could arise from selection of the sample and its distribution. Then, possible biases due to nonresponse on both surveys are evaluated. After this the authors evaluate interviewer effects caused by individual idiosyncracies. The report closes with recommendations about how the data should be analyzed. This paper represents an outside, objective look at the methodology and implementation of the surveys and offers a critique of problems manifested in one or both surveys. For further information describing the methodology and results of both surveys, see MRDB ID# RP0003.

RP0017 Fitzgerald, M. and McCabe, A. The U.S. DOE's Attempt to Site the Monitored Retrievable Storage Facility (MRS) in Tennessee: 1985-1987 Yucca Mountain Socioeconomic Project 05/01/88

This report, prepared for the Yucca Mountain Socioeconomic Project (Task 7.5, Phase III), is concerned with how the U.S. public sector is handling the challenge of implementing a technical, environmental policy in managing the nation's high-level nuclear waste, as reflected in the attempt of the US/DOE to site a monitored retrievable storage facility (MRS) in Tennessee. This study examines the MRS case, from the 1985 DOE decision to proceed with an integrated MRS proposal to the passage of the NWPAA of 1987.

The authors contend that the fashion in which the DOE reacted to the ultimate state and local reviews of its MRS plan, the extent to which the federal agency incorporates subnational views into the proposal eventually presented to the Congress, and the final Congressional response contribute important insights into the problems and prospects for future efforts to establish an effective national HLNW system. To chronicle the course of events, media coverage of the MRS controversy was systematically monitored, relevant Congressional hearings were tracked, documentation provided by agencies and groups involved in the case were reviewed, and personal interviews with virtually all the key actors were conducted.

SE0018 Flynn, Chalmers, Easterling, Fowler, Krannich, Kunreuther, Little, Mertz, Mushkatel, Pijawka, Slovic, & Williams State of Nevada Socioeconomic Studies Biannual Report, 1993-1995 Yucca Mountain Socioeconomic Project 06/23/95

The federal government program to study and possibly develop the nation's first HLNW repository at Yucca Mountain introduced a number of issues and concerns into Nevada's public life. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies: Phase V, Task 10.3) presents Nevada's potential impacts and vulnerabilities as identified by the state of Nevada socioeconomic study team. The focus is on work done between 1993 and 1995. However, this recent work is based on an ongoing study program that began in 1986, and this first biannual report builds and expands on work done prior to 1993.

This report identifies key areas most likely to experience socioeconomic impacts and points out important areas of vulnerability. Due to the high levels of uncertainty that exists in all areas of this project, the impacts and vulnerabilities identified in this report cannot be precisely described. The following major areas of potential impacts discussed in the report include: project description, economic and demographic benefits, Federal mandate impacts, intergovernmental relations, Las Vegas and Clark County, rural communities, Native Americans in Nevada, and compensation and mitigation.

RP0099	Flynn, J.	Information from Three Surveys (Fall, 1989): Frequency Distributions & Preliminary Analyses for Selected Environmental & Repository Questions	05/01/90

The purposes of this document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVB, Task 12.0) are to: (1) format the data from three surveys completed in the Fall, 1989 (Nevada State Survey, Southern California Survey, and the National Survey) so that some of the basic findings could be shown for the three data sets; (2) make a preliminary review of these comparative data and propose a "first-cut" interpretation of the results; (3) provide the basis for discussion among study team members and other interested parties; and (4) to identify future analysis topics and reports on the information contained in these data bases. The three surveys examined: respondents' attitudes and perceptions of risks associated with various types of environmental, industrial, and nuclear facilities; their evaluation of benefits and problems associated with nuclear waste facilities; their evaluation of risks and cost/benefits associated with a HLNW facility, in particular; their attitudes toward the equity of siting such a facility; and their evaluation of DOE's waste management program. These three surveys also examined respondents' images of nuclear waste and various cities; analyses of this data is still in process.

The questions shown in this report are in the order they were presented to respondents during the interviews. Each section has a few brief comments which describe the place (by question number) in each of the survey instruments, and the purpose of the question or set of questions. This is followed by an exact reproduction of the question and a frequency distribution of the answer for each of the three surveys. A brief preliminary analyses of this information is provided along with some commentary on the potential implications of the data. A final section provides some recommendations for further analyses. While there are a number of other documents on the three surveys, this is the first document presenting the data in a format that allows comparison of data across surveys. For other documents on the Nevada State Survey, see MRDB ID#s: RP0076, RP0077, RP0078, and RP0080. For data on the National Survey, see MRDB ID#s: RP0084, RP0085 and RP0088; for the Southern California Survey, see MRDB ID#s: RP0086, RP0087, and RP0089.

RP0110	Flynn, J., *Burns, W., Slovic, P. and Mertz, C.	Development of a Structural Model to Analyze Public Opinion on a High-Level Radioactive Waste Facility Prepared for 1991 International High-Level Radioactive Waste Management Conference, Las Vegas, NV	04/28/91

Studies show that Nevada residents and state officials oppose the proposed high-level radioactive waste repository project at Yucca Mountain. Nevada residents view the Yucca Mountain repository as having extremely high risk; nuclear experts, in contrast, feel the risks are very low. These experts have suggested that public risk perceptions may be reduced by better program management, increased trust in the federal government, and/or by increased benefits and compensation for accepting a repository. The model described in this paper is designed to examine the relationship between risk perception and various strategies for risk management using a confirmatory multivariate method known as covariance structure analysis. This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-C, Task 8.3) will be presented at the 1991 International High-Level Radioactive Waste Management Conference in Las Vegas, NV (April 28-May 3, 1991).

NU0059 Flynn, J., Chalmers, Easterling, Kasperson, Kunreuther, Mertz, Mushkatel, Pijawka, & Slovic with Dotto — One Hundred Centuries of Solitude: Redirecting America's High-Level Nuclear Waste Policy — 05/01/95

This preparation of this book was supported by part by the NWPO Yucca Mountain Socioeconomic Studies (Phase V, Task 10.1). TABLE OF CONTENTS: 1. Overview of a Troubled Program; 2. Problems with High-Level Nuclear Waste and a Little History; 3. Policies and Politics; 4. Complexity and Uncertainty; 5. Public Responses to High-Level Nuclear Wastes; 6. International Experiences; 7. Where Do We Go from Here? 8. Update on the High-Level Nuclear Waste Repository Siting.

NU0060 Flynn, J., Kasperson, R., Kunreuther, H., and Slovic, P. — Overcoming Tunnel Vision and Redirecting the Nation's High-Level Radioactive Waste Program Yucca Mountain Socioeconomic Project — 08/22/96

This manuscript reviews the overall program of the DOE Yucca Mountain radioactive waste program and identifies key areas of public and state/local concerns. Six major problem areas for siting a HLNW facility are discussed: 1. Protection of human health and the environment; 2. Public participation; 3. Intergovernmental relations; 4. Program and project management; 5. Costs and funding; and 6. Scientific and technical issues. The authors believe that the Yucca Mountain program has failed and a thorough review of the 6 problem areas should be undertaken.

SE0019 Flynn, J., Krannich, R., and Williams, J. — 1997 Biannual Report: Draft Outline Yucca Mountain Socioeconomic Project — 05/03/96

This memorandum (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies: Phase V, Task 10.4) includes a draft outline of a proposed 1997 Biannual Report on the repository program. Further work on this task was cancelled due to funding reductions.

RP0120 Flynn, J., Mertz, C. and Slovic, P. — The 1991 Nevada State Telephone Survey: Key Findings Yucca Mountain Socioeconomic Project — 05/01/91

This document presents the findings from the 1991 Nevada State Telephone Survey, which was conducted as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-C, Task 8.3). The findings of the survey show that Nevadans oppose the federal government attempts to locate a HLNW repository at Yucca Mountain. They support a policy of opposition on the part of Nevada officials. They believe that Nevadans should have the final say in whether to accept the repository or not, and they reject the proposition that benefits from the repository program will outweigh the harms. These findings are very similar to survey results from 1989 and 1990 surveys and once again demonstrate very widespread public opposition by Nevadans to the current federal repository program. See MRDB ID# RP0119 for the diskette containing the raw survey data.

RP0078 Flynn, J., Mertz, C. and Toma, J. — 1989 Nevada State Survey Telephone Survey: Frequency Distributions Yucca Mountain Socioeconomic Project — 11/14/89

This document contains the frequency distributions from the Nevada State Telephone Survey conducted in September/October, 1989 to provide current information on how Nevada state residents evaluate the proposed Yucca Mountain repository. This survey was conducted as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-B, Task 8.3). The survey solicited respondents attitudes toward the proposed repository, their evaluation of benefits and problems, the fairness of the selection process, their images of a HLNW repository, and the distance they would be willing to live from a repository and other types of industrial and energy facilities.

This document contains the frequency distributions for the statewide sample, the Clark County subset, and Nye, Lincoln, and Esmeralda Counties. The frequency distributions are in the format of the questionnaire. No analysis is included; MRDB document ID# RP0080 contains preliminary findings from the survey. See MRDB ID# RP0077 for the floppy disk containing the survey data.

RP0127 Flynn, J., Mertz, C., and Slovic, P. The Autumn 1991 Nevada State Telephone Survey Yucca Mountain Socioeconomic Project 12/12/91

In the Autumn 1991, a telephone survey of Nevada state residents was conducted by Decision Research on behalf of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-C, Task 8.2). The survey examined public evaluations of the Yucca Mountain repository program. It also asked questions about the current advertising campaign by the American Nuclear Energy Council (ANEC), which was implemented to attempt to bolster support for the DOE program to develop a national HLNW repository in Nevada. This report presents the findings from the survey. The appendices contain the frequency distributions to each question and the open-ended responses to a question asking the respondent for his/her primary opinion about the ANEC advertisements.

The survey found that (1) the opposition of Nevada residents to the Yucca Mountain program remains very strong with 73.8% of the state respondents saying that they would vote against the repository if they had the opportunity; (2) almost 75% had seen or heard presentations of the ANEC advertising campaign; (3) less than 15% said that the advertisements made them more supportive of the program, twice as many respondents said the advertisements made them less supportive and over half said the advertisements did not change their level of support or opposition; (4) comments made by the respondents on the advertisement campaign were largely negative; (5) the percentage of respondents who thought the development of the repository at Yucca Mountain was inevitable had declined since previous surveys in 1987 and 1988; and (6) about two-thirds thought that the state should continue opposition to the repository, even if that meant turning down benefits that may be offered by the federal government.

TR0046 Flynn, J., Mertz, C., and Slovic, P. Nuclear Waste Transportation: Results of a 1997 National Survey Yucca Mountain Socioeconomic Project 01/01/98

Yucca Mountain, NV is the only place in the US being studied as a possible permanent, geological site to store HLNW, most of which are produced in nuclear power reactors located east of the Mississippi River. If the site is found suitable, a decision that will not be made until some years in the future, an underground repository would be constructed. In 1997, both houses of Congress passed similar bills to create temporary above-surface storage near Yucca Mountain and to require prompt shipment of wastes from reactors to the new facility. The Congressional program would initiate an unprecedented, massive, cross-country shipping campaign that would last more than 30 years.

This report presents results from a national survey of 972 respondents on a set of questions about the transportation of HLNW. The questions about public attitudes and opinions in regard to selected concerns about this transportation program were asked as part of the University of Maryland's 1997 National Omnibus Survey. The survey results show that the public is not well informed about proposed Congressional actions to locate an interim waste storage facility in Nevada and that there is strong opposition to the conditions that would exist with such a program. This report was prepared as part of the NWPO Socioeconomic Studies (Phase VI, Task 6.1).

RP0080 Flynn, J., Mertz, C., and Toma, J. Preliminary Findings: 1989 Nevada State Telephone Survey Draft Yucca Mountain Socioeconomic Project 12/14/89

The Nevada State Telephone Survey is part of an ongoing State of Nevada study of the socioeconomic effects of the federal government's HLNW disposal program (Phase IV-B, Task 8.3). Because people's attitudes and perceptions about environmental and nuclear-related matters are likely to influence actions and behavior which have economic or other consequences, the survey seeks to establish a baseline by which these attitudes and perceptions can be evaluated and examined over time. The findings of this survey effort provide a major source of data that, in the future, can be analyzed in conjunction with other socioeconomic study efforts to facilitate a comprehensive understanding of the impact processes and effects associated with the proposed repository at Yucca Mountain. This survey, conducted during September and October of 1989, had a total of 906 respondents with over-samples in Nye, Lincoln and Esmeralda counties. Very briefly, the survey found overwhelming opposition to the development of a HLNW repository at Yucca Mountain. Respondents supported continued opposition at the state level, even if that meant turning down benefits. Support was also shown for AB222, state legislation making HLNW disposal illegal in the state of Nevada.

This report examines each questions in the survey instrument by running key cross-tabulations and providing a summary of the findings. The report focuses on the relationship of sociodemographic variables to the responses to each question. The analysis examines the following: respondents' environmental attitudes; their image of a nuclear waste repository; their trust in various state, local and federal governmental entities; their evaluation of the benefits and problems associated with the repository; an evaluation of the respondents pro- and anti-repository statements; their perception of fairness and equity regarding development of a repository; and their knowledge and evaluation of recent state legislation. Documentation of the survey methodology and results has been provided by (1) Standage Accureach, Inc., the survey firm, in both the form of both a printout (MRDB ID # RP0076) and electronic database of the results (MRDB ID# RP0077); and Mountain West, who has assembled the frequency distributions to each question by state, and by the counties of Clark, Nye, Lincoln, and Esmeralda.

RP0123	Flynn, J., Mertz, C., Slovic, P. and Burns, W.	A Structural Model Analysis of Public Opposition to a High-Level Radioactive Waste Facility Yucca Mountain Socioeconomic Project	09/01/91

Studies show that most Nevada residents and almost all state officials oppose the propsed HLNW repository project at Yucca Mountain. Surveys of the public show that individual citizens view the Yucca Mountain repository as having high risk; nuclear experts, in contrast, believe the risks are very low. Policy analysts have suggested that public risk perceptions may be reduced by better program management, increased trust in the federal government, and increased economic benefits for accepting a repository. The model developed in this study (conducted as part of the NWPO Yucca Mountain Socioeconomic Studies: Phase IV-C, Task 8.3) is designed to examine the relationship between public perceptions of risk, trust in risk management, and potential economic impacts of the current repository program using a confirmatory multivariate method known as covariance structure analysis.

The results indicate that perceptions of potential economic gains have little relationship to opposition to the repository. On the other hand, risk perceptions and the level of trust in repository management are closely related to each other and to opposition. The impacts of risk perception and trust in management on opposition to the repository result from a combination of their direct influences as well as their indirect influences operating through perceptions that the repository would have serious negative impacts on the state's economy due to stigmatization and reduced tourism.

RP0141	Flynn, J., Slovic, P. and Mertz, C.	Autumn 1993 Nevada State Telephone Survey: Key Findings Yucca Mountain Socioeconomic Project	02/01/94

This report presents the results of a Nevada state telephone survey that was conducted in the Autumn 1993 as part of the NWPO Yucca Mountain Socioeconomic Project, Phase V, Task 9.2. The survey examined public attitudes and opinions toward the federal government's Yucca Mountain repository program and toward the DOEs Nevada Test Site. The survey provides longitudinal data for the repository program and establishes baseline information about public attitudes toward the NTS. This report focuses on the results of the Autumn 1993 survey and places these results in context with earlier survey findings. The respondents for the Autumn 1993 survey were selected from a random sample of Nevada telephone numbers and resulted in 625 completed interviews representing a response rate of 48.7% with a margin of error of plus or minus 4.1%. See MRDB# RP0140 for the data file.

The survey found that Nevadans strongly oppose the federal government's attempts to locate a HLNW repository at Yucca Mountain and support continued opposition by the State. Over half the respondents thought the harms of the repository would outweigh the benefits and that the repository at Yucca Mountain would negatively impact the tourist and visitor economy in Nevada. An overwhelming majority said that Nevada residents should have the final say on whether the repository is built in their state. Most respondents (70.7%) did not trust DOE to provide prompt and full disclosure of any serious problems with the Yucca Mountain project. Over two-thirds of the respondents said they would vote against the NTS, if a vote were held today to establish a nuclear test site in Nevada.

RP0142 Flynn, J., Slovic, P., and Mertz, C. — The Spring, 1993 Nevada State Telephone Survey: Key Findings Yucca Mountain Socioeconomic Project — 05/01/93

The Spring 1993 Nevada State Telephone Survey was conducted by Decision Research on behalf of the State of Nevada, NWPO as part of its ongoing socioeconomic impact assessment study (Phase V, Task 9.1). The survey examined a focused set of public attitudes and opinions toward the federal government Yucca Mountain repository program. It was also designed to monitor responses from earlier surveys conducted. This report focuses on the results of the Spring 1993 survey, and places these results in the context of the earlier findings from surveys done in 1989 and 1991. The 803 completed interviews represent a response rate of 51.0% with a margin of error of error of plus or minus 4.0%. See MRDB# RP0143 for the data file.

The survey found that opposition of Nevada residents to the Yucca Mountain program remains very strong and that the state should continue its opposition and not make a deal for benefits. An overwhelming majority said that the final decision on whether or not the repository is built in the state should be made by Nevada residents. A majority felt the process used to select Yucca Mountain as the nation's first HLNW repository has been unfair. Concerns about the potential stigma impacts continue and over half the respondents thought the harms would outweigh the benefits. Trust and confidence in DOE continues to be a serious problem.

RP0104 Flynn, J., Slovic, P., Mertz, C. and *Toma, J. — Evaluations of Yucca Mountain: Survey Findings About the Attitudes, Opinions and Evaluations of Nuclear Waste & Yucca Mountain, NV — 09/01/90

The purpose of this document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 12.0) is to report on the attitudes, opinions and evaluations of the U.S. federal government HLNW disposal program as recorded in three surveys conducted during the Fall, 1989. The primary focus of the federal program is the proposed site at Yucca Mountain, NV, which has been designated by the U.S. Congress as the nation's only location for intensive study as a potential repository location. Therefore, the major focus of the data collection and analysis has been to address the survey information as it relates to the Yucca Mountain site, and the State of Nevada. The three databases collected during these surveys represent findings for: (1) Nevada; (2) the region of Southern California, which is the major source of tourists and visitors to the Las Vegas area; and (3) the nation as a whole. Other reports analyzing these databases include MRDB ID#s: RP0080, RP0099, RP0103, and RP0105).

The surveys show that nuclear waste disposal is viewed as likely to produce adverse impacts in every aspect of its implementation, and that compared to the other socioeconomic activities that might be considered analogous in some way, a repository program is evaluated as the most feared and least acceptable. Female respondents rate the repository risks as more likely than do male respondents, but strong opposition to the current nuclear waste repository program is evident across all sociodemographic categories and groups. The opposition to building new nuclear electric generating stations is strong and has a strong correlation with the opposition to a national repository. However, there does not appear to be a causal link between opposition to power plants and opposition to the repository. The survey data support the thesis that equity and risk evaluation are significantly related, however, more information on equity issues is felt to be needed. An examination of opinions about the State of Nevada's position shows very strong support for the state's position of opposition to the federal government and the repository program.

NA0002 Fowler, C. — Historic Indian Names in the Yucca Mountain Area Yucca Mountain Socioeconomic Project — 10/15/86

This report presents the family names for Shoshone and Paiute people historically associated with the Yucca Mountain area and contained in published sources. Included with the names are dates and specific areas with which they were associated as well as birth dates and genealogical information where available. This data was collected as part of Task 4.4.1 (Phase II) of the Yucca Moutain Socioeconomic Study. The data contained within will be verified and expanded through subsequent fieldwork conducted by the Native American study team.

NA0018 Fowler, C. with data contributed by M. Hamby, E. Rusco and M. Rusco — Native Americans and Yucca Mountain: A Summary Report Yucca Mountain Socioeconomic Project — 09/01/90

This document (prepared for the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 6.1) summarizes data collected between September 1986 and September 1988 relative to Native American concerns involving the potential siting of a HLNW repository at Yucca Mountain, Nevada. A number of issues of general as well as specific concern to Indian people and tribes in the area are addressed. The study focused on Indian tribes in the three southern Nevada counties (Nye, Clark and Lincoln) and include: the Yomba and Duckwater Shoshone tribes of Nye County; the Las Vegas and Moapa Paiute tribes of Clark County; and because of proximity and cultural connections, the Timbi-Sha Shoshone Tribe of Inyo County, California. The authors provide an overview of the culture, history and use of Yucca Mountain in the past, and the present-day concerns of Western Shoshone and Southern Paiute people for the cultural resources that remain there today.

The world view held by Native Americans is described as are the differences in world view between Native Americans, management agencies, and the courts regarding these resources. Native Americans are looking at the long-term effects on both Indian and non-Indian people. They see the repository as posing major threats to the environment and are overwhelmingly opposed to the repository. Present socioeconomic conditions prevailing on Native American reserved lands, and the plans of these groups for the future are examined and potential impacts from the proposed repository are discussed. The appendices include: an extensive bibliography assembled by the authors; and tabulation of results from a questionnaire that was implemented in 1988 to obtain data on Native American risk perceptions and attitudes toward the proposed Yucca Mountain repository.

NA0021 Fowler, C. with data contributed by M. Hamby, E. Rusco and M. Rusco — Native Americans and Yucca Mountain: A Revised & Updated Summary Report on Research Undertaken between 1987-91 Yucca Mountain Socioeconomic Project (2 volumes) — 10/15/91

This document (prepared as part of the Yucca Mountain Socioeconomic Project: Phase IV-C, Task 6.1) summarizes data collected between September 1986 and September 1988 (with some updates to September, 1991) relative to Native American concerns involving the potential siting of a HLNW repository at Yucca Mountain. It is a slightly revised version of a 1990 report (see MRDB ID# NA0018). The data were collected from Western Shoshone and Southern Paiute people upon whose aboriginal lands the repository potentially is to be located. Western Shoshone people involved in the study were those resident or affiliated with reservation communities at Yomba and Duckwater, NV and Death Valley, CA. Southern Paiute people were at reservation communities at Moapa and Las Vegas. Additional persons of Western Shoshone and Southern Paiute descent were interviewed at Beatty, Tonopah, Caliente, Pahrump, and Las Vegas, NV.

The authors outline something of the culture, history and use of Yucca Mountain in the past, and the present-day concerns of Native Americans for the cultural resources that remain there today. They stress the differences in world view between Native Americans, management agencies, and unforunately, also the courts regarding these resources. They also look at the present socioeconomic conditions prevailing on Native American reserved lands, and the plans of these groups for the future. The appendices also contains an extensive bibliography compiled by the authors. Also see MRDB ID#s NA0022 through NA0025 for companion reports to this document.

NA0001 Fowler, C., Hamby, M., and Rusco, M. Native American Studies (Appendix A.5.4) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report 06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 4.4.1, 4.4.2, 4.5.1, 4.5.2 and 9.0). This document summarizes Native American data collected by the study team during Phase II through literature searches and preliminary ethnographic and socioeconomic fieldwork. The purpose of these activities is to define the precontact, immediate post-contact and present-day characteristics of Native American people and their cultures in southern Nevada. The first sections of the report discusses the settlement patterns, subsistence, kinship and sociopolitical features and aspects of ceremony and ritual of the Beatty Shoshone, Belted Mountain Shoshone, Death Valley Shoshone, and the Pahrump and Ash Meadows Southern Paiute. This data is viewed as important in locating the population and determining its involvement with the repository site at Yucca Mountain. The second section surveys demographic and socioeconomic data concerning American Indians currently residing in the four southern Nevada counties, specifically people who have ancestral ties to this region--those of Western Shoshone and Southern Paiute ancestry.

Included is data on the reservations in each county (including the Timba-Sha Shoshone in Inyo County, CA). The purpose of the survey was to construct a picture of the current location, distribution and condition of the Native Americans. The third section of the report focusses on Native American religious and legal issues relative to the potential siting of a HLNW repository at Yucca Mountain. Preliminary data on the cultural ties of the Western Shoshone and Southern Paiute to the project area is presented along with their concerns with siting a HLNW facility at Yucca Mountain. The American Indian Religious Freedom Act of 1978 as interpreted by the courts is also discussed including a brief review of court cases involving Native Americans. In addition, a brief history of the Western Shoshone Land Dispute is provided. While noting that baseline data on Native Americans is still being gathered, the final section of this report points out a few potential areas of impact (direct and indirect) on Native American people presently residing in the study area.

NA0003 Fowler, C., Rusco, M., and Hamby, M. Native Americans and Yucca Mountain: Ethnographic Sketches Las Vegas, Paranigat and Panaca, and Moapa Southern Paiute and Central Nevada Western Shoshone 01/18/88

This document prepared for the Yucca Mountain Socioeconomic Project (Task 6.0, Phase III) contains historical data on four Native American groups: Las Vegas Valley, Paranigat and Panaca, and the Moapa South Paiutes and the Central Nevada Western Shoshone. The data was compiled by the authors from field notes of I. Kelly, J. Steward and others who conducted research during the 1930's. Each ethnographic sketch describes each group's physical environment, settlement patterns, food resources, kinship ties, culture and religion. The information provided in this document serves as a supplement to document NA0001 which contains ethnographic sketches of the Beatty and Death Valley Western Shoshone and the Pahrump/Ash Mountain Southern Paiute.

NU0045 Freudenburg, W. et al. Social Impacts of Hazardous and Nuclear Facilities and Events: Implications for Nevada and the Yucca Mountain High-Level Nuclear Waste Repository 05/01/92

This document includes six analogous case studies prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IVC, Task 9.3). An introduction by William Freudenburg provides an overview and context for the case studies. One of the contributions that empirical case studies can make is to provice insights into arguments about what might or might not happen in the future, doing so by looking at what has actually happened in the past. Two recurring themes throughout the six studies are the importance of trust and institutional performance.

The six case studies include: (1) Scope, Stakeholder Groups and Impact Issues Raised by the Proposed Hanford, Washington HLNW Repository Site, by L. Carter and W. Willard; (2) Rocky Flats, Colorado: A Case Study, by D. Lodwick; (3) The Feed Materials Production Center in Fernald, Ohio: A Case Study, by R. Hardert; (4) Love Canal 1978-1991: A Case Study of the Social Impacts of Hazardous Waste, by A. Levine; (5) Social Impacts of Toxic Contamination, by S. Kroll-Smith and S. Couch; and (6) Mitigating Environmental Stigma and Loss of Trust in the Siting of Hazardous Facilities, by M. Edelstein.

RA0054 Freudenburg, W. with assistance from J. Gervers — Empirical Studies of Hazard Management: An Introduction and Overview (Draft Report) Yucca Mountain Socioeconomic Project — 09/05/91

This report has been prepared to provide an overview and context for the independent case studies that have been commissioned by the NWPO Yucca Mountain Socioeconomic Project under Phase IVC, Task 9.3. This overview discusses how the individual case studies fit into the larger ensemble of socioeconomic studies prepared to date and with broader, peer-reviewed literature. The overview is divided into three sections. The first provides the basic background information on an issue that unites all the case studies with a significant fraction of the work that has been done under the state socioeconomic studies -- the issue of trust and trustworthiness.

Given the sensitivity of this issue, the second section, which provides a brief introduction to the findings of the independent case studies, does so in terms of three reactions to the issue of trustworthiness that have in fact been heard from supporters and/or employees of DOE -- the low levels of calculated risk probabilities, the likely relationships between experience with a repository and suport for it, and the question of the degree to which the special impacts associated with a nuclear waste repository deserve to be seen as "real." The third and final section, which once again draws heavily from the open literature as well as from the case studies, summarizes the growing evidence on the systematic differences between natural and technological disasters in the socioeconomic impacts they create. For the individual case studies, see MRDB ID# NU0037, NU0038, RA0048, RA0049, RP0121, SC0025, and SC0014.

RA0007 Glickman, T. — Summary of the RADTRAN III Model Yucca Mountain Socioeconomic Project — 01/12/87

This document, prepared as part of Task 5.3.1 of the Yucca Mountain Socioeconomic Study, critieques the RADTRAN III model developed by SNL. This model is a computer code for claculating estimates of certain impacts of the transportation of radioactive materials. These estimates are based on input data that reflect information about the properties of the shipments and the transportation environment. The report discusses a number of limitations with using the RADTRAN model. The critique addresses the following issues: the applicability and effectiveness of the assumptions; the model's effectiveness at the state or local level; its ability to identify high risk areas; the practicality of the model for transportation planning purposes; how the model could be improved for routing decisions; and the uselfulness of the model for rail and vehicular transportation. Another critique of the RADTRAN III model was conducted by Clark University/CENTED (see ID# RA0004). A detailed description of the model was prepared by ASU and can be found in document ID# RA0006.

RA0010 Goble, R., Golding, D. and Kasperson, R. — Potential Retrieval of Radioactive Wastes at the Proposed Yucca Mountain Repository: A Preliminary Review of Risk Issues — 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 7.1, Phase III), is a preliminary review of risk issues involved in retrieving radioactive waste at the Yucca Mountain repository. The nature of the risks associated with a retrieval operation are explored, including a discussion of: casual risk sequences that lead to adverse consequences; preclosure operations and site characterization factors that establish the conditions under which retrieval would take place; and the potential for social amplification of risk events. Diagrams of three risk scenarios are included. An assessment of the adequacy of DOE's evaluations of retrieval risks is provided. The authors identify pertinent DOE regulations and documents dealing with retrieval and retrievability, examine DOE's underlying philosophy and rationale, and clarify DOE's definitions and schedules. This discussion concludes by identifying contradictions and gaps in DOE's existing knowledge.

Some critical unresolved questions involving the current state of knowledge and management approaches to retrieval risks are identified and discussed. The concluding section lists major conclusions found in this study on the retrieval of radioactive waste and issues of significance to the State of Nevada. This document is one of a series of evaluations of risk issues discussing in turn each relevant phase of the repository project (see RA0002-RA0005, RA0009 and RA0011).

RP0039 Greenwood, M., McClelland, G., and Schulze, W. The Effects of Perceptions of Hazardous Waste on Migration Yucca Mountain Socioeconomic Project 09/01/88

The siting of a HLNW repository at Yucca Mountain may well influence the decisions of people to migrate to the southern Nevada region. During the Spring of 1988, a study was undertaken by CU (as part of the NWPO's Socioeconomic Project, Phase IV-A, Task 8.1.3) to examine the psychological decision process used to make migration decisions and to determine experimentally the perceived effects of a nuclear waste repository on migration to the region in which the repository is located. The authors developed the methodology and a computer program that traces the psychological decision process. In this program, the subjects sift through a large quantity of information about alternative areas from which they might migrate and then choose a location for which to migrate.

Section 2.0 provides a fairly detailed discussion of the precise methodology developed for this study, including a description of the computer protocol, recruitment of subjects, and the actual implementation of the choice experiment. Section 3.0 presents the empirical findings, as well as a discussion of possible extensions of the work. This document is a revision of an earlier report (ID# RP0020) and presents more detail on the subjects, including age, gender, marital status, and family income class. This report also includes a far more detailed description and summary of the process records of the subjects. Moreover, a great deal of additional detail is provided on subject choices. The appendix shows examples of the screens and information as they appear on the computer. See MRDB ID# RP0041 for the data disks from this study. Follow-up research conducted with 150 additional subjects during 1989 is discussed in another report (see RP0083).

RP0083 Greenwood, M., McClelland, G., and Schulze, W. The Effects of Perceptions of Hazardous Waste on Migration Yucca Mountain Socioeconomic Project 12/28/89

The siting of a HLNW repository at Yucca Mountain may well influence the decisions of people to migrate to southern Nevada. The State of Nevada's socioeconomic studies have funded two research efforts to examine the psychological decision process used to make migration decisions and to determine experimentally the perceived effects of a nuclear waste repository on migration to a region in which the reposiotry is located. The first research effort was conducted in 1988; the second effort (conducted in 1989) extended the 1988 research by testing an additional 150 subjects using the same methodology. This report (prepared as part of Phase IV-A, Task 8.1.3) presents the findings from both the 1988 and 1989 experiments. the authors developed the methodology and a computer program that traces the psychological decision process. In this program, the subjects sift through a large quantity of information about alternative areas from which they might migrate and then choose a location for which to migrate.

Section 2.0 provides a fairly detailed discussion of the precise methodology for this study, including a description of the computer protocol, recruitment of subjects, and the actual implementation of the choice experiment. Section 3.0 presents the empirical findings, as well as a discussion of possible extensions of the work. The appendix shows examples of the screens and information as they appear on the computer. See MRDB ID#s RP0020, RP0039 and RP0041 for information on the 1988 research.

RP0020 Greenwood, M., McClelland, G., and Schulze, W. The Effects of Perceptions of Hazardous Waste on Migration Yucca Mountain Socioeconomic Project 06/01/88

The siting of a HLNW repository at Yucca Mountain may well influence the decisions of people to migrate to the southern Nevada region. During the Spring of 1988, a study was undertaked by CU (as part of Phase III, Task 8.4.3 of the NWPO Yucca Mountain Socioeconomic Project) to examine the psychological decision process used to make migration decisions and to determine experimentally the perceived effects of a nuclear waste repository on migration to the region in which the repository is located. The authors developed the methodology and a computer program that traces the psychological decision process. In this program, the subjects sift through a large quantity of information about alternative areas from which they might migrate and then choose a location for which to migrate.

Section 2.0 provides a fairly detailed discussion of the precise methodology developed for this study, including a description of the computer protocol, recruitment of subjects, and the actual implementation of the choice experiment. Section 3.0 presents a summary of the findings to date, as well as discussions of potential further analyses of existing data and data that may yet be garnered in future work. The appendices show examples of the screens and information as they appear on the computer. See MRDB ID# RP0039 for final analysis of the 1988 experiments. Further subjects were tested during 1989 and the findings from both the 1988 and 1989 experiments are combined in ID# RP0083.

NA0024 Hamby, M. Socioeconomic Profiles of Native American Communities: Duckwater Shoshone Reservation Yucca Mountain Socioeconomic Project 10/01/91

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-C, Task 6.1) presents a socioeconomic profile of the Duckwater Shoshone Reservation. The report describes the reservation history, economic-demographic and housing conditions, economic opportunities, educational background of the residents, community facilities and services, and the governmental structure of the reservation. A risk perception questionnaire was also administered in 1988 and a tabulation of the results is provided in the appendix. Attitudes toward the Yucca Mountain repository project are also discussed.

NA0025 Hamby, M. Socioeconomic Profiles of Native American Communities: Yomba Shoshone Reservation Yucca Mountain Socioeconomic Project 10/01/91

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-C, Task 6.1) provides a socioeconomic profile of the Yomba Shoshone Reservation. A brief historical sketch of the reservation is provided along with socioeconomic data gathered by the Native American study team. The profile describes economic-demographic and housing conditions, community facilities and services and the governmental structure of the reservation. Also included are the results of a risk perception survey, which was administered in 1988.

NA0006 Hamby, M. Native Americans Contemporary Socioeconomic Sketches, Esmeralda and Lincoln Counties and Death Valley Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 6.0, Phase III), contains socioeconomic data of Native Americans living in three regions near Yucca Mountain: Esmeralda and Lincoln Counties, Nevada and Death Valley, California. These socioeconomic profiles are based on data gathered in field surveys and interviews from Fall 1986 to Spring 1988, from the U.S. Census (1970 and 1980) and from a 1981 document submitted to the U.S. Government by a Death Valley Shoshone group in application for recognition. The socioeconomic profiles in this document consists of descriptions of population distribution, community services, household composition, educational levels, employment, health, housing type and tenure and for the Death Valley group, political structure and tribal enterprise. This report supplements document NA0004 which contains socioeconomic data for Native Americans living in Clark and Nye Counties.

NA0009 Hamby, M. and Rusco, M. Responses to Risk Perception Questionnaire: Western Shoshone Reservations (Volume 1) and Southern Paiute Reservations (Volume 2) 11/04/88

As part of the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 6.0), a risk perception questionnaire was administered to 59 Native Americans in southern Nevada during July and August, 1988. This 2-volume document contains the responses to that questionnaire. The questionnaire that was administered was a modified version of the risk questionnaire that was undertaken in the rural communities of southern Nevada during Phase III. The following Indian groups were included in the survey: the Western Shoshone of the Timbi-Sha of Death Valley, Yomba Shoshone Reservation, and the Duckwater Shoshone Reservation and the Southern Paiutes in Pahrump, the Las Vegas Colony and the Moapa Reservation. Although the sample surveyed was too small to be statistically valid, it serves as a preliminary indication of attitudes toward community, socioeconomic status, and concerns and perceived risks related to development of the repository at Yucca Mountain.

NU0037 Hardert, R. Feed Materials Production Center, Fernald, Ohio: A Case Study Yucca Mountain Socioeconomic Project 05/01/92

This report on the DOE Feed Materials Production Center located near Fernald, Ohio was prepared as part of the NWPO Yucca Mountain Socioeconomic analogous case studies (Phase IV-C, Task 9.3.3). The Fernald study is intended to shed light on the advisability of locating a HLNW repository at Yucca Mountain in Nevada. Major topics discussed in this report include: a physical comparison of the Rocky Flats and Fernald plants; potential nuclear exposure at Fernald; possible political deception at Fernald; legal problems surrounding Fernald; any lessons that can be learned from Fernald that might be applicable to Nevada; and, community response to exposure to hazardous wastes, including the issues of trust and trustworthiness.

IG0010 Herzik, E. and Mushkatel, A. Intergovernmental Relations: A View from the Federal Agencies Yucca Mountain Socioeconomic Project 05/01/89

No abstract.

IG0006 Herzik, E., and Mushkatel, A. Urban Area Intergovernmental Studies Report Yucca Mountain Socioeconomic Project 05/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 5.4.2, Phase III), examines the forms, powers, and interactions of four local governments in the Las Vegas urban area (Las Vegas, North Las Vegas, Henderson and Clark County). The findings in this document are based on data derived from interviews with local government officials and representatives from private organizations and economic interests. The first section provides an overview of the types of intergovernmental problems that may result from the siting of the repository at Yucca Mountain. The analysis of potential problems is linked to the concept of "stakeholder", which are groups that have a stake in the current structure or in the trends of development within an area. Noting potential problems and associated stakeholder groups provides a theoretical framework by which governmental response capabilities can be analyzed.

Section two describes intergovernmental relations within the Las Vegas urban area. Section three links the intergovernmental framework to the repository. The focus of this section is on the ability of Las Vegas urban area local governments to respond to the problems and stakeholder groups activated by the repository. Section four highlights community and governmental concerns specifically related to the issue of transportation. Transportation was identified as the primary concern by each stakeholder group interviewed. This section contains a table listing perceived preliminary mitigation needs for transportation. Section five integrates the role state and federal governmental relations have on local government interactions and response capacity. The concluding section summarizes the description of local governmental capacity in light of the identified problems and stakeholders.

RA0041 Hoskins, R. Review of Cask Design Issues & the Implications for HLNW Transportation Risk Identification: Preliminary Draft Yucca Mountain Socioeconomic Project 07/26/90

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 13.0) reviews the DOE/OCRWM preliminary cask design reports in order to assess the degree to which such casks may ameliorate or amplify transportation risks. The review concentrates on the systems engineering aspects of the preliminary cask designs rather than the details of the shielding, thermal, and structural designs of the casks. The review discusses the following issues: design objectives, regulatory conservatism, cask engineering, increased fuel burnup, consolidated fuel shipment, and cask turn-around time.

In summary, the author found the preliminary design reports to be responsive to DOE's design criteria and appear to be adequate for their intended purpose. While a great deal of detailed analysis and development work remain to be done the reports should serve to allow DOE to evaluate the viability of the designs and begin to get feedback from NRC regarding certification of the cask designs. The author also discusses a complex interrelated number of issues that need to be addressed and resolved to gain public understanding and acceptance of risk related to transportation of spent nuclear fuel as well as other important aspects of spent fuel management. For other reports reviewing DOE preliminary cask design reports, see MRDB ID#'s: RA0039, RA0042 and RA0043.

RA0052 Hoskins, R. Update of Commercially Available Dry Storage Systems for Spent Fuel Storage and Certification of Dual Purpose (Storage/Transportation) Cask: Yucca Mountain Socioconomic Project 12/10/91

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVC, Task 13.1) updates the status of commercially available dry storage systems for spent nuclear fuel through July 1991. Special attention is given to the certification of dual purpose (storage/transportation) casks. It builds on and is an extension of two other reports by the author (see MRDB ID# RA0041 & TR0029). These works by the author show that the real and perceived safety impacts related to transportation of spent nuclear fuel transportation are strongly dependent on the effectiveness by which the design of the waste management system effectively integrates and optimizes at-reactor storage, transportation system, away-from-reactor storage and the repository. Each of these elements of an integrated systems approach to waste management is addressed, including a discussion of the current DOE management system relative to this approach.

TR0033 Jacob, G. The Hazardous Materials Transportation Uniform Safety Act of 1990: Implications for the Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste 06/01/92

This paper was prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IVC, Task 13.2). It presents a preliminary examination of three issues related to the transportation of radioactive materials which were considered during debate over reauthorization of the Hazardous Materials Transportation Act (HMTA) and subsequent passage of amendments to that Act in the form of the Hazardous Materials Transportation Uniform Safety Act of 1990. These issues are: (1) Testing of casks used to haul spent fuel and high-level radioactive waste; (2) Route selection for shipments of radioactive materials; and, (3) Emergency response training for accidents involving radioactive materials.

For each topic, discussion begins by summarizing relevant language of the HMTUSA, followed by a historical look at the issue in light of past regulatory activity and legislative debate. Finally, the implications of the HMTUSA for future actions by Federal and State authorities are discussed. The purpose of the report is to place these issues within the political and historical context of the history of the HMTUSA and nuclear waste transportation in the U.S. Discussion of specific legal or regulatory questions is beyond the scope of this paper.

RA0003 Kasperson, R., Emel, J., Goble, R., Kasperson, J., and Renn, O. Evaluation of Preclosure Risks (Appendix A.2.3) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report 06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 5.2 and 9.0). This document is the third part of a five-part report on the risk assessment research conducted by Clark University during Phase II. This report evaluates the major types of risks associated with different steps in preclosure operations including both direct and secondary consequences. Preclosure risks refer to routine exposures and accidents which could occur in the various operations extending from the unloading of radioactive materials from transport vehicles through the emplacement in the repository itself. The authors feel that DOE has not sufficiently analyzed this area of risk assessment to provide a firm understanding of the preclosure accidents that could occur at a repository, their radiological consequences, or their overall contribution to waste management risks.

This report: 1) characterizes (to extent possible) the logistical operations relevant to risk considerations; 2) examines repository preclosure risks in the context of overall waste disposal risks; 3) models the major risks that will be present with particular attention to their management implications and to their potential interaction with the social system; 4) assesses the adequacy of the current knowledge and data bases, identifying gaps and shortcomings that need to be addressed; and 5) indicates the implications of the analysis for the DOE and the State of Nevada. The authors discuss a number of specific risk issues pertaining to the Yucca Mountain site (and which still require thorough study by DOE) including: remoteness of the site, natural phenomena (particularly floods, earthquakes), human error and quality assurance failures, protest and sabotage activities, and social amplification of technical risks. Other sections of the five-part report can be found in MRDB ID#s: RA0002 (site characterization risks); RA0004 (transportation risks); RA0001 (overall introduction); and RA0005 (conclusion).

RA0005	Kasperson, R., Emel, J., Goble, R., Kasperson, J., and Renn, O.	Summary and Preliminary Identification of Risk Assessment Issues (Appendix A.2.5) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 5.1, 5.2, 5.3.1, 5.3.3, and 9.0). This document is the final part of a five-part report on the risk assessment research conducted by Clark University during Phase II. The first four sections of the report evaluate the risks of site characterization (ID# RA0002), preclosure (ID# RA0003), and transportation (ID# RA0004) with the first section (ID# RA0001) providing an overall introduction to the entire report including a review of the causal model of hazard management. This final section summarizes the findings of these studies and identifies a number of implications for risk assessment and management at the Yucca Mountain site. DOE risk assessments were considered uneven and sometimes incomplete, most notably in its inadequate conceptualization of the risk problems; its failure to give sufficient attention to human error, quality-assurance failures, and acts of sabotage and terrorism; and the lack of a systems study that interrelates and compares the major types of risk associated with characterizing candidate sites and developing and operating a HLNW repository. Some suggestions for the State of Nevada for risk assessment and risk management activities is also included.

RA0001	Kasperson, R., Emel, J., Goble, R., Kasperson, J., and Renn, O.	Nuclear Waste System Risks at the Proposed Yucca Mountain Repository (Appendix A.2.1) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 5.1, 5.2, 5.3.3, and 9.0). This document is the introductory section of a five-part report on the risk assessment research conducted by Clark University during Phase II. The major risk activities conducted during this time included: 1) assembling the relevant technical literature and data base relating to each major type of risk; 2) reviewing the technical quality of DOE risk assessments in light of the overall data base; 3) application of the risk "causal structure" model developed by Clark University to the risk clusters; and 4) characterizing the risks and risk events including reconfiguration of risk data, either explicit or implicit in the data base, into new categories of analysis that have direct relevance to socioeconomic analysis.

This document provides a good overview of the types of issues that should be included in risk assessments, discusses the causal model of hazard management (including flow charts), and identifies the five major risk clusters of concern in the development of the HLNW repository in Nevada: site characterization, transportation, preclosure, postclosure, and retrieval. Also discussed is the role of social amplification of risks in risk assessments. Definitions of risk terminology such as hazards, risks, hazard management, taxonomy of technological hazards, social amplification, and stigmatization are provided. The other sections of the five-part report go on to evaluate the risks of site characterization (ID# RA0002), preclosure (ID# RA0003), and transportation (ID# RA0004). The final section of the report (ID# RA0005) provides a preliminary identification of risk assessment issues associated with the Yucca Mountain site.

RA0004	Kasperson, R., Emel, J., Goble, R., Kasperson, J., and Renn, O.	Evaluation of Transportation Risks (Appendix A.2.4) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 5.3.1, 5.3.3, and 9.0). This document is the fourth part of a five-part report on the risk assessment research conducted by Clark University during Phase II. This document summarizes the findings of the transportation risk studies and develops a preliminary conceptual framework for a complete and comprehensive risk assessment for the transportation of spent fuel. The analysis does not specify all the logical links between the various factors, but should be regarded as a list of aspects structured along a causal chain of initiating events, and includes a discussion of the range of impacts and effects, potential multipliers (aggravating factors), potential divisors (mitigating factors), and interactive amplifiers (such as coincidence with externally released hazards or social concerns). Seven causes of potential damage are discussed: incident-free transportation; vehicle accidents; human error in operation, handling, and loading; defective quality assurance; purposeful sabotage; social unrest and opposition; and external circumstances (natural and man-made).

The authors list 10 critical decision areas that decision-makers in regulatory agencies must consider. Also provided is an extensive review and critique of RADTRAN III, the principle computer model used by DOE to assess transportation risks. The authors felt the model (though promising) cumbersome to use, extremely resource demanding and often rests upon implausible assumptions that detract from its usefulness. The authors note that the omission of sabotage, terrorism, quality control problems, and performance weaknesses and mishandling in the model precludes the analysis of organizational changes in loading and shipping and the desired level of security arrangements. Other sections of the five-part report evaluate the risks of site characterization (ID# RA0002) and preclosure (ID# RA0003). The first section (ID# RA0001) provides an overall introduction to the entire report including a review of the causal model of hazard management and the final section (ID# RA0005) provides a preliminary identification of risk assessment issues associated with the Yucca Mountain site.

RA0002	Kasperson, R., Emel, J., Goble, R., Kasperson, J., and Renn. O.	Evaluation of Site Characterization Risks (Appendix A.2.2) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 5.1 and 9.0). This document is the second part of a five-part report on the risk assessment research conducted by Clark University during Phase II. Clark University develops a conceptual model (including diagrams) of the major types of risks which may be expected during site characterization, indicating how events (such as accidents) translate into adverse consequences (such as human harm or community economic burdens). The four major types of risk discussed include: 1) anticipated, operational risks; 2) low-probability external and multiple-factors events; 3) social and socially amplified hazards; and 4) long-term hazards. This analysis considerably expands DOE's risk assessment in the EA, which only covered anticipated, operational risks during site characterization.

The authors discuss how low probability events or chain of events can trigger serious consequences by providing signals to the public that the program is mismanaged or dangerous. Such events could increase social disruption, such as political protest activities, sabotage, and terrorism. Also discussed are other deficiencies in DOE's risk assessment studies besides the narrow scope of analysis. DOE's assessment of site characterization sites was found to be particularly deficient in connecting risk events and special socioeconomic impacts, especially those arising from social amplification of risks. The earlier draft of this document (completed under Task 5.1) contains essentially the same information; however, it does contain a selected list of attacks on nuclear power reactor sites by terrorist and other sub-national groups (both in the US and other countries). Other sections of the five-part report are found in MRDB ID# RA0003 (preclosure risks); RA0004 (transportation risks) and RA0001 (overall introduction) and RA0005 (conclusion).

IM0004	Kasperson, R., Ratick, S. and Abdollahzadeh, S.	Distributional Equity Problems at the Proposed Yucca Mountain Repository Yucca Mountain Socioeconomic Project	07/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 7.4, Phase III), addresses the distribution of impacts to the State of Nevada and to the nation likely to be associated with the impact of the proposed Yucca Mountain repository. This report is one of four analyses of the overall equity problems and needs to be read in conjunction with the authors' proposed overall framework for equity studies (see document IM0003). The objective of this report is to consider how an analysis might be made of the distribution of projected outcomes between state and nation. This report identifies the analytical issues and problems and proposes an approach for overcoming them, but does not actually implement the proposed analysis.

The proposed approach consists of a set of interrelated components: (1) to estimate the value of a HLNW repository at the Yucca Mountain site to the nation as a whole; (2) to identify and assess the types and magnitudes of important project-related impacts and to allocate these impacts between the state and nation; (3) to consider other nuclear-related activities that have occurred in Nevada; (4) to identify and propose alternative principles of social justice that can be utilized to assess the fairness of the state/nation distribution of impacts; and (5) to identify and evaluate the management options available for reducing and/or redressing the inequities that would be uncovered in this study. The authors propose various approaches that can be used in tackling these tasks. This document is one of a series of papers prepared by Clark University/CENTED (IM0002-IM0005) discussing equity analysis.

IM0003	Kasperson, R., Ratick, S., and Renn, O.	A Framework for Analyzing and Responding to Equity Problems Involved in High-Level Radioactive Waste Disposal Yucca Mountain Socioeconomic Project	06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 7.4, Phase III), presents an overall framework for equity problems and management involving HLNW disposal. The proposed framework will help clarify the nature of equity issues, the types of studies needed and potential analytical approaches. This report discusses the purpose of equity analysis in relation to radiological waste repository development and defines key concepts or issues involved in equity analysis

The conceptual framework adopted by the authors is composed of two linked models. The first model is a decision tree for key choices in radioactive waste disposal and repository siting, with particular attention to the entry of equity consideration. The second model depicts the key components of inequity analysis and management and the nature of their interrelationship. This document is one of a series of documents (IM0002-IM0005) involving equity analysis.

RP0063	Kasperson, R., Renn, O., Slovic, P., with Brown, H., Emel, J., Goble, R., Kasperson, J. and Ratick, S.	The Social Amplification of Risk: A Conceptual Framework Yucca Mountain Socioeconomic Project	01/12/88

Despite the expenditure of billions of dollars and steady improvements in health, safety, and longevity of life, people view themselves as more rather than less vulnerable to the dangers posed by technology. Particularly perplexing is that even risk events with minor physical consequences often elicit strong public concern and produce extraordinarily severe social impacts, at levels unanticipated by conventional risk analysis. A comprehensive theory is needed that is capable of integrating the technical analysis of risk and cultural, social, and individual response structures that shape the public experience of risk. The main thesis of this paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase III, Task 7.5) is that risk events interact with psychological, social, and cultural processes in ways that can heighten or attenuate public perceptions of risk and related risk behavior.

Behavorial patterns, in turn, generate secondary social or economic consequences but may act also to increase or decrease the physical risk itself. Secondary effects trigger demands for additional institutional responses and protective actions, or, conversely (in the case of risk attenuation), impede needed protective actions. The social structures and processes of risk experience, the resulting repercussions on individual and group perceptions, and the effects of these responses on community, society, and economy compose a general phenomenon that the authors' term "the social amplification of risk." This paper sets forth an initial conceptualization of the elements, structure, and processes that make up this phenomenon.

IM0002	Kleindorfer, P., Knez, M., Kunreuther, H., MacLean, D.	Valuation and Assessment of Equity in the Siting of a Nuclear Waste Repository Yucca Mountain Socioeconomic Project	05/31/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 7.4, Phase III), considers questions of valuation and assessment of equity in the context of siting hazardous facilities such as the proposed nuclear waste repository at Yucca Mountain, Nevada. This report considers theory and experimental evidence associated with the following two issues: (1) how do individuals value fairness in the siting process -- what attributes of procedure and outcome are important to them and how do these interact with one another in yielding an overall assessment of fairness or equity of a specific siting decision, and (2) are there threshold values or conditions on procedure or outcome such that these conditions must be met in order for a siting decision to be considered equitable or acceptable.

This document discusses the theory of collective choice and experimental evidence from decision sciences. A survey-based empirical procedure for assessing the values and perceptions of individuals with respect to the fairness of the Yucca Mountain Repository is then proposed. The limitations of the proposed approach are analyzed from a philosophical perspective. In particular, problems with compensation and intergenerational equity for the repository siting context are indicated, and several serious complications for valuing and assessing risk equity implicit in the characteristics of the repository siting decision are discussed. The appendix contains an essay, "Equity in Economics and Decision Sciences: Theory and Experiments", which reviews literature related to equity (including equity concerned with collective choice and equity at the individual level).

RP0061 Krannich, R. and Little, R. 1988 Rural Community Surveys: Background Report Yucca Mountain Socioeconomic Project 06/30/89

This report, prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Tasks 8.1.1 & 5.1), provides basic documentation of research procedures and response patterns for a series of community surveys conducted in six southern Nevada rural communities in the Spring of 1988. See document ID# RP0073 for an update of this report, which includes the results from the 1989 survey in Goldfield. The objectives of the survey were broad, reflecting a need to establish an extensive data base with which to document existing demographic and social/cultural conditions in the 6 communities. The survey addressed the perceptions and attitudes of area residents regarding nuclear waste storage and related risk issues. The four-version questionnaire used in the survey (see the Appendix) included questions dealing with community social integration and satisfaction, personal well-being, political attitudes and behavior, trust in government and science, attitudes and perceived risks associated with a variety of nuclear and non-nuclear facilities and activities, attitudes and perceptions about the proposed HLNW repository, as well as basic demographic background characteristics of rural community residents.

This report includes: a description of the study setting and the survey methodology used in each of the study communities and the frequency distributions and measures of central tendency for each question in the questionnaire. The tables have been organized into several discreet subject areas that correspond to major components of the questionnaire. The tables present the frequency distributions for all the study communities to facilitate cross-community comparisons. Prior to each section of the report is a brief discussion of the major conceptual variables which are addressed by the questions in that section, along with commentary regarding some of the more important community differences. Other more focused efforts to analyze this survey data can be found in several professional presentations by the research team (see document ID#'s: RP0029, RP0047, & RP0064) and in the Interim Report on the status of the Yucca Mountain Socioeconomic Project (SE0006). The computer printout and the data tape of the survey results can be found in document ID#'s RP0026 and RP0027, respectively. In addition, key sociocultural relationships in the 6 communities and the community of Goldfield are examined in another report by the authors (see ID# SC0021).

RP0058 Krannich, R. and Little, R. Goldfield Community Survey: Data Collection Summary Report & Questionnaire (5 Vols.) Yucca Mountain Socioeconomic Project 06/30/89

This brief report summarizes the research methodology utilized in conducting a survey of 123 adult residents in Goldfield, Nevada during June, 1989 (response rate, 80.9%). This research was conducted as part of NWPO's Yucca Mountain Socioeconomic Project (Phase IV-A, Task 16.4). This survey was patterned after the 1988 rural community surveys conducted in Amargosa Valley, Beatty, Pahrump, Indian Springs, Mesquite and Caliente. The survey addressed the perceptions and attitudes of area residents regarding nuclear waste storage and related risk issues and included questions dealing with community social integration and satisfaction, personal well-being, political attitudes and behavior, trust in government and science, attitudes and perceived risks associated with a variety of nuclear and non-nuclear facilities and activities, attitudes and perceptions about the proposed HLNW repository, as well as basic demographic background characteristics of rural community residents.

The Goldfield survey utilized the same questionnaire as the other rural community surveys with the addition of three new items that were inserted at the request of Esmeralda County officials. These questions involved current commuting patterns, potential interest in future Yucca Mountain employment, and potential commuting or relocation responses that might be used to deal with employment at Yucca Mountain. Copies of the modified questionnaires are included in the appendix to this report. The report describes the sample selection, survey administration, and data processing of the survey. This document does not analyze or discuss the survey results. The key frequency distributions for the Goldfield survey and the six 1988 rural community surveys can be found in ID# RP0073 along with a brief summary of the findings and major differences across the 7 communities. The data disk containing the Goldfield survey results can be found in document ID# RP0060 and the computer printout of the results in RP0059. The analysis of key sociocultural relationships in the 7 communities is reported on in another document by the authors (MRDB ID# SC0021).

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RP0073	Krannich, R. and Little, R.	Rural Community Surveys: Updated Background Report Yucca Mountain Socioeconomic Project	09/28/89

This report provides the basic documentation of research procedures and response patterns for a series of community surveys conducted in six southern Nevada rural communities in the spring of 1988 and a seventh in June, 1989. The surveys and subsequent data analysis were conducted by RMSS as part of the NWPO's Yucca Mountain Socioeconomic Project. This report (prepared as part of Phase IV-B, Task 5.1) updates the 1988 Rural Community Background Report (ID # RP0061) by adding the results of the 1989 Goldfield community survey. The objectives of the surveys were to establish an extensive data base with which to document existing demographic and social/cultural conditions in the rural study communities and to address perceptions and attitudes of area residents regarding nuclear waste storage and related risk issues. The survey included questions dealing with community social integration and satisfaction, personal well-being, political attitudes and behavior, trust in government and science, attitudes and perceived risks associated with a variety of nuclear and non-nuclear facilties and activities, attitudes and perceptions about the proposed HLNW repository, as well as basic demographic background characteristics of rural community residents.

This report includes: a description of the study setting and survey methodology used in each study community and the frequency distributions and measures of central tendency for each question in the questionnaire. The tables have been organized into nine subject areas that correspond to major components of the questionnaire and present the frequency distributions for all seven study communities to facilitate cross-community comparisons. Prior to each section of the tables is a brief discussion of the major conceptual variables which are addressed by the questions in that section, along with commentary regarding some of the more important community differences. Other more focused effort to analyze this survey data can be found in other documents by the research team (see ID #'s RP0029, RP0047, RP0064 & SC0024) and in the Yucca Mountain Socioeconomic Project Interim Report (SE0006). Raw data of the 1988 survey results can be found in ID #'s RP0026 and RP0027. Other documentation of the Goldfield survey can be found in MRDB ID #'s RP0058, RP0059, and RP0060.

SC0021	Krannich, R. and Little, R.	Analysis of Key Sociocultural Relationships in Seven Southern Nevada Rural Communities Yucca Mountain Socioeconomic Project	11/30/89

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase IV-B, Task 5.1) addresses a number of key sociocultural conditions observed in seven southern Nevada rural communities which surround the proposed Yucca Mountain HLNW repository site. The analysis of these conditions is based on survey data collected using self-completion questionnaires in the 7 communities. The communities of Amargosa Valley, Beatty and Pahrump in Nye County, Indian Springs and Mesquite in Clark County, and Caliente in Lincoln County were surveyed in the spring of 1988. Goldfield in Esmeralda County was not surveyed until June, 1989. A complete description of the study design and implementation procedures is available in another report (see MRDB ID# RP0073).

The purpose of this analysis is to determine how the study communities and various population segments within them are distributed on certain key sociocultural variables as well as noting important intercommunity differences. The focus is on 5 general categories of variables: (1) community integration and participation, (2) community satisfaction, (3) community values involving orientations toward community change, (4) trust in political structures, and (5) trust in science. These variables were selected because they can provide important insights into the nature of the communities and their potential responses to a project such as the proposed Yucca Mountain repository. In order to understand probable future social and cultural impacts of repository construction, it is necessary to fully understand the social and cultural context of the communities in which impacts would emerge. This report is intended to add to that necessary level of understanding.

SC0001	Krannich, R. and Little, R.	Baseline Community Social Profiles for Communities in Nye, Esmeralda, Lincoln and Clark Counties (3 Volumes) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.2.2, and 9.0). A major component of these studies is to understand and project the impacts of the repository on the social and cultural structure of southern Nevada. The first section of this report (A.5.1) describes how the social/cultural component of the study is linked to other study components, such as economic-demographic, community facilities and services, fiscal, transportation, risk assessment and perception, etc. The remainder of the report contains detailed baseline descriptions of the social/cultural structures of the communities in southern Nevada. Volume 1 (222 pp) covers the communities of Amargosa Valley, Beatty, Pahrump and Tonopah in Nye County and Goldfield in Esmeralda County. Volume 2 (102 pp) discusses the communities of Caliente, Pioche and the Alamo-Hiko area in Lincoln County. The third volume (262 pp) covers the communities of Boulder City, Henderson, Indian Springs, Las Vegas, Mesquite and North Las Vegas in Clark County. Data used in compiling the profiles were derived from available documents and from study team field observations and interviews conducted during Phase II with a variety of local residents in the community.

Each community profile documents important historical development trends that underlie contemporary social and cultural conditions. Current demographic characteristics and economic development trends are discussed as is the spatial dispersion of the community. Each profile discusses: the community's major social groups and organizations and their role in the community; the cohesion and interaction patterns of the community; the "way of life" in the community including recreational activities; key community issues and political disputes; and attitudes toward the nuclear waste repository. Also discussed are the relationships and areas of conflict between communities within each county. The Clark County volume includes a discussion of the role of the federal government and military activities within the county, military-civilian relationships within Indian Springs, and the role of the gaming industry in the urban areas, particularly in Las Vegas. Further ethnographic research, conducted during Phase III, is reported on in MRDB ID# SC0007.

SC0007	Krannich, R., Endter, J., Little, R., and Trend, M.	Ethnographic Summary Report (6 Vols.) Amargosa Valley, Beatty, Pahrump, Pahranagat Valley, Eastern Lincoln County, and Indian Springs	10/01/88

This document contains baseline ethnographic profiles of Indian Springs, Amargosa Valley, Beatty, Pahrump, Pahranagat Valley and Eastern Lincoln County, prepared for the Yucca Mountain Socioeconomic Research Project (Phase III, Task 5.1). This report describes the background history, economic conditions, politics, formal public and non-public institutions, informal organizations, community activities and processes, attitudes and perceptions, and nuclear issues of each community. These communities were included in this study because they could potentially experience impacts associated with the contstruction of the repository and associated transportation systems.

This document summarizes the ethnographic findings of two community field workers who lived in these communities on a rotating basis from August, 1987 through June 1988. This data expands the social-cultural understanding of these communities as described in Phase II Social-Cultural Profiles (see document SC0001).

RP0122	Krannich, R., Little, R., Mushkatel, A., and Pijawka, D.	Southern Nevada Residents' Views About the Yucca Mountain HLNW Repository and Related Issues: A Comparative Analysis of Urban and Rural Survey Data (Yucca Mountain Socioeconomic Project)	10/01/91

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVC, Task 5.2) presents a comparative analysis of the ways in which urban and rural residents of southern Nevada perceive the proposed Yucca Mountain HLNW repository. The report is based on an analysis of data drawn from two separate surveys undertaken in 1988. The first of these surveys focused on the attitudes and perceptions of residents in the Las Vegas metropolitan area. The second survey addressed similar issues, but focused on the views of residents in six rural communities in three counties adjacent to the Yucca Mountain site: Amargosa Valley, Beatty and Pahrump in Nye County, Indian Springs and Mesquite in Clark County, and Caliente in Lincoln County.

This report presents a parallel analysis of responses from the two surveys in an attempt to identify ways in which the views and orientations of residents in the rural and urban study areas may be similar or different. The report focuses on five major topic areas: (1) responses related to the acceptability of the repository, (2) perceived risks associated with the proposed repository, (3) perceptions of possible effects stemming from nuclear activities at the NTS, (4) perceptions of the trustworthiness of government entities responsible for constructing and/or managing the repository, and (5) risk aversion to a variety of hazardous and noxious facilities.

SC0025	Kroll-Smith, J. and Couch, S.	Social Impacts of Toxic Contamination of Hazardous Wastes Yucca Mountain Socioeconomic Project	05/01/92

This report is one of a series of analogous case studies conducted as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IVC, Task 9.3.5). The authors conducted extensive research in three communities that experienced toxic contamination. Through these three cases and an examination of the literature, the authors describe and explain individual and social responses that appear to be common in cases of toxic contamination, and which they believe would be likely to take place if contamination were to occur at the proposed Yucca Mountain site. The report highlights several important areas of social disruption and personal trauma that are likely to follow the recognition or fear that the local environment is contaminated. It is critical to realize that these problems are not due only to actual contamination, but are caused or exacerbated by the social response to the technological hazard or disaster.

The research also found that the disastrous consequences are liable to take place regardless of the actual level of contamination or of physical damage caused by the contamination. All that is needed is the fear of potential contamination, and a lack of trust in the ability of the responsible institutions to protect the public from harm. That fear is a natural companion to the presence of radiation, and, as illustrated by the case studies, regardless of the best intentions, the nature of governmental response tends to produce mistrust in communities that host technological hazards. Moreover, in the three cases studied, rather than diminishing over time, mistrust increased the longer contact between the government and the communities was maintained. Without the development both of clearly adequate mechanisms to provide for the long-term physical safety of local residents, and of methods for establishing and maintaining trust between residents and government officials, the establishment of a HLNW repository at Yucca Mountain would be likely to have very deleterious effects on neighboring residents and their communities.

RP0014	Kunreuther, H., Easterling, D. and Kleindorfer, P.	The Convention Planning Process: Potential Impact of a Repository in Nevada Yucca Mountain Socioeconomic Project	06/01/88

This report, prepared for the NWPO Socioeconomic Project (Phase III, Task 8.4.4), presents preliminary results from two studies that test whether a HLNW repository sited at Yucca Mountain, Nevada will diminish the willingness of meeting planners to schedule conventions, trade shows and other meetings in Las Vegas. See document RP0038 for final analysis of results. The first study, a focus group interview with 9 meeting planners, was conducted to guide the development of a larger and more formal questionnaire survey of meeting planners who were known to have selected Las Vegas for a meeting. Subjects first answered questions that described the process by which they chose Las Vegas among possible convention sites. They then reconsidered their decision in light of a number of scenarios pertaining to the repository-related events at Yucca Mountain. The sample and procedure of both the focus group and the telephone-mail-telephone survey is described.

Section IV presents data indicating the impact of accidents and environmental hazards on planners' preferences. This section begins by examining the effect that a wide range of disturbances has on the planning decisions made by the focus group, and moves to the impact of more specific repository-related events on the planning and cancellation decisions made by telephone-mail-telephone respondents. Section V outlines additional studies and data that would help estimate the extent of convention business that Las Vegas could lose if the repository is sited at Yucca Mountain. Appendix A contains a copy of the questionnaire used in the telephone-mail-telephone survey. This document is followed up by a data disk which contains key data files for the telephone survey (see document RP0023) and the data disk's coding manual (see document RP0024).

RP0038 Kunreuther, H., Easterling, D., and Kleindorfer, P. — The Convention Planning Process: Potential Impacts of a Repository in Nevada Yucca Mountain Socioeconomic Project — 09/01/88

This report (prepared as part of the NWPO Socioeconomic Project: Phase IVA, Task 8.1.4) presents results from 1988 two studies that test whether a HLNW repository sited at Yucca Mountain, Nevada will diminish the willingness of meeting planners to schedule conventions, trade shows, and other meetings in Las Vegas. The first study, a focus group interview with 9 meeting planners from the Philadelphia area, found little evidence that planners' selection decision would be influenced by environmental hazards, unless planners were led to believe that these hazards would have a direct impact on convention delegates and the planner could be held personally responsible for any such impacts. Participants did point out that they would be sensitive to continued media coverage of a negative event, as this might stigmatize the city in the eyes of delegates. The results from the focus group guided the development of a larger and more formal questionnaire survey of 153 meeting planners who were known to have selected Las Vegas for a meeting. Subjects first answered a number of questions that described the process by which they chose Las Vegas among the possible convention cities. They were then instructed to reconsider their decision in light of seven different scenarios pertaining to the repository at Yucca Mountain.

Analyses indicate that, based on current perceptions of the repository, we can expect that between 3% and 28% of the planners who would normally select Las Vegas for their meeting will choose another city if and when the repository begins operation at Yucca Mountain. If extensive media attention accompanies the siting of the repository, these bounding estimates increase to 10% and 37%. Planners are especially reluctant to consider Las Vegas for a meeting under a particularly severe repository scenario (i.e., one that indicated a number of radioactive releases and transportation problems over the first 10 years of operation, with amplified media coverage). Here, between 39% and 68% of planners predisposed toward Las Vegas would choose another city instead. Approximately 30% of planners in the sample reported that they would definitely try to move an already scheduled meeting from Las Vegas if an investigative report describing these incidents were released. The report discusses a number of issues that must be considered in extrapolating the survey results to an estimate of the actual impact of the repository on the Las Vegas convention industry.

IM0012 Kunreuther, H., Kleindorfer, P., Richards, K., Desvousges, W., Gregory, R., Slovic, P., and Kasperson, R. — Analysis of Compensation and Mitigation for the Yucca Mountain Socioeconomic Impact Project: Draft Yucca Mountain Socioeconomic Project — 04/26/87

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase II, Tasks 6.1, 6.2 & 6.3) reports on the research conducted during 1986 and early 1987 on how compensation and mitigation measures might affect and improve socioeconomic conditions that could arise if Yucca Mountain is selected as a repository site. During this period, the authors developed a framework intended to help understand how individuals, both near potential repository sites and elsewhere, perceive the risks of a HLNW facility, how their personal, social and demographic characteristics might interact with these perceptions, and most importantly, what motivates their being in favor or opposed to a HLNW facility. Specifically, the authors were interested in the manner in which alternative compensation and mitigation measures might affect the attitude which various types of individuals would have toward a repository within 100 miles of their home.

A research framework for linking compensation and mitigation options to individual decision processes was developed and is described in Chapters 1 and 3. The framework is linked to the literature and to previous experience using such options in siting hazardous facilities. The authors designed and implemented two survey instruments to test hypotheses arising from this framework. Focus groups were utilized to understand how the survey questions might best be posed and to determine an inventory of concerns which might be addressed by compensation and mitigation. The results of these focus groups are described in Chapter 2. The inventory of concerns generated by these focus groups was further buttressed and corroborated by a systematic analysis of newspaper reports concerning the issues, as reported in Chpater 1 and 2. A baseline telephone survey for both national and Nevada samples were implemented and the initial results of the national survey are reviewed in Chapter 3. Finally, Chapter 4 summarizes the principle findings in the analysis to date and describes research plans for the next phase of the project.

RP0003 Kunreuther, H., Slovic, P., Nigg, J., and Desvousges, W. — Final Report: Risk Perception Telephone Survey Yucca Mountain Socioeconomic Project — 09/04/87

During Phase II of the NWPO Yucca Mountain Socioeconomic Project, two telephone surveys of people's risk perception were conducted--one, nationally and one in the State of Nevada. This document (prepared as part of Phase III, Task 7.5) is a revision of an earlier draft that was prepared as Appendix A.2.7 of First Year Progress Report (Phase II, Tasks 6.3.3 and 9.0). This final report includes additional analyses conducted on the relationship between the respondents' location or distance from the repository and their risk perceptions. A major component of the studies is to measure the risk-related impacts associated with the siting of a HLNW repository, particularly how people's risk perceptions influence their behavior. These impacts represent a new and important addition to conventional socioeconomic impact studies and much of the Phase II work has focused on the development of methodologies for assessing these impacts. This document summarizes how the telephone surveys were implemented, the sampling plan utilized, the conceptual framework that has guided the survey questionnaire and the findings of the surveys. The role of the focus groups and the inventory of concerns in the development of the telephone survey questionnaire are also described (also see ID#'s RP0006 and RP0002, respectively).

The telephone surveys describe and measure: characteristics of individuals (e.g., risk awareness, knowledge of a repository, location) that may influence risk perceptions; risks people perceive from the HLNW repository; views, or mind sets, they form about the HLNW repository; changes in behaviors (e.g., changes in retirement decisions or industrial relocations) induced by the location of the repository; and changes in well-being of Nevada citizens, if the repository were located at Yucca Mountain along with whether tax rebates would make a HLNW repository more acceptable to nearby residents. The results from the telephone survey are preliminary with regard to the overall Socioeconomic Project and are only one part of the total project effort. However, the findings imply that further steps to model and ultimately predict, the risk-induced behaviors are warranted. Other risk perception and behavior research conducted by the study team during Phase II is discussed in the report "Risk Perception, Risk-Induced Behavior and Potential Adverse Economic Impacts from a Repository at Yucca Mountain, NV (ID# RP0001).

NU0005 Lemons J. and Malone, C. — Framework for Decisions about Nuclear Waste Disposal — 10/31/88

Recent decisions have established Yucca Mountain, Nevada, as America's first characterization site for a HLNW repository. The decision remains controversial because it generated numerous understudied and unresolved value-laden public policy issues. This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0) describes several alternative frameworks for assessing decisions about nuclear waste disposal.

NU0002 Lemons, J. and Malone C. — Siting America's Geologic Repository for High-Level Nuclear Waste: Implications for Environmental Policy — 03/18/89

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0) discusses the siting a geologic repository for isolating high-level nuclear waste up to 10,000 years, a controversial undertaking never before attempted in the U.S. The NWPA of 1982 exempted repository siting from important requirements for environmental review under NEPA. In December 1987, the NWPAA identified Yucca Mountain as the first site to be characterized for a high-level nuclear waste repository. In light of the unproven nature of the technology being evaluated, the scientific uncertainties associated with Yucca Moutain, and the lack of proven methods for risk evaluation, the environmental policies for repository siting represent a significant departure from more traditional, comprehensive, and interdisciplinary environmental review for siting nuclear projects. The policies warrant further study by those interested in how present as well as future decisions about complex technologies may be made.

NU0004 Lemons, J. and Malone, C. High-Level Commercial Nuclear Waste Disposal and Environmental Ethics Proceedings of Haztech Internat'l Conference on Hazardous Waste Materials Management, Cleveland, OH 09/21/88

In this paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0), the authors present a case study of current national policy that is being implemented with respect to disposal of commercially-generated HLNW. This issue involves environmental ethics and decisionmaking among scientists, public interest groups, corporate contractors, government agencies, and the U.S. Congress. An analysis of environmental aspects of the issue provides insight to the forces that influence decisionmaking and the need for integrating ethics into environmental science and public policy-making.

This study emphasizes how sound decisionmaking can be assisted by attention to ethical principles and certain public policy concerns both mandated and implied by NEPA. While much more is at issue in the repository siting program than environmental ethnics, the authors characterize this ethical gap as the missing link that allowed significant failure in public policy as it relates to nuclear waste repository siting. Moreover, they describe why any major federal program to resolve the nuclear waste problem must be consistent with principles of environmental ethics.

NU0001 Lemons, J. and Malone, C. Scientific, Public Policy and Ethical Implications of the Nuclear Waste Policy Act and its Amendments 03/18/89

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0) has been accepted for publication in Research in Technology and Philosophy. Between 1982 and December 1987, identification of potential repository sites for long-term disposal of high-level commerical and defense nuclear wastes was guided primarily by the NWPA of 1982. The process of identifying and evaluating potential sites under NWPO generated extreme controversy. Since December 1987, the guiding legislation has been the NWPAA, which identified Yucca Mountain, NV as the preferred location as well as the only site to be characterized. This decision has three important consequences. First, it undervalues the NEPA as a comprehensive national commitment to protection of the environment by replacing both the substance and procedure of NEPA review with less holistic and piecemeal compliance with more narrow environmental statutes. Second, it does not include full consideration of criteria demands for ethically-based public policy decision. Third, credibility problems confront DOE and contribute to controversies surrounding the agency because of the lack of infusion of ethical considerations into past and recent decisions.

Given the fact that the siting process under NWPA was very controversial, and the fact that NWPAA was enacted as recently as December 1987, it is presumptuous to be too definitive about how the repository issue ultimately should be resolved. Therefore, the overall purpose of this paper is to describe some of the ethical implications of nuclear waste siting decisions and to suggest that they be continuously examined as the nation progresses towards a solution to the nuclear waste problem. The authors discuss: (a) the DOE record in managing nuclear facilities; (b) ethical implications of NEPA, NWPA, and NWPAA; and (c) specific value-laden public policy issues derived from the passage of NWPAA. It is important to understand these reasons in some depth because ethical analysis of nuclear waste disposal has been given little more than a rhetorical role in the politics of nuclear energy.

NU0006 Lemons, J. with Thompson, P., Kraft, M., Clary, B., and Piasecki, B. Nuclear Waste Disposal: A Case Study in Environmental Science, Public Policy and Ethics 01/30/89

Actions taken during the last decade now culminate in plans to dispose of high-level spent fuels and defense wastes in geologic repositories. Most of the actions were guided by the NWPA of 1982 and resulted in a series of sustained controversies, especially concerning where the repositories should be located. This siting controversy has been "settled" for the time being by the December 1987 Nuclear Waste Policy Act Amendments (NWPAA) that designates Yucca Mountain, Nevada, as the preferred location. Many provisions of NWPA and NWPAA eclipse key elements of NEPA.

Yucca Mountain combines both the wastes from DOE's extensive weapons-production facilities of the past and the ongoing wastes from U.S. commercial facilities. By inheriting the most problematic wastes from DOE as well as the high-level wastes from the commerical sector, Yucca Mountain's importance is unparallelled in the history of U.S. radioactive waste management decisions. This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0) is a research proposal to NSF to focus on understudied and underdocumented ethical questions deriving from the passage of NWPA/NWPAA that relate to public policy goals and research about ethical issues. The questions proposed for research are grouped into several categories: (a) equity, (b) accountability, (c) the role of science, and (d) environmental ethics.

NU0003 Lemons, J., Malone, C. and Piasecki, B. — America's High-Level Nuclear Waste Repository: A Case Study of Environmental Science and Public Policy — 10/13/89

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVA, Task 15.0) discusses the disposal of high-level commerical nuclear wastes, the so-called spent fuel, which is one of the most politically and ethically complex environmental issues. A series of actions taken over past decades has resulted in plans to dispose of spent fuels in geologic repositories. This decision has ignited numerous controversies, especially concerning where the repositories should be located. This siting controversy has been "settled" for the time being by a federal law that designates Yucca Mountain in southern Nevada as the preferred location. However, the decision: (a) is inconsistent with the National Environmental Act as a comprehensive policy act, (b) does not reflect full consideration of value-laden public policy issues, and (c) adds to credibility problems confronting the DOE and therefore contributes to controversies surrounding the agency's decisions. Aspects of how this decision came about and how it is being implemented provide an interesting case study of how our society is presently dealing with scientifically, politically, and ethically complex technological problems.

RA0048 Levine, A. — Love Canal, 1978 to 1991: A Case Study of the Social Impact of Hazardous Wastes Yucca Mountain Socioeconomic Project — 05/01/92

This report on Love Canal was prepared as part of the NWPO Yucca Mountain Socioeconomic Project analogous case studies (Phase IV-C, Task 9.3.4). Love Canal is a semi-suburban residential section of Niagara Falls, New York that had been contaminated by a long forgotten buried chemical waste dump site, used by the Hooker Chemical Company between 1942 and 1952. This paper is directed to policy makers trying to anticipate what may happen if residential areas are purposefully contaminated, if people living there find out about it, and if government agencies have to address the problem. The purpose of this case study is to describe and analyze the events that have transpired at Love Canal, and to illustrate dilemmas, problems, factors, issues that probably will be present in any technological disaster. Although the cause of the event will differ, as will the history of each place and the particular people involved, we can anticipate that there will be diverse actors with differing expectations, needs, goals and interpretations of the events that occur, depending on their stake in the outcome of the entire event.

SC0031 Little, R. — Caliente Revisited: 1995 Yucca Mountain Socioeconomic Project — 10/01/96

This document presents ethnographic data on Caliente, Nevada gathered during February 1995 as part of the NWPO Yucca Mountain Socioeconomic Studies (Phase V, Task 4.1). This research endeavor was undertaken by six graduate students at Utah State University under the direction of Dr. Little. Dr. Little and colleagues had conducted fieldwork in Caliente in 1987 and 1988. Recent events suggested that it would be an opportune time to re-visit Lincoln County to determine how events had affected perceptions and attitudes toward the proposed nuclear waste facility. The 1995 data is generally consonant with the earlier data. The community is still divided over the desirability of siting the nuclear waste repository at Yucca Mountain.

Safety issues remain at the forefront of those who oppose the repository, while jobs and national responsibility provide rationales for supporters. Health risks associated with ground water contamination remain concerns for many residents on both sides of the repository issue. The federal government continues to be considered as untrustworthy by most, and an enemy by some. State and local government are held in somewhat greater esteem. Mistrust of government is still reflected in the sense of futility expressed by many respondents. These residents believe that regardless of health or safety, if the federal government wants to site the repository at Yucca Mountain they will do so, regardless of the wishes of Nevadans. Some respondents stated that they supported the repository only because they had no choice, and believed that they might as well try to get something out of the inevitable. Interestingly, recent events (such as the rail accident 25-miles from Caliente and the earthquake at Yucca Mountain) seemed to have had little effect upon repository safety issues.

SC0024	Little, R. and Krannich, R.	Major Sociocultural Impacts of the Yucca Mountain HLNW Repository on Nearby Rural Communities Yucca Mountain Socioeconomic Project	09/01/90

The proposed Yucca Mountain HLNW repository has the potential to generate a broad array of socioeconomic impacts in both urban and rural communities of southern Nevada. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 5.4) provides a summary of selected, potentially significant social and cultural impacts that have already occurred or might reasonably be expected to arise in the four Nevada communities located nearest the Yucca Mountain site: Amargosa Valley, Beatty, Indian Springs, and Pahrump.

The focus of the report is upon local residents' perceptions of the proposed repository and risk-related concerns, as well as actual or potential repository impacts on established community social structures. In particular, attention is directed to actual and potential effects on community social integration and involvement, community conflict, and levels of community and personal satisfaction. This summary of repository impacts on social conditions in the four selected study communities is based on research conducted by RMSS during 1986-90. The assessment draws upon, but does not duplicate, information presented in a series of previous reports and papers documenting social and cultural conditions in rural, southern Nevada communities (see MRDB ID#s: SC0001, SC0007, SC0021, RP0029, RP0047, RP0064, and RP0073).

NU0038	Lodwick, D.	Rocky Flats, Colorado: A Case Study Yucca Mountain Socioeconomic Project	05/01/92

This case study (prepared as part of the NWPO Yucca Mountain socioeconomic analogous case studies: Phase IVC, Task 9.3.2) is based on an analysis of newspaper articles released since 1951 about the Rocky Flats plant in Colorado. This content analysis covers articles written through May 18, 1991. The report traces the primary events and stakeholders who were publicly associated with the plant over the past 40 years and the changing perceptions, as presented by reporters, about the plant. Sociological research on technological hazards concludes that the manner in which information about hazards is presented to community members greatly affects their responses.

The Rocky Flats case study shows that the management corporations and the federal government have not yet learned how to work with these technologies. DOE and its managers have tried to underestimate or coverup the hazards. This has served to destroy their trustworthiness. This pattern has been consistent throughout the 40 years of the plant's operation. The author states that current technology is too complex and knowledge too limited to be able to foresee and control the normal accidents of the future. She recommends in future risk management, including the proposed Yucca Mountain project, that potential hazards be overestimated rather than underestimated as has been the case in the past.

RP0153 Mertz, C., Flynn, J. and Slovic, P. The 1994 Southern California and Phoenix Telephone Survey: Key Findings Yucca Mountain Socioeconomic Project 01/11/95

This report describes the results of two 1994 telephone surveys conducted with residents of southern California and the Phoenix metropolitan area as part of the NWPO Yucca Mountain Socioeconomic Project (Phase V, Task 9.4). The purpose of the surveys were to examine attitudes and opinions toward the federal government's nuclear waste program and its management and to assess the potential impacts a HLNW repository could have upon tourism and economic conditions of Las Vegas and the state of Nevada. Two versions of the instrument were used in each sample. Version 1 elicited images for four cities and asked people to indicate among these cities as places to vacation. Version 2 did the same for four states. O'Neil Associates of Tempe, AZ conducted the interviews. A total of 801 residents of Southern California were interviewed between July 23, 1994 and September 12, 1994 with a response rate of 56.6%. Four hundred interviews were conducted in the Phoenix sample during the period of July 14 through August 16, 1994 with a response rate of 50.4%.

The surveys found that people have concerns about the risks associated with hazardous facilities and the ability of the nation to safely manage HLNW. Distrust of DOE as a capable and honest agency was expressed. A vast majority of the respondents support more local and state control over decision about the Yucca Mountain repository. Although respondents understood the potential economic benefits associated with a nuclear waste facility, the costs of such a facility were viewed as outweighing the benefits. There was support for compensation measures but less support (although an important minority) for benefits schemes. (See MRDB# RP0154 for ASCII data files.)

RP0151 Mertz, C., Flynn, J., & Slovic, P. The 1994 Nevada State Telephone Survey: Key Findings Yucca Mountain Socioeconomic Project 12/07/94

This report describes the results of a 1994 telephone survey of Nevada state residents that examined their attitudes and opinions toward the federal government's Yucca Mountain repository program and its management. This survey and report were prepared as part of the NPWO Yucca Mountain Socioeconomic Study (Phase V, Task 9.4). Several random samples were used for this survey. The first was a sample of 800 residents throughout the entire state of Nevada. Additional samples consisted of 202 interviews in Nye County and 100 interviews each in Esmeralda and Lincoln counties. Standage Accureach, Inc. of Denver, CO conducted the telephone interviews between July 15, 1994 and September 20, 1994. The response rate was 50.4% for the statewide survey and 56.4% for the three-county supplemental samples. See MRDB# RP0152 for ASCII data files.

Overall, the survey found that Nevada citizens continue to strongly oppose the Yucca Mountain project, they have concerns about the ability of the nation to safely manage HLNW because of the hazardous nature of the wastes and the capabilities of the waste managers. Respondents expressed distrust of DOE as a capable and honest agency. Most people do not believe the process for selecting Yucca Mountain as a potential repository was fair or equitable. Generally, people think that the repository developers should be responsible for addressing losses to health and property but they are less supportive of benefits for accepting the facility in Nevada. Majorities of the respondents support more local and state control over decisions about the Yucca Mountain repository.

TR0011 Mountain West (MW) Preferred Transportation System Options: Transportation Needs Assessment Yucca Mountain Socioeconomic Project 11/16/88

This document, prepared as part of the Transportation Needs Assessment for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 15.2), identifies critical system design elements and technical and social issues that must be considered in conducting a comprehensive transportation impact analysis. Development of the needs assessment and the impact analysis is especially complex because of the absence of information and experience with shipping HLNW and because of the "low probability, high consequence" aspect of the transportation risk. This paper addresses the preferred transportation system by grouping issues within three areas: cross-cutting issues, transportation system design, and operational procedures.

The seven cross-cutting issues include: comprehensive risk assessment and risk management; transportation planning and analysis system; transportation system impact monitoring; data management system; institutional relations; regulatory structure/liability system; and emergency preparedness. The Preferred Transportation System design discusses: volumes and timing of shipments; cask design and testing; modal mix; routing equipment and vehicle standards; infrastructure; and defense waste. The Operational Procedures section discusses: operations planning; DOE carrier requirements; personnel training and qualifications; cask maintenance; vehicle maintenance; vehicle stoppage; shipment monitoring and prenotification; inspection and enforcement; and physical protection. Other reports prepared as part of the Transportation Needs Assessment are: Design of Transportation Impact Studies (TR0003); Description of the DOE Planned System for the Transportation of Nuclear Waste to a Repository at Yucca Mountain (TR0004); Literature Review (TR0014); and Evaluation of the DOE Planned Transportation System (TR0015).

TR0014 Mountain West (MW) Literature Review: Transportation Needs Assessment Yucca Mountain Socioeconomic Project 12/02/88

This literature review, prepared for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 15.5), is part of a series of reports comprising the Transportation Needs Assessment for the proposed repository. Substantial literature exists for the assessment of specific types of risks (such as the potential compromise of cask integrity) in the transportation of spent fuel and other HLNW. However, few studies have attempted comprehensive risk assessments or developed integrated risk-management approaches to the transportation system. A detailed review of existing conceptual approaches to risk estimation reveals that most transportation studies have utilized whatever historical data is available without concern for the quality of the data, its uncertainties and biases. Many studies have resorted to the use of statistical inference for the sake of convenience. There have been problems with the representation of incident consequence and severity with strong reliance on empirical data from fault trees and Poisson models to establish event probabilities. The preferred approach to risk assessment and management is a comprehensive approach. This review focuses on the key literature and data that contribute to the identification and development of a comprehensive risk-management system for the transportation of spent fuel.

The report is divided into three chapters. Chapter 1 discusses the major crosscutting issues involved in the assessment of transportation risks and the need for a comprehensive risk management system. Chapter 2 reviews available literature regarding: volumes and timing of shipments; cask design and testing; modal mix, routing; equipment and vehicle standards; and infrastructure. Governmental reports and regulations regarding HLNW transportation is the focus of Chapter 3. For other documents in the Transportation Needs Assessment series, see MRDB ID#s: TR0003, TR0004, TR0011, and TR0015.

TR0015 Mountain West (MW) Evaluation of USDOE Planned Transportation System: Transportation Needs Assessment Yucca Mountain Socioeconomic Project 12/22/88

This report, prepared for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 15.4), is part of a series of reports comprising the Transportation Needs Assessment for the proposed repository. This document evaluates the U.S. DOE planned transportation system against the Preferred Transportation System, which is described in another report in the series (see MRDB ID# TR0011). The DOE planned system is described in MRDB ID# TR0004. Other documents in the series include: Design of the Transportation Impact Studies (ID# TR0003) and a Literature Review (TR0014). This report evaluates currently available information on the DOE planned transportation program and the DOE decision schedule for each of the system issues and elements described below. The report is divided into three sections.

Section 1 discusses the crosscutting elements of the planned system: comprehensive risk assessment and management; planning and analysis system; impact monitoring; data collection and management; institutional relations; and regulatory structure/liability. Section 2 evaluates the following design elements: volumes and timing of shipments; cask design and testing; modal mix, rail and truck shipment options; routing; equipment/vehicle standards; infrastructure; and defense waste. The final section evaluates the operation procedure elements of the planned DOE system: operations planning; DOE carrier requirements; personnel training and qualifications; cask and vehicle maintenance; vehicle stoppage; shipment monitoring and prenotification; inspection and enforcement; and physical protection (sabotage/terrorism).

TR0018 Mountain West (MW) Nevada Department of Transportation: State Agencies Update Yucca Mountain Socioeconomic Project 04/01/89

This report, prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Task 4.0), is essentially an update of the material produced during Phase II for Appendix A.6.0, Intergovernmental Relations and State-Level Cost Analysis, of the First Year Socioeconomic Progress Report (see ID #IG0001). That previous material was presented to NDOT staff for review and comment. The resulting comments and revisions as well as additional new material from other Yucca Mountain Socioeconomic study efforts were incorporated into this report. This report contains a brief description of NDOT functions and responsibilities, sources of revenues, and expenditures by function for FY 1984 through FY 1987. In addition, potential impacts to the agency are discussed; four potential routes were selected to illustrate the magnitude of costs associated with bringing these highways up to standards deemed necessary by the state for the safe transportation of high-level nuclear waste.

IG0012 Mountain West (MW) Nevada Department of Human Resources: State Agencies Update Yucca Mountain Socioeconomic Project 05/01/89

This report, prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Task 4.0), is essentially an update of the material on the Department of Human Resources submitted in December 1986 and incorporated into the Phase II First Year Socioeconomic Progress Report, Appendix A.6.0, Intergovernmental Relations and State-Level Cost Analysis (see ID# IG0001). Also, this report documents some of the service level standards and other cost factors that were used to formulate the projections presented in the "Interim Report on the State of Nevada Socioeonomic Studies" (see ID# SE0006). Because this is an update of a previous report based on various material and analyses prepared for the "Interim Report", it does not attempt to repeat the material in the original report.

This report provides a brief review of the three divisions of the Human Resources Department that appear likely to bear most of the impacts from the repository: Division of Welfare, Division of Mental Hygiene/Mental Retardation, and the Division of Health (Radiological Health Section). Projected impacts to the three divisions are discussed and cost estimates provided for 1988-2030.

CF0009 Mountain West (MW) Goldfield, Esmeralda County: 1989 Community Profile (Preliminary Draft) Yucca Mountain Socioeconomic Project 08/01/89

This profile of the Goldfield community within Esmeralda County has been prepared by Mountain West under contract with NWPO (Phase IVA, Task 16.4) as part of a continuing effort to study the socioeconomic effects of the proposed Yucca Mountain high-level nuclear waste repository. This report would not have been possible without the cooperation, information, and labor of Esmeralda County officials and the citizens of Goldfield, and it also borrows heavily from previous research conducted by Planning Information Corporation and the Goldfield Survey conducted by Rocky Mountain Social Science for the NWPO.

The purposes of the Goldfield, Esmeralda County Profile are: (1) to assess the potential of the community and, hence, Esmeralda County to incur impacts as a result of activities relating to the Yucca Mountain high-level nuclear waste repository; (2) to develop a description of the community's economy, population, and demographics in the context of the greater Esmeralda County area; (3) to describe the community resources, facilities, and services; and (4) to develop an understanding of residents' attitudes toward their community and the issues facing it.

ED0017 Mountain West (MW) The Economic Development Implications of Case Study Business Impacts on the City of Las Vegas Yucca Mountain Socioeconomic Project 10/15/89

This report (prepared as part of NWPO's Yucca Mountain Socioeconomic Project, Phase IV-A, Task 16.1) presents a strategic analysis of economic development options for the City of Las Vegas, based upon case study impacts of three businesses and upon earlier target industry work done for the metro area (see MRDB ID# ED0007, ED0008, and ED0014). The author contends that although Las Vegas has a unique economy, in that it is unusually specialized, it also possesses some strong locational advantages that would enable its policy-makers to create broader diversity, if those advantages are leveraged. With aggressive economic development marketing and community improvements, metro Las Vegas has real opportunity to compete for 20 percent of the "basic" industries in the nation. Section 2 identifies those targets. However, the City needs to attract industries that will add net fiscal benefits, rather than drain more City revenues than they contribute.

Section 3 summarizes and evaluates the impact on the City of three case study businesses that represent important portions of its current economic base. The industries include defense (represented by REECo), gaming (Golden Nugget), and information processing (represented by Citibank). For each of the case studies, company representatives provided information that enabled Mountain West to quantify their economic, demographic, real estate, and fiscal impacts upon the City of Las Vegas. (The appendix to this report presents the detailed impacts of each of the case study businesses.) Finally, Section 4 presents the strategic and programmatic implications of the case studies and discusses: strategies for residential development; economic leakages; focused marketing in certain Southern California industries; marketing for regional/information processing; policies to leverage the gaming industry and the defense industry into other economic bases; work force training issues; and emerging growth management issues that will ultimately effect the city's economic development.

MM0001 Mountain West (MW) Preliminary List of Factors for Site Characterization Monitoring Nevada Site: Yucca Mountain High-Level Nuclear Waste Repository 05/12/86

This document, prepared by the Mountain West study team as part of the NWPO Yucca Mountain Socioeconomic Studies (Phase I, Task 2.0), presents a preliminary list of factors that should be included in a monitoring program during site characterization activities. While this list includes categories identified by DOE in the Mission Plan, it also recommends a more detailed monitoring program that is broader in scope than the one identified in the Mission Plan. Special impacts will also require monitoring and are included in this document under the Risk Perception and Assessment factors section.

The Factors List is divided into the following major categories: demographic, economic, housing and land use, community facilities and services, transportation, fiscal, social/cultural, and risk perception, risk assessment and emergency preparedness. A brief rationale for the inclusion of these factors in the scope of the monitoring program is discussed. A detailed list of factors is included in each section, including a brief description of the factor, the methodology or source of data, the frequency of data collection, and a list of data to be collected. The authors note that this list should be viewed as preliminary in nature and should be updated as Nevada's socioeconomic studies and monitoring activities proceed.

IM0001 Mountain West (MW) Impact Management and Mitigation Program Yucca Mountain Socioeconomic Project 08/12/87

This report was prepared for NWPO as part of Task 11.0 of the Yucca Mountain Socioeconomic Study (Phase II). This document sets forth a framework by which the socioeconomic technical work of the Yucca Mountain Socioeconomic Study can be integrated witht he impact managment and mitigation efforts of the Nevada state and local governments. The Impact Management and Mitigation Program (IMMP) has been conceptualized as having three major functions which must be closely coordinated and integrated but which are somewhat separate both in theory and in potential operation. The three functions are: the decision-making process; policy analysis and formation; and the management or implementation capability.

The process is seen as interactive in that the Socioeconomic Study and Monitoring Program should provide a support function to the IMMP, which should in turn guide the technical work and determine factors to be monitored. Section 2.0 discusses the five major activities of the impact management process: technical studies, policy analysis, control/intervention, strategy selection, and implementation and evaluation. Section 3.0 examines some of the implications for administering the program and possible roles of the state and local governments. Section 4.0 recommends work activities for the implementation of the program in Phase III.

MM0002 Mountain West (MW) Phase III Monitoring Program Design Activities Yucca Mountain Socioeconomic Project 08/14/87

This document, prepared as part of Task 10.0 (Phase II) of the Yucca Mountain Socioeconomic Study, discusses the role of the Monitoring Program within the context of the Socioeconomic Study and an Impact Management and Mitigation Program. The linkages between monitoring, the socioeconomic studies, and impact management and mitigation are discussed along with the need for these components to be fully integrated and interactive. The establishment of a fully developed Monitoring Program is a major undertaking that the study team proposes to be undertaken by a process of incremental implementation. Until further work is completed and baseline data collected, the potential monitoring factors can only be estimated. A list of preliminary monitoring factors is included in the appendix of the document. Section 2.0 outlines the conceptual design for the full-scale monitoring program and discusses the major components of the program including project description, risk factors, economic, demographic, housing and land use, government and public services, social/cultural, and well-being.

The study team recommends the establishment of the Nevada Monitoring Reference Data Base (MRDB), a data and information management system, be implemented as the first component of the monitoring program. The purpose of the MRDB is to provide effective and efficient access to the data produced by the Yucca Mountain Socioeconomic Study as well as other applicable data such as DOE and other federal agency reports, books, articles and other data pertinent to the project. The MRDB would not contain the original material but provide quick and accurate reference to the available sources. Section 3.0 provides an overview of how the MRDB would be designed and operated.

ED0011 Mountain West (MW) County Level Comparison of the REMINV FS 53 Model Preliminary Baseline Projections with Other Source Projections 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 2.4, Phase III), is an demonstration of the REMINV FS 53 socioeconomic model for southern Nevada and how it compares with projections from other sources. The REMI FS 53 (REMINV FS 53 for Nevada) model is a computer-generated system which is designed to address particular planning and analytic needs including those of water resources, related economic analysis, energy development impact assessment, missile defense systems planning, public fiscal impact assessment, general economic forecasting and public policy evaluation. The purpose of this report is to present preliminary comparisons of the default control baseline (DCB) forecasts as generated by the REMINV FS 53 system with other socioeconomic baseline projections. Comparisons with other socioeconomic baseline data allows the REMINV FS 53 model system to be calibrated and continuously updated to current baseline conditions using local survey based data. The calibrated DCB forecast provides the control baseline for simulating project effects and related policy changes.

The REMI FS 53's capabilities and features particularly the Nevada model (the REMINV FS 53) are described. The program will generate a series of 49 related data tables on employment, regional and personal income, and population. These include basic summary tables as well as more detailed data tables with 10-sector and 49-sector tables. The sub-area regions in the REMINV FS 53 are Clark County, Nye County, Lincoln County, Washoe County and the rest of the state. The forecast comparisons are made for total employment, personal income, population and labor force participation rate to establish percent differences between REMINV-PRIME FS 53 DCB and other source projections. Specific recommendations are made at the end of this report for calibration of both the economic and demographic components of this model.

SE0006 Mountain West Study Team An Interim Report on the State of Nevada Socioeconomic Studies Yucca Mountain Socioeconomic Project 06/30/89

This report is one product of a three-year research effort by a large and diverse social science research team. The Yucca Mountain Socioeconomic Studies have been initiated and are funded by the NWPO; this report was prepared as part of Phase IV-A, Task 12.0. Chapter 1 provides the context within which nuclear waste disposal at Yucca Mountain is being considered. It provides the specifics of the Yucca Mountain proposal and of the US nuclear waste disposal program. More generally, it looks at both the social/political and technological environment within which nuclear waste disposal must take place. The conclusion is that every dimension of the program has important elements of ambiguity and uncertainty. Within this context, the socioeconomic studies and this report attempt to anticipate the full range of social and economic consequences of the repository for the State of Nevada; the region of Southern Nevada; Clark, Lincoln, Nye, and Esmeralda counties; and the Native American, rural and urban communities in the defined study area.

This report presents findings for both the standard socioeconomic effects and special effects, which includes a unique set of characteristics resulting from the hazards of HLNW. Chapter 2 begins by defining the mechanisms by which hazard characeristics of the repository could be translated into real, behavioral consequences for Nevada and its citizens. The applicability of this model to the repository case is then illustrated by considering actual projects or events that have produced risk-induced effects. Attention is then turned to a multi-pronged approach to more formally test the central hypotheses and to begin to quantify the important relationship. Chapters 3 and 4 proceed to examine existing conditions and projected future conditions, respectively. As an Interim Report, this document is not intended to represent final or complete findings in either the standard or special effects area. Rather, it should be viewed as reporting on work undertaken to date and findings that have been interpreted according to the current state of research and knowledge.

SE0001	Mountain West Study Team	Final Draft Study Design Yucca Mountain Socioeconomic Study	10/22/86

This document (prepared as part of Phase I, Task 3.0) presents the conceptual framework to be used in conducting NWPO's Yucca Mountain Socioeconomic Studies. This study design discusses the methodology to be used in each of the major areas of the study (economic, demographic, community facilities and services, fiscal, intergovernmental relations, social/cultural, political behavior, Native American, and risk assessment and perception) and how the various components will be integrated. Both first-year and 3-year work task activities are outlined by major category. Also discussed is the organizational structure for the management and administration of the study.

An earlier draft of this study design was reviewed by NWPO, the State/Local Steering Committee and the Technical Review Committee in June, 1986. Their comments on the earlier draft and the study team's response are included in the Appendix of this document. The earlier draft (422 pp) is on file and includes a literature review of the major areas of study, a technical description of PAS and FisPlan, and background material on various components of the study that the study team felt would be useful (risk perceptions factors, SIA, etc.).

SE0002	Mountain West Study Team	Summary Report Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

The Mountain West study team was awarded a 3-year contract by NWPO to conduct socioeconomic studies of the impacts of developing a HLNW repository at Yucca Mountain. This project commenced in late Spring, 1986 with an organizational and design phase (Phase I) followed by a period of intense fieldwork which took place between late September, 1986 and mid-April, 1987 (Phase II). This document (prepared as part of Phase II, Task 9.0) provides a description of the conceptual framework developed for assessing repository-related impacts. This study is unique in that the full range of socioeconomic impacts are being studied including: project description, economic-demographic, community facilities and services, fiscal, intergovernmental relations, social/cultural, Native Americans, transportation, and risk assessment and perception. This document includes sections on each of these research areas.

The primary emphasis during Phase II was on conceptual and methodological design work and on baseline data collection. This document demonstrates how the various components of the study will be integrated in order to assess the impacts of the repository on southern Nevada. Numerous diagrams are used to illustrate the overall framework, the interrelationships among the various components, and the conceptual approach to specific subtasks. In addition to this summary document, there are a series of appendices which discuss in more depth the activities undertaken by individual research teams. A later project report (see MRDB ID# SE0006) reports on all research conducted since the beginning of the project through June, 1989 and identifies repository-related impacts found to date.

SE0003	Mountain West Study Team	Phase III: Study Design Addendum Yucca Mountain Socioeconomic Study	06/05/87

This document presents the Plans of Work for Phase III of the NWPO Yucca Mountain Socioeconomic Study (July 1, 1987 to June 30, 1988). These Plans of Work (prepared as part of Phase II, Task 8.0) are intended to be read in conjunction with the Phase II progress report (MRDB ID# SE0002). A major objective of the progress report is to present a detailed demonstration of the methods, approaches, and current information available at the conclusion of Phase II. Both the progress report and the original Study Design (ID# SE0001) provide the essential context within which this addendum to the Study Design should be read. The major areas of study include economic, demographic, community facilities and services, fiscal, intergovernmental relations, social/cultural, Native American, and risk assessment and perception. A proposed budget for the Phase III work is included with some initial allocations within the study team to various components of the research effort.

The study design also presents a revised organizational plan for managing and coordinating the Phase III work. A revised 3-year work plan is provided. Based on recommendations from NWPO, SLGPG and the TRC, this plan includes the integration of the risk studies with other project components.

TR0004	Mountain West Transportation Needs Assessment Study Team	Description of the U.S. DOE Planned System for the Transportation of Nuclear Waste to a Repository at Yucca Mt Transportation Needs Assessment: Yucca Mountain Socioeconomic Project	12/02/88

This document, prepared as part of the Transportation Needs Assessment for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 15.3), describes the DOE's current plans for the transportation of nuclear waste to a repository. This description of the DOE Planned Transportation System (DOEPTS) is compared to the Preferred Transportation System in document ID# TR0015. This report presents currently available information on the DOE planned transportation program, ongoing and planned studies, and the DOE's decision schedule for each of the system issues and elements described below. The DOEPTS is decribed in terms of seven crosscutting issues, seven design elements, and nine operational elements of the transportation system.

Section 2.0 of this report discusses the crosscutting issues of the DOEPTS: comprehensive risk assessment and risk management, transportation planning and analysis system, transportation system impact monitoring, data management system, institutional relations, regulatory structure/liability, and emergency preparedness. Section 3.0 discusses the transportation system design elements from the DOEPTS: volumes and timing of shipments, cask design and testing, modal mix/truck and rail shipment options, routing, equipment and vehicle standards, infrastructure, and defense waste. Section 4.0 discusses the elements of transportation system operational procedures: operations plan, DOE carrier requirements, personnel training and qualifications, cask maintenance, vehicle maintenance, vehicle stoppage, shipment monitoring and prenotification, inspection and enforcement, and physical protection. Other reports prepared as part of the Transportation Needs Assessment include: Design of Transportation Impact Studies (TR0003); Preferred Transportation System Options (TR0011); and Literature Review (TR0014).

TR0003	Mountain West Transportation Needs Assessment Study Team	Design of Transportation Impact Studies: Transportation Needs Assessment Yucca Mountain Socioeconomic Project	12/20/88

This document, prepared for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 15.6), is part of the Transportation Needs Assessment. This report is intended to serve two primary functions: (1) To present a framework for conducting a comprehensive assessment of the impacts of transporting HLNW to a repository at Yucca Mountain, Nevada; and (2) To outline the research and data which are needed to conduct the comprehensive transportation impact assessment. While the focus of the report is on repository shipments in the State of Nevada, much of the information is applicable to repository shipments at the "corridor" state and the national level, as well as shipments to the Waste Isolation Pilot Project (WIPP). The first portion of this report presents the impact assessment system according to five transportation system cross-cutting issues, seven transportation design elements, and nine transportation system operational procedure elements.

The Transportation Research Needs portion of this report outlines the research and data needs for conducting the comprehensive impact assessment. This includes the analytical tools, research topics, information and data which are needed for a comprehensive impact assessment. The Transportation Research Needs portion of the report is divided into two sections: (1) outlines the immediate research needs and consists of the UNLV Short Term Work Plan for the Nuclear Waste Transportation Research Center (NWTRC); and (2) outlines the research needs to be addressed following the first year of the NWTRC. For these out-year research needs, preliminary study designs have been prepared, which include: general research approach, fields of expertise necessary, who should have responsibility for conducting the research, its importance to the State of Nevada and the urgency in beginning the research. Other reports prepared as part of the Transportation Needs Assessment are: Description of DOE Planned System for the Transportation of Nuclear Waste to a Repository at Yucca Mountain, (TR0004); Preferred Transportation System Options (TR0011), Literature Review (TR0014); and Evaluation of the DOE Planned Transportation System (TR0015).

CF0012 Murray, M. Meeting Minutes and Summary: Health Effects Consulting Team, July 13-14, 1995 Nevada Yucca Mountain Health Effects Study 08/09/95

On July 13-14, 1995, the state of Nevada convened an expert panel to develop a plan for baseline studies of public health and safety, and a system to monitor possible future social and economic impacts and events, related to the proposed Yucca Mountain nuclear waste repository. This meeting was held as part of the State's Yucca Mountain Socioeconomic Studies (Phase V, Task 6.3). Issues discussed at the meeting included: populations at risk from a repository or interim storage site for HLNW in Nevada; establishing the existing health characteristics of the affected population; describing the nature of health risks (radiological and nonradiological) for the population at risk; identifying and evaluating existing information and ongoing activities to monitor risk exposures and assess their impacts on public health; exploring the relationship between somatic health effects of radiation exposures and psychological, socioeconomic, and other potential effects on affected populations that could be associated with a HLNW facility; and recommendations on the study design.

IG0011 Mushkatel, A. Nevada Division of Emergency Management: State Agencies Update Yucca Mountain Socioeconomic Project 05/01/89

This report, prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Task 4.0), is an update of the material produced during Phase III on the Nevada Division of Emergency Management (see ID #IG0007). In February and March of 1989, additional interviews were conducted with NDEM personnel to determine if significant changes had occurred that would affect the cost projections contained in the June 1988 report. There have been several important changes including reorganization of the NDEM, completed studies of telecommunication systems for use in emergencies, and new planning by the NDEM directly related to the siting of the repository, which necessitates new cost projections for this agency.

This update report does not attempt to repeat much of the information contained in the early report. Rather it focuses on the nature of the reorganization in the agency, and the impact of the telecommunication study and new planning initiatives regarding training of personnel by the NDEM and their affects on the original cost projections. It is clear that these changes have resulted in the original cost projections being outdated and that they are far too low an estimate of the costs the NDEM will face if the Yucca Mountain repository is sited in Nevada.

IG0007 Mushkatel, A. Nevada Division of Emergency Management: NWPA and Federal Mandate Demands and State Costs Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared as part of the Yucca Mountain Socioeconomic Project (Task 4.1, Phase III), profiles the Nevada Division of Emergency Management (NDEM). This report first describes the functions of the NDEM, its mission, its fiscal base and its organization. Next an examination of some significant state and federal legislation which affect the division's potential role in managing and planning for the repository is provided (This legislation also affects the Nevada Highway Patrol; see Document IG0008.) Finally, a detailed analysis of the fiscal costs already assumed by the Division because of the mandates associated with the repository is included, along with the cost projections for the agency should the repository be sited in Nevada. The appendix contains NDEM fiscal budget sheets taken from state records. This document is one of a series of deliverables discussing Nevada state agencies (see document IG0002 through IG0008). The methodology for assessing state agency impacts is discussed in document IG0001.

IG0003 Mushkatel, A. State Level-Cost Analysis and Intergovernmental Relations: The Nevada Public Service Commission Yucca Mountain Socioeconomic Project 06/01/88

This document prepared for the Yucca Mountain Socioeconomic Project (Task 4.1, Phase III) profiles the Nevada Public Service Commission (PSC). The first part of this document is devoted to the history, organization and mission of the PSC which is to regulate: rates and activities of the utilities providing intrastate services; and activities of a variety of intrastate transportation companies including the intrastate operation of five railroads. The function and duties of the two sections of the PSC (the Policy Section and the Regulatory Operations Section) are identified with the discussion focusing on the three divisions of the Regulatory Operations Section (rates & tariff division, staff council and the transportation division) which would be affected by the repository. The transportation division is of particular importance for the repository as one of its functions is to monitor intrastate railroads to ensure shipments of radioactive and hazardous materials are in compliance with PSC regulations. The first part also analyzes the fiscal base of the PSC.

The second part of this document describes the origin, content and potential implications for the repository of the administrative General Order 52 issued by the PSC in 1986 relating to the intrastate transport of nuclear material within Nevada. The final part of this document analyzes in detail the costs already incurred by the PSC because of the repository's potential location, as well as preliminary cost projections should the repository be sited in Nevada. This document is one of a series of deliverables discussing Nevada state agencies (see documents IG0002 through IG0008). The methodology for assessing state agency impacts is discussed in document IG0001.

IG0008 Mushkatel, A. State Level-Cost Analysis and Intergovernmental Relations: The Department of Motor Vehicles and Public Safety Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 4.1, Phase III), profiles the Department of Motor Vehicles and Public Safety (DMV) and the impact the repository may have on it. The DMV is organized into seven divisions: Traffic Safety, Investigation, Motor Carrier, Registration, Driver's License, Administrative Services, and the Nevada Highway Patrol (NHP). While this report considers the larger DMV, its major focus is on the NHP because the anticipated impacts of the repository will fall primarily upon this division. This report first reviews the organization and mission of the NHP. Next, a discussion of the NHP budget is provided within the context of the larger state agency (the DMV) in which it is housed. Third, a discussion of the difficult issue of emergency communication is provided. This discussion involves Assembly Bills 352 and 719 which were passed by the State Legislature in 1987 and pertain to the transportation of hazardous materials.

Finally, a detailed analysis of the costs already absorbed by the NHP because of the repository is provided along with preliminary cost projections for the NHP should the repository be located in Nevada. These cost projections are based upon interviews with agency personnel in response to several scenarios derived from DOE documents and project descriptions, as well as projected state actions in response to the siting. The appendix contains the budget of the DMV for 1985-86, 1987-88, and 1988-89. This document is one of a series of papers discussing Nevada state agencies (see document IG0002 through IG0008). The methodology for assessing state agency impacts from Yucca Mountain is discussed in document IG0001.

RP0079 Mushkatel, A. and Pijawka, D. The Analyis of the Urban Area Survey Data Yucca Mountain Socioeconomic Project 11/14/89

The Las Vegas Urban Survey, conducted as part of the NWPO Yucca Mountain Socioeconomic Project in the spring and summer of 1988, provided a rich database that was reported on in a Background Report in 1989 (see MRDB ID # RP0054). The Background Report pointed out many areas in need of additional analysis. This report (also prepared as part of the NWPO program, Phase IV-B, Task 5.2) extends some of the analysis conducted for the original study. Specifically, the sociodemographic variables were crosstabulated with questions in four additional clusters: transportation concern, prior hazard experience, political/governmental attitudes, and political participation activities. In addition, two control variables were used to determine if the observed relationships between the sociodemographic items and the variables from the four clusters would vary when controlling for the distance a resident lived from a major transportation route, or the political jurisdiction where one resided.

This report documents the relationship of 13 different sociodemographic factors (i.e., age, marital status, employment, occupation, education, ethnic background, home ownership, community tenure, union membership, sex, religion, income, and property ownership) in explaining a large array of variables from the 4 clusters. This report examines the importance of sociodemographic factors and their contribution to understanding other factors that are strongly related to repository risk perceptions. Finally, the relationship of the sociodemographic variables with repository risk perceptions are reviewed in this report to permit readers to discern the overall relationship that exist between risk perceptions and the variables under scrutiny.

RP0139	Mushkatel, A. and Pijawka, D.	Institutional Trust, Information, and Risk Perceptions: Report of Findings of the Las Vegas Metro Area Survey June 29-July 1, 1992 (Yucca Mountain Socioeconomic Project)	09/01/92

This study (prepared as part of the NWPO Yucca Mountain Socioeconomic Study, Phase IV-C, Task 5.3) reports on the preliminary results of a survey of attitudes and perceptions of Las Vegas area residents regarding the proposed HLNW repository. The survey's focus was to examine the various dimensions of trust and confidence in the government's efforts to develop the country's nuclear waste repository at Yucca Mountain, NV. The survey examined levels of public trust and such trust dimensions as belief in the source of risk information, fairness of the site selection process, agency honesty, accuracy of risk estimations, public access, and control.

A random sample of 701 residents of the urbanized Clark County area was interviewed by telephone from June 26 to July 1, 1992; the response rate was 62.4%. As the survey was being implemented, news of an earthquake 12 miles from Yucca Mt. (June 29, 1992) provided an opportunity to expand the scope of the survey from a sample of 500 to 700 and include 5 additional questions pertaining specifically to the event, its impacts, and public policy preferences regarding the repository program. This report presents only the marginal statistics of most of the survey questions.

RP0147	Mushkatel, A. and Pijawka, D.	The 1994 Clark County, Nevada Survey: Key Findings on Trust, Risk Perception and the HLNW Issue Yucca Mountain Socioeconomic Project	07/01/94

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase V, Task 9.3) summarizes the findings from a telephone survey of Clark County, Nevada residents. The purpose of the survey was to examine public perceptions and attitudes toward the proposed HLNW repository at Yucca Mountain. The survey included questions related to: level of opposition or support for the repository; perceived risks from the repository; risks of transporting nuclear wastes; risks of the NTS; trust in the federal government to manage the repository; trust in DOE to provide prompt and full disclosure of the problems with the repository; and trust in risk information from DOE and other sources on the HLNW repository program. A final objective of the survey was to ascertain the extent to which recent (1994) disclosures by DOE about radiation tests on humans conducted during the 1940s and 1950s affected perceptions of trust in DOE and risks associated with the repository.

This is the third survey conducted in the Las Vegas metropolitan area; two previous surveys were conducted in 1988 and 1992. A comparison of similar items from the three surveys is included in this report. Respondents for the 1994 survey were selected from a random sample of telephone numbers in the Las Vegas metropolitan area by Survey Sampling, Inc. Standage Accureach, Inc. conducted the survey interviews between February 25, 1994 and March 15, 1994. There were 500 completed interviews with a response rate of 50.1% and a margin of error of plus or minus 5%.

IG0001 Mushkatel, A., and Atkinson, G. Intergovernmental Relations and State-Level Cost Analysis (Appendix A.6.0) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report 06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 3.1.1, 3.1.3, 3.3.1-3.3.6, and 9.0). One component of the study is to estimate the fiscal and political costs to the State and its localities emanating from the mandates of the NWPA of 1982. This document contains a description of the conceptual framework for the intergovernmental relations and state-level cost analysis research and how it is integrated with the economic-demographic approach to estimating fiscal impacts. A review of the NWPA and its implications for the state and local jurisdictions is included along with a list of state agencies which either have been created in response to the NWPA or have been affected. The following state agencies were researched during Phase II: Div. of Environmental Protection, Radiological Health Section, Div. of Mental Hygiene/Mental Retardation, NDOT; their functions and how they are likely to be involved in HLNW activities throughout the various stages of the repository development is described. Projected costs (1987-2009) are also estimated for the Div. of Environmental Protection, Radiological Health Section, NDOT, and Div. of Mental Hygiene. (For updates on NDOT, Div. of Emergency Managment, & Dept. of Human Resources, see ID#s TR0018, IG0011, & IG0012, respectively.)

In addition, local officials and staff from Nye, Lincoln and Clark Counties and the cities of Las Vegas, North Las Vegas and Henderson were interviewed to determine their response to the HLNW repository site selection process and the mandates of the NWPA. Activities that have already occurred are identified by jurisdiction and where possible costs of these responses are estimated. A demonstration model for tracking and projecting the responses and associated costs is also presented. Future activities expected to be occur are provided along with projections of costs for 1987-2009. This document contains data collected as part of Tasks 3.1.1, 3.1.3, and 3.3 (Phase II). The earlier draft documents for these tasks are on file and contains essentially the same data with the following differences. The draft report for Task 3.1.3 contains some additional data collected on the NV Dept. of Human Resources not included in this final document. The draft for Task 3.1.1 provides some additional explanation of how the local government costs incurred due to the repository were calculated.

SC0011 Mushkatel, A., Herzik, E., Freudenburg, W. and Molotch, H. Urban Area Study Design Yucca Mountain Socioeconomic Project 11/20/87

No abstract.

RP0054 Mushkatel, A., Nigg, J., and Pijawka, D. Urban Risk Survey: Public Response, Perception & Intended Behav. of Las Vegas Metro Residents to the HLNW Rep. Yucca Mountain Socioeconomic Project 07/13/89

This report presents the preliminary data analysis of a survey completed in 1988 of the Las Vegas metro area. This survey, conducted as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Task 8.1.2) was designed to ascertain the extent and magnitude of the social impacts on the urban residents attributable to the proposed HLNW repository at Yucca Mountain. A random sample of 549 households were interviewed from the communities of Las Vegas, North Las Vegas, Henderson, and the urban unincorporated areas of Clark County. The survey was designed to gauge possible changes in perceptions under different "future histories" (scenarios) of the repository and its management. This document constitutes the background report on this urban risk survey. Further analysis of the urban survey data can be found in MRDB ID# RP0079.

This document provides the marginal frequencies relating to the independent variables and specifically examines the demographic characteristics, attachment to community factors, and previous experience with both natural and technological hazards of respondents. Also discussed in the context of their meaning to repository perceptions are: well-being, political and governmental attitudes, general hazard or risk concerns, radiological concerns, attitudes toward science and technology, and transportation concerns. Finally, the report concludes with a comparison of respondents' answers in the pre- and post-scenario period to determine the effects of the scenarios on their perceptions and their future intended behaviors. See MRDB ID# RP0055 for the computer print-out containing the frequency distributions for each question in the survey and RP0043 for the data diskette.

RP0015 Mushkatel, A., Nigg, J., and Pijawka, D. PEPCON Explosion Survey: Objectives of Study and Methodology (Sample Design and Henderson Special Sample) Screening Questionnaire; Questionnaire Instrument 06/09/88

This document describes the objectives and methodology of the PEPCON explosion survey, conducted as part of NWPO's Yucca Mountain Socioeconomic Project during Phase III (Task 8.4.2). The primary objective of this study is to assess the effect of the May 4, 1988 PEPCON explosions on residents of Henderson and nearby areas of Clark County. Of particular importance to this study is the effect of the event and the responses to it that may affect residents' perceptions of the safety of the proposed nuclear waste repository at Yucca Mountain and the ability of emergency management organizations to effectively respond to a major hazardous materials event. This document explains the methodology of both the general population survey and the Henderson special sample, designed as an "oversample" to compare Henderson residents' experiences and resulting perceptions of the incident to that of other Clark County residents. Also included in this document are copies of the survey instruments (both the screening questionnaire and the phone questionnaire) used by telephone interviewers. This survey was conducted 10 June 1988 to 10 July 1988 by UNLV. The survey findings can be found in another document (MRDB ID# RP0062). See ID#s RP0050 and RP0093 for the data disk and computer print-out of the data, respectively.

RP0149 Mushkatel, A., Pijawka, D. Nuclear Waste Transportation in Nevada: A Case for Stigma-Induced Economic Vulnerability Yucca Mountain Socioeconomic Project 12/30/94

There has been a continuing controversy over stigma-induced economic effects from the proposed HLNW repository in Nevada. One element of the repository program, the transportation of nuclear waste in Nevada, has surfaced as a particularly troubling area in terms of public risk perceptions and mitigation planning. This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies, Phase V, Task 5.2) examines and demonstrates the kinds of vulnerabilities that Nevada will experience as a result of nuclear waste routing decisions. The fact that risk perceptions may create market changes suggests that stigma is an important issue for Nevada to consider in planning for and mitigating the potentially adverse socioeconomic impacts of the repository. The authors review the literature related to how the public perceives and reacts to both nuclear waste shipments and proposed shipment routes. In addition, they discuss the data on the public's expectations regarding the impacts of waste shipments on surrounding property values, and the conditions under which homebuyers would purchase properties in areas near nuclear waste routes.

RP0148 Mushkatel, A., Pijawka, D., Alozie, N., and Jones, P. Governmental Trust and Risk Perceptions Revisited & Reconceptualized: The Final Analysis of the 1992 Las Vegas Metropolitan Area Survey 11/01/94

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase V, Task 5.1) is the third in a series of examinations on the importance of trust in understanding Nevada urban residents' perceptions and opposition to the proposed HLNW repository at Yucca Mountain (for other reports see MRDB #s: RP0135 and RP0139). This report examines data from a 1992 survey of Las Vegas metropolitan area residents to determine the importance of political trust in understanding the public's opposition to the proposed repository, as well as their perceptions of the risks associated with different elements of the facility. As such, the report does not attempt to review all of the findings from the earlier papers. Rather, it examines the political trust research and then provides a multivariate analysis of the 1992 survey data.

RP0107	Mushkatel, A., Pijawka, D., and Dantico, M.	Risk-Induced Social Impacts: Effects of the Proposed Nuc Waste Repository on Residents of Las Vegas Metro Area Yucca Mountain Socioeconomic Project	09/01/90

The purpose of this report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Task 5.7) is to summarize some of the key findings related to the impacts of the proposed nuclear waste repository on residents of the Las Vegas metropolitan area. The report focuses on data from two surveys: the Urban Risk Survey, implemented in 1988, and the Clark County portion of the Nevada State Survey, undertaken in 1989. The report provides an overview of key findings related to public response and concerns about the repository program, including level of awareness, concern about harmful effects, benefits versus risks, and repository imagery. The findings also address the role of political trust in repository risk perceptions. Political trust and perceptions of management capabilities were examined for the major repository risk clusters, and for transportation risks, specifically.

The authors go on to address the question of the relative risks of the repository and, by so doing, provide a risk context for the repository. Both surveys asked respondents the minimum acceptable distance they were willing to live by a variety of hazardous facilities, including a nuclear waste repository. The analysis compares the repository to other facilities in terms of public acceptability and relative industrial risks. Lastly, to assess possible future impacts of an operating repository, the findings addressed residents' responses to a set of repository risk scenarios. Pre-and post-intervention data is compared to determine the size and direction of possible changes in perceived quality of life and behavioral intentions to migrate from the area, invest in Southern Nevada, and participate in political activities over the repository siting. For other reports by the authors on Las Vegas urban area impacts, see MRDB ID#s RP0048, RP0054, RP0079 and RP0097.

RP0135	Mushkatel, A., Pijawka, D., Jones, P., and Ibitayo, N.	Governmental Trust and Risk Perceptions Related to the High-Level Nuclear Waste Repository: Analysis of Survey Results and Focus Groups (Yucca Mountain Socioeconomic Project	06/01/92

A substantial number of reports and articles have recently surfaced on governmental trust and public perceptions of the credibility of DOE's HLNW repository program. However, there seems to be little consensus on the nature of public trust, its relationship to governmental agencies responsible for environmental safety, and the dimensions of trust that are critical to understanding public concern. To further our understanding of trust and to begin to operationalize trust perceptions and dimensions, two focus groups were held in Las Vegas. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVC, Task 5.3) presents the results of the analysis of the focus groups and discusses some of the more salient implications of the results for further research on trust.

Section I discusses the nature and utilization of focus groups in general, briefly describes the participants at the two focus groups, the participant selection process, and the script used for purposes of discussion. Section II of this report provides a brief literature overview of governmental trust that includes a discussion of the importance of trust in public opposition to the repository. This section is especially inportant because it provides empirical information on the dimensions of governmental trust and the repository program taken from a comprehensive survey of residents in the Las Vegas metropolitan area. This section serves as a backdrop for the analysis of the focus groups found in Section III.

ED0036	Nevada Development Authority	Updated Las Vegas Business Climate Assessment Data Yucca Mountain Socioeconomic Project	02/01/95

This document (prepared as part of the NWPO Socioeconomic Project, Phase V, Task 2.1) updates the statistical information presented in the 1990 Las Vegas Business Climate Assessment (see MRDB# ED0023). This update consists of a series of tables and figures comparing population trends and economic patterns of Las Vegas and Nevada to other nearby markets and with national figures.

RP0155 Peters, E., Flynn, J., and Slovic, P. Monitoring Affect and Images for the Yucca Mountain Socioeconomic Impact Assessment Yucca Mountain Socioeconomic Project 01/01/96

This study (conducted as part of the NWPO Socioeconomic Studies, Phase V, Task 9.5) examines a variety of techniques for eliciting images of places and how the psychological impact of those images might be assessed more sensitively. Using a variety of self-report measures, we examine the possible influence of affect and images on preferences for places. Participants (N=160) responded to seven stimulus objects (including nuclear energy, church, and Las Vegas, Nevada) on scales intended to elicit subjects' feelings towards each stimulus. The scales ranged from the imagery ratings used in previous studies by the Yucca Mountain Socioeconomic Team to ratings of discrete emotion terms. The results suggest that discrete emotion terms are more reliable and explain a much greater proportion of the variance in preferences compared to previous affective measures used. Recommendations are made to use a matrix of affect, designated images, and behavioral items in telephone research to assess and monitor the impact of potential placement of a HLNW repository at Yucca Mountain.

RP0033 Peters, H. and Hennen, L. The Accident at Gorleben: A Case Study of Risk Communication and Risk Amplification in FRG (Germany) Yucca Mountain Socioeconomic Project 07/01/88

This document presents findings from a case study conducted for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 7.4) of an accident that occurred on May 12, 1987, in a "pilot mine" at Gorleben, West Germany where the feasiblity of a repository for HLNW was being investigated. Although the accident happened during conventional mining work and had nothing to do with radioactive waste, this event received much public attention and news coverage and had a strong impact on the political debate on the Gorleben project of a repository mine for radioactive waste and even on the nuclear power controversy in general. An overview of the West German use of nuclear power, the nuclear waste disposal concept with the planned Gorleben repository and the circumstances of the accident are provided along with an overview of aspects of the social controversy pro and contra nuclear power. However, this study does not aim to evaluate the accident from a geological point of view nor does it aim to evaluate the West German waste disposal concept.

The focus of this study is on the interdependencies between different regional levels of political communication (local, state and federal level) and different level of argumentation (industrialization, nuclear power, Gorleben project, accident in the shaft). This study demonstates the effects of risk amplification that resulted from this accident. The discussion includes: (1) how the percieved risk of a specific event may be amplified by its connection with a current issue; (2) how a specific event can drive latent broader issues up in the rank order of the national agenda, thus amplifying the social relevance of those broader issues; and (3) how a specific event can alter the boundary conditions of communication concerning the broader issues (i.e., by influencing the credibility of social actor, and hence, reversing the burden of proof).

RP0013 Petterson, J. Goiania Incident Case Study Yucca Mountain Socioeconomic Project 06/01/88

This document describes the social amplification process of a radiological accident that occurred in Goiana, Brazil in September 1987. The author originally conducted fieldwork within a week of the accident's discovery. As part of the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 7.5), the author conducted a follow-up study in April, 1988 to determine how fast and in what form, the community, state and nation had recovered form the incident. A further objective of the study was to clarify the processes by which the perceived risks and concerns are channelled into actual impacts. This document includes additional data obtained from interviews, publications and unpublished reports collected in the follow-up visit of April 1988. This document describes in some detail the extent of physical, economic, social and political medium-term impacts and describes the efforts the federal and local institutions to mitigate those impacts.

PD0088	PIC, Thompson Professional Group, and DR	An Independent Cost Assessment of the Nation's High-Level Nuclear Waste Program Yucca Mountain Socioeconomic Project	02/01/98

This report presents the findings of a comprehensive, independent assessment of the Total System Life Cycle Costs for the nation's HLNW program and the proposed repository at Yucca Mountain, NV. This study finds that the costs will be $53.9 billion in constant 1996 dollars. The costs include expenditures to date and estimated costs for the study, licensing, development, and operations necessary to implement the federal program including transportation. The important assumptions, data sources, calculation, and considerations that have significant effects on the total cost estimate are detailed in the report.

The total cost reported is considered a conservative estimate that includes a contingency margin for ordinary complications but does not include estimates for uncertainties that could add significant additional costs to this program. These uncertainties, which range from the cost of extended at-reactor storage, to accidents in cross-country transportation, to the technologies of emplacement, retrieval, or closure, are also described in the report. This report was prepared as part of the NWPO Yucca Mountain Socioeconomic Studies (Phase VI, Task 5.1).

TR0001	Pijawka, D.	High-Level Nuclear Waste Route Selection A Report on the Meeting of the Regional Task Group of the Western Interstate Energy Board	06/30/86

This document, prepared during Phase I (Task 6.0) of the NWPO Yucca Mountain Socioeconomic Studies, presents a summary of discussions and issues raised at a meeting of the Regional Task Group on High-level Nuclear Waste Route Selection of the Western Interstate Energy Board (WIEB) on June 11-13, 1986. The purpose of this report is not to present a developed route selection model, but to address the salient factors and issues to be considered in the Task Group's development of a framework for route selection. The first section provides an overview of discussions, which include the objectives of the meeting and the issues addressed regarding route selection of high-level nuclear waste shipments in the western states. The section ends with a proposed model of a decision process for route selection.

The second section addresses the draft framework for route selection developed by WIEB staff personnel. Following a brief overview of the framework, several recommendations are made for improving and enhancing the proposed framework. The section ends with a causal model of hazard management and the recommendation is made to consider route selection in a larger context of hazard management and control. The final section of the report provides a list of references that are pertinent to route-specific risk assessment and route selection studies.

RP0062	Pijawka, D., Mushkatel, A. and Marountas, R.	The PEPCON Explosion: Residents' Behavior, Evaluation, and Perceptions of Safety Yucca Mountain Socioeconomic Project	07/13/89

On May 4, 1988, the Pacific Engineering and Production Company (PEPCON), located in Henderson, NV, exploded causing extensive damage throughout the community and many injuries. The plant was one of the few in the country producing a rocket fuel exidizer, ammonium percholorate, which is a highly volatile chemical. This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-A, Task 16.5) reports on a telephone survey conducted in June and July of 1988 to gather information on the effects of the PEPCON explosions on residents of Henderson and the Las Vegas urban area. The report focuses directly on residents' behavior in coping with the emergency situation, perceptions regarding media information and emergency organizations, and concerns over safety, industrial plants, and governmental management of hazardous facilities.

Chapter 2 provides a chronology of events covering the period from May 4, 1988 to the end of September 1988. Chapter 3 and 4 present the findings from the Henderson sample of the survey. Chapter 3 describes the respondents' socioeconomic characteristics, provides data on respondents' awareness of the explosion, first concerns and initial actions taken to assure safety, describes behavior during the next phase of the emergency period, and ends with an analysis of the role and use of the media during the emergency. Chapter 4 addresses questions related to the residents' evaluation of emergency organizations, perceptions of safety, and concerns over the chemical industries in the area. Data is also provided on the direct effects of the explosion in terms of damage to homes and businesses and the pace of the recovery. Chapter 5 reports on the key findings that are relevant to the residents' response during the emergency period for the Las Vegas metropolitan area survey. Comparisons to the Henderson sample were made where appropriate. See MRDB ID# RP0050 for the raw survey data in electronic format and ID# RP0094 for the computer print-out of the frequency distributions.

RP0052	Pijawka, D., Mushkatel, A., and Nigg, J.	Preliminary Statistical Results of the PEPCON Accident Survey (Draft) Yucca Mountain Socioeconomic Project	11/21/88

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase III, Task 8.4.2) presents the preliminary results from the PEPCON accident survey that was conducted in June and July of 1988. The final report analyzing the survey results can be found in MRDB ID# RP0062. The data disk and computer print-out of the frequency distributions are contained in RP0005 and RP0094, respectively.

TR0037	Planning Information Corp (PIC), UNLV Transportation Research Center (NWTRC), and NWPO	High-Level Nuclear Waste Shipping Route Maps to Yucca Mountain and Shipment Number Estimates Multi-Purpose Canister Base Case	01/01/95

With Yucca Mountain, Nevada, being named by Congress as the only site to be studied for disposal of the irradiated fuel from the nation's commercial nuclear power plants, the question of how this nuclear waste would be transported to Yucca Mountain becomes an important one to everyone in the nation. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase V, Task 2.2e) presents the authors' analyses to date of the nuclear waste shipments and routes to the potential Yucca Mountain destination. Individual state maps and data sheets are arranged in alphabetical order.

The maps in this report represent the most likely highway and rail routes for the shipments of nuclear waste to Yucca Mountain using the DOE's proposed Multi-Purpose Canister system for nuclear waste storage, transportation and disposal. The maps show the most direct routes from the 75 current commercial nuclear power plant locations and 5 nuclear waste storage sites to Yucca Mountain. The analysis assumes current DOE transportation plans and policies, current federal and state routing regulations, current rail and motor carrier practices, and DOE's current information regarding use of rail or highway for shipments from individual reactor sites.

FS0003	Planning Information Corporation (PIC)	Nevada State Revenue Analysis Yucca Mountain Socioeconomic Project	06/01/88

This report, prepared for the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 3.3), analyzes the revenue system for the State of Nevada for the ultimate purpose of estimating the impacts associated with the siting of a nuclear waste repository at Yucca Mountain. Each major revenue source is analyzed separately -- identifying relationships between the economic or demographic base, the revenue base and the revenues generated. The importance of gaming and sales and use taxes to the State General Fund are discussed. Other revenue sources analyzed include: insurance premium tax, excise taxes on liquor, cigarettes and tobacco products, jet fuel, manufacturers of drugs and non-tax revenue sources (licenses, fees and fines, user charges, etc.). Trends and changes in the rates and/or base for key state taxes are highlighted.

A model is developed for each component to allow impact estimation that takes into consideration how changes in economic or demographic factors would affect specific Nevada state government revenue sources. This document presents the baseline data for the State fiscal impact assessment which will be conducted in Phase IV of the State's Yucca Mountain Socioeconomic Project. The revenue analysis for local governments in Nevada are presented in a companion report "Nevada Local Government Revenue Analysis" (ID# FS0004).

ED0005 Planning Information Corporation (PIC) Characteristics of the Las Vegas/Clark County Visitor Economy Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 2.1.5, Phase III) presents the results of a review of studies on the Clark County visitor economy and the Clark County visitor. This report contains a description of perspectives and trends in the profile of the Las Vegas visitor, an exploratory model for projecting/estimating the Las Vegas/Clark County economy. The introduction discusses the industry background, its history and some current issues such as the conflict between different types of visitors, the effect of the California Lottery and the maturing of the gaming industry. The authors also conducted interviews with individuals involved with both the marketing and operations side of the gaming-visitor industry to obtain their insights on a number of issues, such as: the maturing of the Las Vegas visitor market, the resort concept, important market segments, the effect of state lotteries and Atlantic City, national recession, shift to slots, etc. Section 2.0 summarizes the responses of the respondents.

Section 3.0 examines the Visitor Profile Study, which is an ongoing survey effort conducted by the Las Vegas Convention and Visitors Authority to profile the commercially significant visitor for marketing purposes. Section 4.0 discusses various measures/indices (visitor volume, gross gaming revenues, trends, etc.) of the Clark County visitor economy. This section also compares Clark County measures with state-wide measures and briefly discusses increased visitor activity in the border town of Laughlin. This section presents Nevada and Clark County data which is available for calibration of a model of the Las Vegas/Clark County visitor economy. Section 5.0 explores modelling development and model options and presents a conceptual model of the Las Vegas/Clark County visitor economy. This section describes possible linkages in the Las Vegas/Clark County visitor economy and discusses model components and presents exploratory equations and models for making projections.

FS0004 Planning Information Corporation (PIC) Nevada Local Government Revenues Analysis Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the NWPO Yucca Mountain Socioeconomic Study (Phase III, Task 3.3), analyzes the revenue system for local governments in southern Nevada. The entities analyzed include the Counties of Clark, Lincoln and Nye and the incorporated cities within those counties. Major revenue sources for the local governments are analyzed separately to identify the relationships between the economic or demographic base, the revenue base and the revenues generated. Significant legislative history affecting local revenue sources and the state's role in creation, statutory limitation, and distribution of taxes on the local level is discussed. Local revenue sources analyzed include: sales and use taxes, ad valorem taxes, local gaming taxes, and non-tax sources, such as user charges, licenses, fee/fines, etc. For each county, trends are presented for important economic and demographic variables. Trends and changes in the rates and/or base for key local taxes are highlighted.

A model is developed for each county, based on relationships between changes in the economic base, changes in the revenue base, and changes in the specific revenues. The modeling exercise focuses on General Fund revenues and all other funds except debt. This report does not extend the model to allow for an assessment of the impacts of projected revenues on future fiscal assessment which will be conducted during Phase IV of the State's Yucca Mountain Socioeconomic Project. The revenue analysis for the State of Nevada is presented in a companion report "Nevada State Revenue Analysis" (ID# FS0003).

FS0007 Planning Information Corporation (PIC) Summary of Background Fiscal Data and Analysis for the Nevada Socioeconomic Impact Assessment Study to Date Yucca Mountain Socioeconomic Project 01/01/89

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase IV-A, Task 3.0) discusses some of the key economic, demographic and fiscal elements that lead to the "bottom line" fiscal projections summarized in "An Interim Report on the State of Nevada Socioeconomic Studies (see MRDB ID# SE0006). Section 1 of this background report provides a summary of statewide economic and demographic factors that are underlying the three projection scenarios discussed in the "Interim Report." Projections of key state revenue sources under each case are summarized in Section 2. Sections 3, 4, and 5 summarize the economic and demographic components of growth and projections of key revenue and expenditure components for Clark, Lincoln and Nye Counties, respectively (including each county's school district).

PD0021	Planning Information Corporation (PIC)	Repository Workforce, Residency, Puchases and Other Characteristics Yucca Mountain Socioeconomic Project	06/15/89

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-A, Task 1.0) includes reports on four related investigations involving characteristics of the proposed HLNW repository at Yucca Mountain and the expected residency of repository workers. The first report is an analysis of residency and other characteristics of the workforce at NTS. In Phase III, a questionnaire of the NTS workforce was conducted and tabulated (see MRDB ID# PD0005). The rationale for the survey was that the most useful point of reference in considering the likely characteristics and residency of prospective repository workers is the characteristics and recent residency choices of workers at NTS, an installation involving the same lead agency, many of the same prime contractors, and many of the same project management policies as at the proposed repository. The first report in this document presents results from a cross-tabulation analysis to identify the characteristics (especially residency) of various subgroups of NTS workers.

The second report presents the results of an analysis of the NTS survey data to identify a residency model that could explain the residency patterns of NTS workers and which could be applied to similar groups of workers at the repository. The third report presents the results of an investigation of the likely economic effects in southern Nevada of NTS (and, by analogy, the repository) project purchases. Using data obtained from DOE and its prime contractor (REECo) during Phase III, this investigation considered in-state and out-of-state purchases in various categories and the Nevada "content" of in-state purchases. The fourth report is a synthesis of standard repository characteristics--costs, employment, residency, purchases, direct sales and use tax revenues, prospective GETT payments, etc.

ED0016	Planning Information Corporation (PIC)	Special Features of the Southern Nevada Economy: Nellis Air Force Base and Nevada Test Site (U.S. DOE) Yucca Mountain Socioeconomic Project	06/21/89

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-A, Task 1.0) describes two special features of the southern Nevada economy--Nellis Air Force Base and the Nevada Test Site. The descriptions are in socioeconomic terms: number of employees, wage rates and labor costs, material purchases, employee family characteristics and residency, etc. There are several reasons for conducting special studies of Nellis AFB and NTS. First, in order to understand the southern Nevada economy, one must understand the activities of the two facilities (Nellis and NTS) that comprise major portions of the basic economic activity in the region. Second, activity levels at Nellis and NTS are not directly a function of the local capture of regional and national activity (the kinds of relationships incorporated in input-output models such REMI), but of policy decisions by the executive and legislative branches of the federal government. Thus, there is a question of how accurately REMI describes current activity at federal installations.

Third, both Nellis and NTS face contingencies regarding future activity. By understanding these factors, one may more reliably describe these contingencies and their economic effects in southern Nevada. Fourth, the proposed HLNW repository would also be a federal installation. By understanding existing federal installations in the area, one may develop more reliable assumptions about the features of future installations such as the repository. This report has three sections: (1) a description of Nellis AFB; (2) a preliminary description of the NTS and U.S. DOE activity in Nevada; and (3) a data report on the NTS and U.S. DOE activity in Nevada. The data presented in this report was gathered in mid-1988.

CF0008	Planning Information Corporation (PIC)	Description of a Proposed Computer-Assisted Development Tracking & Analysis System for City of Henderson, NV Yucca Mountain Socioeconomic Project	08/30/89

The volume of development and development proposals in the City of Henderson has created a large and growing information management problem. This report describes a proposed computer-assisted system that has been designed for tracking proposed development in Henderson. The Henderson Development Tracking and Analysis System (DETAS) consists of two main parts: a tracking system and an analysis system. The DETAS data base system consists of a process of data entry (through standardized report forms and by user-specified special queries and reports). This document describes the data input process and shows illustrations of the proposed data entry forms and report formats. A brief description of the DETAS Community Impact Analysis System is also included. The design of this system was funded by the NWPO Yucca Mountain Socioeconomic Project (Phase IV-A, Task 16.3). The proposed system is currently under review by the City of Henderson.

FS0008	Planning Information Corporation (PIC)	A Modeling System to Assess the Fiscal Impacts of Residential & Non-Residential Development in North Las Vegas Yucca Mountain Socioeconomic Project	08/30/89

This report documents the first phase of the development of a fiscal model developed to assist in the assessment of fiscal impacts of land development in North Las Vegas (funded through the NWPO Yucca Mountain Socioeconomic Project, Phase IV-A, Task 16.2). The report accompanies a floppy disk version of the model (ID # FS0009). The model has been designed as a tool for local officials to track project characteristics, assessment assumptions and findings, and is calibrated to reflect North Las Vegas conditions--that is, the types, levels and costs of services currently provided in North Las Vegas, the current infrastructure development plans for North Las Vegas, and the current yield of various revenue sources for North Las Vegas.

Section 1 of this report presents the model itself, much as it is presented in the floppy disk version. Section 2 presents several sample applications of the model. Each is accompanied by commentary identifying the significant features of the application. Section 3 presents a chart outlining the several lines of research which underlie the fiscal impact model, with respect to both the test version (the Phase I model) and the elements required to produce an enhanced version (the Phase II model.) The model is in the Phase I stage and local officials are currently testing the system in actual applications before development of the second phase of the model.

FS0010	Planning Information Corporation (PIC)	Visitor-Related Economic and Revenue Impacts Model Yucca Mountain Socioeconomic Project	12/01/89

This document describes the Visitor-Related Economic and Revenue Impacts (VERI) model that was developed as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IV-B, Task 3.0). The purpose of this model is to be able to project impacts on Nevada's tax revenues due to changes in the visitor sector of the economy. This document accompanies the computer disk version of the model (see MRDB ID# FS0011). Instructions for installation and operation of the model are included. The model utilizes Lotus 2.2 software. Appendix A presents the results of a test run of the VERI model in both graphic and table form. Appendix B displays the model screen and menus which the VERI user will encounter.

The model has three components. The first component, the Visitor Model, calculates Visitor Direct Spending for the Baseline and Test (alternative impact) conditions and passes spending and consumption information to the Remulator and Tax Revenue Models, the other two components of the model. The user provides the inputs for both the baseline and test scenarios. The Remulator Model (REMI Emulator) calculates direct, indirect, and induced output, employment and population based on a REMI forecast performed in Phase IVA of the Yucca Mountain Socioeconomic Project. The Tax Revenue component of the model then distributes the tax revenues to the various tax categories and funds.

PD0030	Planning Information Corporation (PIC)	Repository Scenario Development System (Draft) Yucca Mountain Socioeconomic Project	07/28/90

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVB, Task 1.1, 1.2, and 1.3) describes the repository scenario development system (RSDS), which is a model that captures key alternatives regarding key elements of the repository in a way that produces project descriptions useful for local socioeconomic assessment. The RSDS identifies approximately 20 key repository variables--some have to do with the national repository program, others with the standard effects of the repository program in Nevada, and still others with special effects. Designed as a user-operated system, the RSDS provides the user with options for each variables (or in some cases override options). These selections draw on portions of a data base on various aspects of the repository program, drawn from over 20 publications on repository characteristics, plus assumptions by the model builder to fill in portions of the data base on which no reliable information has yet been produced by DOE or its contractors.

The model then links the relevant portions of the data base to produce a "repository scenario" which includes: (1) a list of the assumptions which define the scenario; (2) a limited project description useful as an input to a REMI projection; and (3) a more complete project description containing information on the many dimensions considered in making the scenario assumptions. The report discusses several dimensions of uncertainty in the repository project, each of which becomes a user-defined variable in the RSDS. The dimensions of uncertainty cover all aspects of the repository project: (1) the project itself (its schedule, cost and major components); (2) the standard effects (employment, purchases, etc.); and (3) the special effects (the type, timing, general location and immediate consequence of events that trigger special effects, and the linkage of events to reinforce or attenuate their immediate consequence). Finally, the reports provides displays the user menus and sample outputs.

PD0044	Planning Information Corporation (PIC)	Yucca Mountain Repository Scenario System: Background, Summary, and Progress Report (Draft) Yucca Mountain Socioeconomic Project	09/13/91

One focus of the NWPO Yucca Mountain Socioeconomic Project has been the development of a repository scenario system. The purpose of this system has been to overcome the limitations and inconsistencies of ad hoc project description efforts by: systematically addressing the many aspects of the project at the national and state level; by providing the means for maintaining and accessing currently available project-related data produced by DOE and its contractors; and by incorporating the many dimensions of uncertainty with which the project is fraught, and the range of project-related concerns among affected entities.

This report (prepared as part of Phase IV-C, Task 1.1) discusses the background and current status of the repository scenario system. A computerized model and data base have been developed for transfer to the non-technical user, placing in the user's hands the capability to develop alternative repository scenarios useful as inputs to standard economic-demographic models, and, equally relevant, in strategic planning and in the assessment of socioeconomic impacts more generally at the state and local levels. The intention is to enable users to consider repository program uncertainties and incorporate topics of local concern more effectively, and thereby to participate more effectively in policy planning and project oversight.

PD0071	Planning Information Corporation (PIC)	Project Description Scenario Development System (PDSDS) Version 2.0: Summary Documentation & Users Guide Draft Yucca Mountain Socioeconomic Project	03/17/93

This document was prepared in conjunction with the Nye County Nuclear Waste Repository Program and the NWPO Yucca Mountain Socioeconomic Project (Phase V, Task 2.2). It provides a summary documentation and users guide for a model and database system designed to develop coherent scenarios for the repository program and project -- scenarios in terms useful as inputs for socioeconmic assessment, or in strategic planning of repository issues on a regional basis, or simply as a tool to explore the complex interrelationships in a large, long-term, and complex national program and project. The model and database are called the (Repository) Project Description Scenario Development System (PDSDS): Version 2.

This report is a users manual and summary documentation for PDSDS: Version 2. The introduction describes the origin, concepts, major components, and current status of the repository scenario development system. Subsequent sections provide a guide for installation for PDSDS: Version 2 and operation of its three major modules. This users manual is not intended as a full documentation of the research, modeling, and computerization effort reflected in PDSDS: Version 2.

PD0072	Planning Information Corporation (PIC)	Monitoring Sectors and Geographies Vulnerable to Stigma: A Model Framework and Approach Yucca Mountain Socioeconomic Project	03/22/94

NWPO studies to date indicate potentials for stigma effects on places identified with HLNW facilities and activities. The effects may originate externally via decisions of nonresidents affecting the visitor/gaming/tourism economy of Las Vegas and the state, or internally via decisions of residents affecting land value or investment in locations perceived as vulnerable to risk. In either case, stigma effects may have implications for vulnerable economic sectors, geographies, and/or demographic sub-groups.

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase V, Task 2.2) begins a process to develop methods and procedures for systematic monitoring of vulnerable sectors, geographies, and demographic sub-groups. It focuses on the visitor/gaming/tourism sector in the Las Vegas Valley and Clark County. Future efforts will examine other vulnerable areas. The process involves review and analysis of several relevant information sources, identification of useful linkages to describe a vulnerable sector on a systematic and multi-dimensional basis, and the application of such linkages to generate such a description.

PD0073	Planning Information Corporation (PIC)	PDSDS: FY1994 Scenarios Background Materials Yucca Mountain Socioeconomic Project	11/11/94

This document compiles the background materials produced in relation to the FY 1994 project description efforts of the NWPO Yucca Mountain Socioeconomic Project (Phase V, Task 2.2). The first section documents the PDSDS process -- review of the models in current status, user group workshops and identification of next steps and priorities. The second section are items documenting extensions or analyses of the geography of nuclear waste database to support recalibration or revision of the national program module of PDSDS. The third section are items documenting analyses of expenditures, procurement and employment to support recalibration or revision of the Nevada project module of PDSDS.

PD0074	Planning Information Corporation (PIC)	Project Description Scenario Development System (PDSDS): FY 1994 Scenarios, Data Report Yucca Mountain Socioeconomic Project	12/07/94

This report presents the detailed results of three project description scenarios completed in FY 1994 to project the direct effects (standard, transportation and stigma) of the HLNW program in Nevada. The results are based on three alternative sets of assumptions developed by the State of Nevada Nuclear Waste Project Office (Phase V, Task 2.2d), Nye County Nuclear Waste Repository Program, Clark County Nuclear Waste Division and PIC. The focus of this report is to present the tabular results of the three scenarios developed using PDSDS. The majority of the tables in each scenario present annual data (cost, labor, procurement, etc.) by repository cost component.

ED0037	Planning Information Corporation (PIC)	The Clark/Las Vegas Visitor-Gaming Economy (Draft) Yucca Mountain Socioeconomic Project	05/12/95

This document presents the results of an analysis of the Clark/Las Vegas visitor-gaming economy prepared as part of the NWPO Yucca Mountain Socioeconomic project (Phase V, Tasks 2.2a and 2.2b). This investigation establishes procedures for analysis of existing state and local information which describes the visitor-gaming economy in local terms--casinos and casino departments, locations such as the Strip, rooms, visitor population, and gaming revenues, including those in major casinos, minor casinos, and elsewhere under restricted gaming licenses; analysis of casino locations and industry sectors; analysis of non-casino, visitor-supported activity; and analysis of local resident spending in casinos.

A preliminary framework description of relevant variables, information sources and key linkages for monitoring the visitor-gaming sector in Clark County is presented followed by an overview of the visitor sector research design. The third section describes the state and local information sources. The final sections discuss the economic activities of three groups of establishments which receive direct visitor-spending (major casinos, minor casinos, and non-casino establishments) and the visitor-supported portion of these activities.

TR0041	Planning Information Corporation (PIC)	Transportation of Spent Nuclear Fuel and High-Level Waste: A Systematic Basis for Planning & Management at National, Regional, & Community Levels	09/10/96

Since the early 1980s, DOEs strategy for management of spent nuclear fuel (SNF) and HLNW has assumed the transport of these highly toxic materials from roughly 80 temporary storage locations in 36 states to a single permanent geologic repository, perhaps via a centralized above-ground interim storage site. Despite much discussion in many forums, the characteristics of a national shipment campaign for SNF and HLNW remain quite uncertain. One way to plan and manage under conditions of uncertainty is to develop scenarios which reflect specific assumptions regarding relevant factors, and which then provide detailed information (e.g., shipments by cask type, origin, route segment, and year) needed as the basis for planning and management. Given such information, the numerous agencies which must be involved can work from the same sheet of music, so to speak, incorporating changes in new or revised scenarios which are consistently developed at the national, regional, and community levels.

This study (prepared as part of the NWPO Socioeconomic Studies: Phase V, Task 2.5/CAT15) applied an integrated assessment system to develop scenarios considering three sets of potential utility transportation choices, two alternative routing strategies and two alternative truck cask options. The report reviews the several factors which need to be considered in the assessment of national shipment campaigns for the transportation of SNF and HLNW. In the process, it describes the assumptions made for the several scenarios developed in this study and the information generated at the several steps in the integrated assessment process.

PD0083	Planning Information Corporation (PIC)	Interim Storage and Transportation of Spent Nuclear Fuel: Who Pays for What, How Much, and When? Yucca Mountain Socioeconomic Project	10/10/96

While recent policy discussion has revolved around the legal and moral obligations of the federal government or questions of safety and waste management strategy, the core of the interim storage and transportation issue is the costs involved, particularly the distribution of these costs among the different parties who stand to pay. Despite its core role in policy issues, these costs have not been considered on a comprehensive basis. This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Studies, Phase V, Task 2.4) considers a framework for comprehensive costs analysis of alternative strategies and schedules for interim storage and transportation of commercial spent fuel and high-level defense wastes. The options for interim onsite storage are based on an assessment of 84 shipment sites, considering whether each site will ship uncanistered SNF by legal-weight truck or canistered fuel by rail. The onsite options include extended operations of spent fuel pools as storage facilities after reactor shutdown, dry storage facilities using storage-only canisters, and dry storage using dual-purpose canisters.

Transportation options include shipment of uncanistered fuel in legal-weight truck casks or canistered fuel in rail transportation casks. The interim offsite storage option is a centralized facility in Nevada. Onsite storage costs include fuel loading or near-site transportation enhancements required to enable sites to ship by rail rather than legal-weight truck, or by large rather than small rail casks. Transportation costs include the costs of transportation casks and canisters and shipment services; the cost of heavy-haul at the origin for some rail shipment and at the destination for all rail shipments is not included in the current framework. The preliminary assessment focuses on the framework for costs analysis of interim storage and transportation--who pays for what, generally how much and when.

CF0003	Planning Information Corporation (PIC)	Reconnaissance of Community Facilities and Service Systems in Esmeralda County Yucca Mountain Socioeconomic Project	02/01/87

This document, prepared as part of Task 3.1.2 of the Yucca Mountain Socioeconomic Study (Phase II), provides a brief description of selected community facilities and services in Esmeralda County. The first section of the report contains a summary of the setting, economy, population, and housing in Esmeralda County. The services and facilities surveyed include: emergency management, Esmeralda County Volunteer Ambulance Services, Sheriff's Department, Volunteer Fire Departments, and the Esmeralda County School District. There is also a brief summary of the capacity of the water and sewer systems in Goldfield.

CF0002 Planning Information Corporation (PIC) Profile of Local Government Facilities, Services and Fiscal Conditions for Southern Nye County Yucca Mountain Socioeconomic Project 02/16/87

This document, prepared as part of the NWPO Yucca Mountain Socioeconomic Study (Phase II, Task 3.1.1), provides an inventory of the baseline community facilities and services provided by Nye County and the Towns of Amargosa Valley, Beatty, Pahrump and Tonopah. In addition to those five jurisdictions, the following jurisdictions were also inventoried for this profile: Nye County School District, Nye County Hospital District, Beatty Water and Sanitation District, Beatty General Improvement District, Amargosa Valley Improvement Association, Pahrump Valley Library District, and Tonopah Public Utilities. Facilities and services inventoried include: general government, health care, social services; law enforcement, fire protection, schools, water, sewer and solid waste services areas (geographic and people served); location, size and condition of facilities; the types and conditions of major equipment; number and classifications of staff; users fees and utility hook-up fees.

Information is provided concerning the problems, issues and conditions that shape current and future operations of the facility or service under consideration. Information about the number of people who use the various services (arrest statistics, human service case loads, ets.) is also included. A detailed budget analysis is included as the last section for each jurisdiction. A brief budget summary is also provided at the end of each service to provide a sense of the fiscal scale for the service. Where available, budgets were collected for five years preceding the inventory. The data collected during the inventory process is used in establishing the service standards and subsequently to make community service, facility and fiscal projections. The methodology used in arriving at service and budget factors is described in another document (ID# FS0002). This data was then used in making model runs and projections for the First Year Progress Report, which demontrated the NWPO impact assessment system at its current state of development (ID#'s SE0003 and CF0001).

CF0004 Planning Information Corporation (PIC) Inventory of Lincoln County Emergency Management Systems and Schools Yucca Mountain Socioeconomic Project 02/27/87

This document, prepared as part of the NWPO Yucca Mountain Socioeconomic Study (Phase II, Task 3.1.2), provides an inventory of the emergency management capabilities in Lincoln County and the Lincoln County School District. A complete inventory of community facilities and services in Lincoln County will be accomplished in later phases of the Study. The information contained in this report was gathered during interviews with government officials and department heads during October, 1986. The emergency management functions in Lincoln County are provided by volunteer fire departments, a volunteer ambulance service, the County Sheriff's office and the Caliente Police Department. Emergency planning, coordination and training programs are handled by the Lincoln County Emergency Management Director's office in Panaca. This document describes the facilities, equipment and services of the following: Emergency Management Director's office, Lincoln County Sheriff's Department, Lincoln County Jail, Caliente Police Department, Caliente Fire Department, Lincoln County Hospital and the Union Pacific Railroad emergency response capabilities, At the end of each section is a brief paragraph describing the funding level of each service.

The final section of the document provides information on the Lincoln County School District. The information on the following is provided: facilities and their capacity and usage; staffing; enrollment figures and trends; and school transportation services. The date collected during the inventory process is used in establishing the service standards and subsequently to make community service, faciltiy and fiscal projections. The methodology utilized in calculating the service and budget factors is described in another document (ID # FS0002). This data was then used in making model runs and projects for the First Year Progress Report, which demonstrted the NWPO impact assessment system at its current stage of development (ID #'s SE0003 and CD0001).

FS0002 Planning Information Corporation (PIC) Service and Budget Factors: Technical Memorandum Yucca Mountain Socioeconomic Project 03/25/87

This document was prepared as part of the NWPO Yucca Mountain Socioeconomic Study (Phase II, Task 3.1.1). The fiscal analysis component of this study attempts to provide a quantifiable measure of the costs and benefits to local governments generated by the repository. In order to project baseline and with project expenditures at the local government level, a series of equations are derived that link population with demand for services, staff and capital facilities. The expenditure component of the fiscal model is comprised of 3 parts: operation expenses, capital facility demands and exogenous cost estimates. This document describes the methodology used in calculating the services standards to be used in the initial fiscal impact assessment model run to demonstrate the system in the First Progress Report (June 1987).

Tables display the operating, staff and capital facility projections standards for the following entities: the General Funds of Nye County and the Towns of Amargosa Valley, Beatty, Pahrump and Tonopah; the Nye and Lincoln County School Districts, Lincoln County Emergency Services, and the City of Caliente Emergency Services. The data collected during the inventory process for the community services and facilities profiles is used in calculating the service and budget factors. The Nye County and Lincoln County Community Profiles are contained in other documents; see MRDB ID#s CF0002 and CF0004, respectively.

ED0001	Planning Information Corporation (PIC)	Linkages to Project Description (Appendix A.3.1) and Employment/Local Economy (Appendix A.3.2) Yucca Mountain Socioconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 2.1.1, 2.1.3, 2.1.4, 2.3, and 9.0). This document contains the first two sections of a five-part report on the economic and demographic activities undertaken by PIC during Phase II. The first section (A.3.1) discusses the linkages between the project description, the development scenarios and other elements of the E-D/fiscal assessment system. The purpose of this report is to demonstrate how the NWPO socioeconomic assessment system (at its current stage of development) can be applied to assess the impacts of alternative scenarios for the repository project. Two scenarios were developed for demonstration purposes; the PAS model is used in making the projections. The second section (A.3.2) discusses the baseline employment and local economy in Nye, Clark, Lincoln and Esmeralda Counties without the repository. For each county, the discussion includes: overall employment and economic trends, basic activity and nonbasic response, employment residency patterns, employment and earnings by sector, and baseline projections for employment by sector. The baseline projections include: total employment, basic employment, nonbasic employment, employment by place of residency, earnings (basic and nonbasic), earnings by place of residency and place of work, etc.

Some data is also disaggregated for Nye County South and North. Secondary data sources include the US Census and BEA data. Impact projections with the repository are also made for 1987-2009 under the two alternative scenarios and include total and basic employment by sector, personal income components, and labor force participation. This document contains data collected as part of Tasks 2.1.1, 2.1.3 and 2.1.4 (Phase II). The earlier draft documents for these tasks are on file and contain essentially the same data with the following differences. The draft for Task 2.1.1 contains employment and earnings data at the state and study area level. The draft for 2.1.4 has more basic employment data broken out for Nye County North and South and discusses the methodology for the basic employment analysis and work residency distribution, while the draft for 2.1.3 discusses the location quotient analysis in more depth. The other three sections of this report cover labor force and income (ID# ED0002), population and demographic characteristics (ID# ED0003), and housing and land use (ID# ED0004).

CF0001	Planning Information Corporation (PIC)	Public Infrastructure, Community Services and Facilities, and Fiscal (Appendix A.4.0) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 3.1.1, 3.1.2, and 9.0). The purpose of this report is to demonstrate how the NWPO socioeconomic assessment system (at its current stage of development) can be applied to assess the impacts of the repository on local government services and facilities and expenditures and revenues. Two scenarios are developed for demonstration purposes; the basis for the two impact scenarios is described in another appendix of the Progress Report (ID# PD0001). However, the lack of a complete project description precludes a reliable description of potential impacts. Therefore, the projections (1987-2010) of facility and service demands, expenditures and revenues associated with the population levels projected to occur during the baseline and two impact scenario are very preliminary in nature. The FisPlan model is used for the projections with the PAS model providing the projections for the population-driven components of FisPlan. An explanation of how the budget and service factors utilized in calibrating FisPlan were developed is contained in document ID# FS0002.

The projections are also based upon an inventory of existing facility and service levels that was completed by PIC during Phase II. A complete description of existing facility and service levels in Nye County and the unincorporated towns in southern Nye County is contained in the Nye County Profile (ID# CF0002). Inventories in Esmeralda and Lincoln Counties were limited to emergency response agencies (see ID#'s CF0003 and CF0004) during Phase II. Projections were made for Nye, Clark and Lincoln Counties, Amargosa Valley, Beatty, Pahrump, Las Vegas, No. Las Vegas, Boulder City, Henderson, Caliente and each of the three county school districts. The Nye County projections include: capital facilities demand and staffing (courthouse, sheriff, fire dept, library, schools, etc.), expenditures (general government, public safety, judicial, etc.) and revenues (taxes, licenses, etc.). The projections for Clark and Lincoln Counties are limited to emergency response agencies, the general fund expenditures and revenues, and the county school districts. A brief narrative discussion of the impacts accompanies the projections tables.

ED0003	Planning Information Corporation (PIC)	Population/Demographic Characteristics (Appendix A.3.4) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 2.1.5, 2.1.6, 2.3, and 9.0). This document is the fourth section of a five-part report on the economic and demographic activities undertaken by PIC during Phase II. The purpose of this report is to demonstrate how the NWPO socioeconomic assessment sytem (at its current stage of development) can be applied to assess the impacts of alternative scenarios for the repository development. Two scenarios were developed for demonstration purposes; the Planning and Assessment System (PAS) model is used for making the projections. This section of the report discusses population and demographic characteristics of Nye, Clark, Lincoln and Esmeralda Counties. The other four sections of this report cover: linkages between the project description, the development scenarios and other elements of the E-D/fiscal assessment system and employment and the local economy (ID# ED0001); labor force and income characteristics (ID# ED0002); and housing and land use (ID# ED0004).

This document contains historical and baseline data on total population, population by age, sex and race, median age, household size, vital statistics, population change and migration (including a profile of inmigrants), and school enrollment. The demographic trends of each county are discussed in a brief narrative accompanying the data tables. Secondary data sources include: NV Office of Community Services, ESD, US Census, 1985 Nye County Special Census, and BEA. PIC also made baseline projections (without repository) and cumulative impact projections (with repository) for the two demonstration scenarios. Projections are presented for components of residential population change and population age distribution (1987-2009) for Clark, Lincoln and Esmeralda Counties and for Nye County South. Subarea population allocations are also discussed with graphs comparing the baseline projections with the two impact scenarios.

ED0004	Planning Information Corporation (PIC)	Housing and Land Use (Appendix A.3.5) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 2.3, 2.4, and 9.0). This document is the last section of a five-part report on the economic and demographic activities undertaken by PIC during Phase II. The purpose of this report is to demonstrate how the NWPO socioeconomic assessment sytem (at its current stage of devlopment) can be applied to assess the impacts of alternative scenarios for the repository development. Two scenarios were developed for demonstration purposes; the Planning and Assessment System (PAS) model is used in making the projections. The other four sections of this report cover: linkages between the project description, the development scenarios and other elements of the E-D/fiscal assessment system and employment and the local economy (ID# ED0001); labor force and income characteristics (ID# ED0002); and population and demographic characteristics (ID# ED0003).

This document contains detailed data collected as part of Tasks 2.3 and 2.4 (Phase II) on the housing characteristics of Nye, Clark, Lincoln and Esmeralda Counties and their subareas. Data is provided on household size and composition, household headship, housing trends, housing units by type, housing availability and costs for both rental and sales units, vacancy rates, and availability of mobile home and RV lots. There is also some information provided on the availability of developable land. The primary secondary data source is the US Census. Baseline projections (without repository) and cumulative impact projections (with repository) for the two demonstration scenarios are also provided for households, housing units by type and occupancy, and components of residential population change (births, deaths, employment-related migration, etc.)

ED0002	Planning Information Corporation (PIC)	Labor Force and Income (Appendix A.3.3) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 2.1.2, 2.3, and 9.0). This document is the third section of a five-part report on the economic and demographic activities undertaken by PIC during Phase II. The purpose of this report is to demonstrate how the NWPO socioeconomic assessment sytem (at its current stage of development) can be applied to assess the impacts of alternative scenarios for the repository project. Two scenarios were developed for demonstration purposes; the Planning and Assessment System (PAS) model is used for making the projections. This section of the report discusses labor force and income trends and baseline conditions in Nye, Clark, Lincoln and Esmeralda Counties. The other four sections of the report cover linkages between the project description, the development scenarios and other elements of the E-D/fiscal assessment system and employment and the local economy (ID# ED0001); population and demographic characteristics (ID# ED0003); and housing and land use (ID# ED0004).

This document presents data on total labor force, labor force participation by age and sex, unemployment, personal income components, etc. National and state-wide figures are presented for comparison purposes. Secondary data sources include: NV Office of Community Services, ESD, BEA and the US Census. Baseline projections (1987-2009) of labor force and personal income are also included. Cumulative impact projections with the project are made for 1987-2009 under the two scenarios that were developed and include personal and labor income and total labor force and labor force participation rates. Data presented in this document was collected as part of Tasks 2.1.2 and 2.3 (Phase II); the prior draft for this report is on file and contains the same data. However, the earlier draft also presents the data at both the state and national level.

ED0012	Planning Information Corporation (PIC)	Nellis AFB and its Contribution to the Southern Nevada Economy Yucca Mountain Socioeconomic Project	05/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 1.0, Phase III), is a status report on Nellis AFB and its contribution to the southern Nevada economy. During Phase III, the authors collected information needed to describe Nellis AFB in socioeconomic terms. This information is needed as inputs to the economic-demographic model, which in turn is needed to properly assess the role of Nellis AFB in southern Nevada. The information includes reasonably detailed multi-year information on the following topics: levels of activity and facilities at Nellis AFB, personnel (military and civilian) directly associated with Nellis AFB, contract expenditures to develop and maintain the base, on-base housing, residency patterns (on- and off- base) of Nellis AFB military personnel, dependents associated with military personnel, military retirees living in southern Nevada and their residency, retirement pay to military retirees living in southern Nevada and dependents associated with military retirees living in southern Nevada.

A brief summary of the data collected to date is contained in this report. This status report outlines the reasons for collecting data on Nellis AFB, the procedures used in information collection and the topics of the investigation. The appendixes of this report contain news clippings relevant to Nellis AFB, letters sent to the Las Vegas Department of Economic Development by PIC concerning data relevant to Nellis AFB and a fact sheet published by the U.S. Air Force about Nellis AFB and its economic impact on Nevada.

PD0005	Planning Information Corporation (PIC)	NTS Employee Questionnaire: Data Coding and Summary Tabulation Yucca Mountain Socioeconomic Project	05/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 1.0, Phase III), describes summary tabulations for the NTS employee questionnaire. This document contains: a description of the uses and applications for the data derived from the NTS questionnaire (with all questionnaire codes noted) and first cut summary tables of data results. This database contains the following information on NTS employees: current residency (location, housing type, etc.) and preferences; commuting patterns, length of employment at NTS, occupation and work location, union status, mobility plans, demographic data and satisfaction with community services, work, etc.

CF0005 Planning Information Corporation (PIC) Inventory of System Characteristics (Working Draft) Yucca Mountain Socioeconomic Project 05/01/88

This document prepared for the Yucca Mountain Socioeconomic Project (Task 3.1, Phase III) is an inventory of local government facility and service systems in southern Nevada. The material presented in this document represents an updating and extension of the ongoing southern Nevada service system inventory process begun in Phase II. This inventory is a collection of information sorted agency by agency, service by service describing four broad topics: the population served by the agency or program; agency service standards and activity levels; the staff, facilities and equipment of the agency; and the agency budget and expenditures (capital and operating). The inventory is presented by county and municipality and by type of service within each jurisdiction. The following jurisdictions are included in the inventory: Clark County, Las Vegas, North Las Vegas, Henderson and Indian Springs, Lincoln County, Caliente, and Nye County. The services inventoried include: general government, judicial, public safety, public works, parks and recreation, social services, education and health care. Emergency response services are not covered in this document.

ED0010 Planning Information Corporation (PIC) Contributions of DOE/NV and NTS to the Southern Nevada Economy Yucca Mountain Socioeconomic Project 05/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 1.0, Phase III), reports on the status of ongoing research into the contribution of the DOE/NV and NTS to the southern Nevada economy. The purpose of this research is to accurately describe the NTS in the economic-demographic model and to fully assess the contribution of NTS to the southern Nevada economy. The NTS information further provides a valuable point-of-reference in the preparation of repository assumptions.

This document contains information pertaining to: employment of DOE/NV and its contractors for 1978-88; payroll information for major DOE/NV contractors in 1985-87; total labor cost information on the major contractors in 1985-87; total costs of DOE/NV operations; and information on dollar amounts of 1987 contracts with various contractors and organizations, such as REECo, EG&G, Holmes & Narver, Wackenhut, Fenix & Scission. The appendix contains letters by PIC to E. Lundgaard of US/DOE asking permission to access more information from NTS. The Appendix also contains newsclippings relevant to the NTS discussing: the INF treaty, possible test ban accords, the NTS/REECo strike of 1987, the September 1987 NTS spill test accident and underground nuclear testing.

ED0009 Planning Information Corporation (PIC) Retirement Migration and Military Retirement Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 2.1, Phase III), presents a preliminary profile of retirement inmigration in Clark County. Retirement "non-earning" income comprises a significant share of the southern Nevada economy, therefore it is important to understand this sector (comprised of retirement inmigrants, military retirees, and snowbirds) in order to be able to assess potential impacts from the Yucca Mountain repository on this group. This report presents the results of efforts to develop a database and begin development of a model to address the migration income and expenditure dimensions of these groups. Section 2.0 contains data on Clark County migration patterns and trends (1975-80) including data on: in- and out-migration by age cohorts and place of origin (state and county); per capita income by age, type of occupation; and consumer expenditure by type of expenditure, by age and household income. The implications of this information and its application as a projection of retirement age migration to (and from) Clark County are also explored in Section 4.0. Primary data sources are: U.S. Census, Bureau of Labor Statistics, and the IRS.

In later sections, the authors present a preliminary model of inmigration to Clark County, the model calculates inmigration to Clark County by age group for a given period and calculates the income associated with the migration stream. The authors have also prepared a preliminary model to calculate the annual economic benefit to military retirement in southern Nevada in terms of amount of military retirement pay "imported" by resident military retirees. Projections are made using various scenarios for both civilian and military retirement. The last section briefly discusses snowbird (seasonal migrants, retired and semi-retired persons who migrate in the winter to warm climates in the South and Southwest) migration and income spending patterns.

CF0010	Planning Information Corporation (PIC)	Community Development Report: Town of Beatty, Nevada Yucca Mountain Socioeconomic Project	08/01/88

Over the coming years, Beatty faces substantial growth prospects that would fundamentally change the way local government does business. This report (prepared as part of the NWPO Socioeconomic Project: Phase III, Task 3.4) analyzes the specific changes that may occur due to mining and other economic development, and makes certain recommendations regarding actions that could be taken by local government to accommodate or influence those changes. Section 1 describes the local setting of the potential development, including employment, earnings and income trends in Nye County, and demographic trends in Nye County and in the communities of Beatty, Amargosa Valley and Pahrump. Section 2 considers several growth scenarios for the Beatty area. Section 3 analyzes current housing supply in Beatty and Amargosa Valley. Section 4 analyzes the current condition of the major public facility and service systems in Beatty, and the capacity of these systems to accommodate growth. Section 5 analyzes the recent historical and current fiscal conditions of local government entities in the study area. Section 6 presents an analysis of the fiscal needs and resources of local governments due to the growth described in Section 2. Section 7 includes PIC's conclusions and recommendations based on the analysis presented in Sections 1-6.

Appendix A reviews alternative assumptions and their implications for growth associated with Bond Gold and other mining development prospects in the Beatty area. Appendix B describes the economic and demographic implications of alternative assumptions regarding Bond Gold peak construction and operation. Appendix C describes the economic and demographic effects of an additional mine development which are modeled on those estimates for Bond Gold. Appendixes D and E describes historical fiscal conditions and fiscal model output, respectively, for Nye County, Nye County School District, and the Town of Beatty.

FS0014	Planning Information Corporation (PIC) and Mushkatel, A.	Fiscal Effects of Proposed Transportation of Spent Nuclear Fuel on Nevada State Agencies Yucca Mountain Socioeconomic Project	06/01/98

This document (prepared as part of the Nevada Yucca Mountain Socioeconomic Studies, Phase VI, Task 4.1) outlines the fiscal effects of transporting HLNW into Nevada on four Nevada state agencies: Department of Transportation, Nevada Highway Patrol, Division of Emergency Management; and the Public Service Commission. The effects are based on one scenario, which is discussed in the report. The information was collected through interviews with state agency personnel. The estimated costs for the four state agencies are summarized in the report.

The total for the first three years of the prospective shipment campaign is $489 million, a very large proportion of which is for accelerated infrastructure improvements along affected highway routes, and the provision of highway ports of entry on I-15 near the Arizona and California state lines.

PD0001	Planning Information Corporation (PIC), Clark University/CENTED, and Mountain West (MW)	Project Description (Appendix A.1.0) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 1.0 and 9.0). The purpose of this report is to demonstrate how the NWPO socioeconomic assessment system (at its current stage of development) can be applied to assess the impacts of alternative scenarios for the repository development. Two scenarios are developed: the DOE Scenario, based upon information in the EA, and the Alternative Scenario, assuming a 50% increase in project employment. Annual estimates are presented for site characterization and construction and development: direct employment, employment residency, project costs, in-state purchases, requirements for specified materials, day-shift work trips, shipments of materials by truck and rail, and key revenues (property and sales and use taxes) generated by the project. A major portion of the document discusses the importance and linkages of these economic-demographic and fiscal components in the assessment system during the construction and operation phases. This document contains data collected as part of Task 1.0 (Phase II). An earlier draft document for this task is on file and contains essentially the same data with some elaboration on the information presented in this document, including a discussion of the site characterization impacts.

PIC discusses the current availability of data on the project and points out the lack of a complete project description precludes a reliable description of the impacts. There is a brief review by Clark University of the status of the risk assessment work conducted thus far by DOE on the risks of site characterization, transportation (including the RADTRAN model) and preclosure. Clark provides a more extensive review of its Phase II risk assessment work in other reports (see ID# RA0001 through RA0005). There is also a very brief section which mentions other types of activities which could result in socioeocnomic impacts: organizational and institutional, traffic, noise, land use, air, water, aesthetics, and archaeological. The organizational and institutional and the transportation/traffic effects are discussed in more detail in document ID # IG0001 and TR0002, respectively.

RA0006	Radwan, A., and Kalevela, S.	Review of RADTRAN III Documentation and Assessment of Theoretical Background Yucca Mountain Socioeconomic Project	01/01/88

This report, prepared as part of Task 5.3.1 of the Yucca Mountain Socioeconomic Study (Phase II), describes the theoretical background of the RADTRAN III computer program. RADTRAN III is designed to analyze the radiological impact of transporting radioactive materials. The program performs two principal computations: computation of the radiological impact due to "incident-free" transport of radioactive material; and computation of the radiological impact of vehicular accidents involving radioactive material shipments. The program is also composed of six submodels. The two computations and each of the submodels and their parameters and assumptions are described in this document. A critique of the RADTRAN III model is contained in two other documents--one by Clark University/CENTED (ID# RA0004) and one by Glickman with Johns Hopkins University (ID# RA0007).

TR0002	Radwan, A., and Zaniewski, J.	Special Transportation Infrastructure and Potential Impacts (Appendix A.4.3) Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report	06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Studies, First Year Progress Report prepared for NWPO (Phase II, Tasks 3.2.1, 3.2.2, 3.2.3, and 9.0). This report provides a preliminary assessment of the transportation infrastructure surrounding the Yucca Mountain site and the potential impacts from construction and operation of the repository. The analyses are based primarily on secondary data sources such as the EA and data obtained from NDOT. The authors first review and critique the documents prepared by DOE on transportation impacts at Yucca Mountain. The second section reviews the current standards and procedures used by NDOT for the design of roads and pavements and for the evaluation of pavement conditions. Thirdly, the authors conduct preliminary analyses to assess the impacts of future traffic demands on highway, pavement, and railroad performances. Gross estimates (using EA data) of peak traffic flows along segments of US Highway 95 to the site are developed for both with and without the repository scenarios. The level of service of each road segment is assessed. Factors to be considered in asssssing impacts on pavement conditions are discussed including the potential impact of overweight trucks.

A preliminary assessment of the impact of railroad traffic along the Union Pacific mainline is also provided. Finally, a proposed work plan for future research activities to address deficiencies identified in the report is provided. This document summarizes and combines earlier draft reports prepared as part of Tasks 3.2.1 and 3.2.2 (Phase II). The earlier draft documents for these tasks are on file. The draft for Task 3.2.1 reviews and critiques the current studies and plans of DOE. The draft for Task 3.2.2 reports on the data collected from interviews conducted with NDOT personnel.

RA0059	Resnikoff, M.	Assessment of Transportation Impacts: Use of RADTRAN to Assess Risks of Severe Accidents Yucca Mountain Socioeconomic Project	01/11/94

This study (prepared as part of the NWPO Yucca Mountain Socioeconomic Project, Phase V, Task 13.2) evaluates the probability of severe transportation accidents and develops inputs to the computer model employed in transportation risk assessments, RADTRAN. The author examines in detail the accident rates employed in RADTRAN and the breakdown of these accident rates into accident severity categories. The history of accident probability/consequence estimates determined for previous versions of RADTRAN, up to and including RADTRAN 4.1, are reviewed. The supporting references for the accident severity fractions used in RADTRAN 4.1 and the assumptions employed to derive the accident severity fractions are analyzed.

The author then compares the accident severity fractions with a range of 38 severe accidents which have actually occurred on the highways and rails to determine whether the accident severity fractions actually encompass all severe accidents. Storage conditions in dry storage casks are radically different from conditions in fuel pools. The implications arising from these differences for the calculations of accident severity fractions and inputs to RADTRAN 4.1 are discussed in this report. Finally, based on the author's review of extreme accidents and the assumptions underlying the accident severity calculations, new accident severity fractions and a new range of inputs to be utilized in RADTRAN 4.1 are developed. The results of this study raise questions about container response and the expected release of radioactive pollutants that are also important inputs to RADTRAN 4.1 and important contributors to the transportation risk.

RA0064 Resnikoff, M. Study of Transportation Accident Severity Yucca Mountain Socioeconomic Project 02/01/95

When and if a high-level nuclear waste repository begins to operate in the U.S., a large backlog of irradiated fuel from the nation's power reactors will begin to move on highways and rails. With 3000 tons of irradiated fuel or more scheduled to move each year, and shipments criss-crossing the country, transportation accidents will inevitably occur for the myriad of reasons that can couse any accident. Careful safety planning can reduce the probabilities and mitigate the effects of an accident. The question this report addresses is: how likely is it that a severe accident could actually broach a shipping cask and lead to a release of readioactive material? Could such an accident happen once a year or once every million years? This report investigates in detail the accident rate and the accident severity spectrum, evaluating 40 severe accidents in some detail. This report was prepared as part of the NWPO Yucca Mountain Socioeconomic Studies (Phase V, Task 13.5).

RA0065 Resnikoff, M. Scoping Comments for the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel & HLNW at Yucca Mountain, Nye County, Nevada 12/01/95

This document contains the comments provided by the author to DOE on the scoping of their Environmental Impact Statement (EIS) for the Yucca Mountain repository. These comments relate to the transportation of high-level waste and irradiated fuel to the proposed Yucca Mountain repository. The author requests that the scope of the EIS include additional data regarding severe transportation accidents so that transportation risks can be more reliably determined. In addition, several issues regarding fuel integrity and transportation safety have arisen since the NRC's 1977 EIS that also need to be included. These comments were prepared as part the NWPO Yucca Mountain Socioeconomic Studies (Phase V, Task 13.2).

SC0006 Rucker, R. Report on the Development of the Transportation Corridors in the Las Vegas Valley Urban Area Yucca Mountain Socioeconomic Project 03/23/88

This document prepared as part of the Yucca Mountain Socioeconomic Project (Task 5.4.3, Phase III) follows the social historical development of the highway corridors of the Las Vegas metropolitan area from the 1960's to the mid-1980's. This document emphasizes the political and social struggle of citizen groups particularly the Clark County Concerned Citizens (CCCC) who opposed the location and sometimes even the development of the urban area highways. This report contends that the controversy surrounding the construction of both the east and west "legs" (I-515 and U.S. 95, respectively) is analogous to future opposition to routing the high-level nuclear waste through the Las Vegas urban area. The information in this document was derived from interviews with those who were significantly involved in the decisions specifying where the transportation arteries would be located or those who knew about those decisions and from secondary sources such as local newspapers.

SC0005 Rucker, R. History, Participation and Sociocultural Impact of Gaming on the Las Vegas Valley Urban Area Yucca Mountain Socioeconomic Project 06/01/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Task 5.4.3, Phase III), discusses the history, economics and social aspects of gaming in the Las Vegas metropolitan area. The initial section of this report provides a history of legalized gambling in the United States, focusing on social trends for and against it. The second section overviews social, economic and psychiatric research on gambling behavior. The third section provides a history of gambling in Las Vegas and Nevada, including a description of the state of the industry today with tables on corporate involvement and gaming tax revenues. A history of the Las Vegas Convention and Visitors Authority, its function and its influence on the social aspects of gambling is presented in the fourth section. In the final sections, the author provides profiles of Clark County visitors and local (Clark County) gamblers.

NA0022 Rusco, E. Native Americans and State and Local Government Yucca Mountain Socioeconomic Project 10/01/91

This report (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVC, Task 6.1) discusses Native American concerns arising from the possibility of establishment of a nuclear repository for HLNW at Yucca Mountain. Their concerns fall principally into two main categories. First, the strongest objection to the repository comes from traditional Western Shoshones, who have organized into the Western Shoshone National Council, a new political/governmental structure in Nevada Indian country. Their objections are based on a claim that the Western Shoshones still own Yucca Mountain and also on the assertion that putting HLNW into the ground is a violation of their religious-based views regarding nature.

Second, there are several reservations around the Yucca Mountain site that might be affected in various ways by the building of the repository. This paper discusses two questions: the bearing of the continued vigorous assertion by traditionalist Western Shoshones of their land claim; and the extent to which Nevada state and local governments are able to understand and represent Indian viewpoints about Yucca Mountain.

NA0008 Rusco, E. Establishment of the Yomba Reservation Yucca Mountain Socioeconomic Project 10/04/88

This document, prepared for the Yucca Mountain Socioeconomic Project (Phase IVA, Task 6.0) is an account of the establishment of the Yomba Reservation, which is located in the upper Reese River Valley in the northwest region of Nye County, Nevada. The first part of this report describes the background history of the reservation. An ethnographic account of the "aboriginal conditions: of the Reese River Valley, the process of "EuroAmerican intrusion" and the Yomba Western Shoshone's subsequent adaptation to their new situation are described. Next, the report examines the federal government's change of attitude towards Native Americans in the 1930's which manifested itself in the steps taken by the Bureau of Indian Affairs and Native American organizations to buy ranchland in the Reese River Valley for a self-sustaining reservation. The actual management of this project and the settlement of local Western Shoshone families are elaborated. The later part of this report examines the early development of the Yomba Reservation and provides an account of the formation of the political organization and other entities by the Yomba Shoshone following the formal establishment of the Yomba Reservation.

NA0023 Rusco, M. Socioeconomic Profiles of Native American Communities: Las Vegas Tribe of Paiute Indians Yucca Mountain Socioeconomic Project 10/01/91

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-C, Task 6.1) presents a socioeconomic profile of the Las Vegas tribe of Paiute Indians. Most of the data presented was collected in 1987 and 1988 during a house-to-house census. During the census interviews, respondents were asked their opinion about available housing, economic opportunities and various community services, and were given an opportunity to express any concerns they had about the proposed nuclear waste repository at Yucca Mountain. A copy of the questionnaire with the tabulated results is included in the appendix. A risk perception questionnaire was also administered in 1988 and a tabulation of the responses is included as well. A brief historical sketch of the Las Vegas Colony is provided along with the socioeconomic data gathered by the Native American study team. In addition, the potential sociocultural impacts that the construction of a nuclear waste repository at Yucca Mountain would have on the tribe is discussed.

NA0007 Rusco, M. and Hamby, M. Socioeconomic Profiles of Native American Communities: Moapa, Yomba Shoshone, and Duckwater Shoshone Indian Reservations 09/01/88

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-A, Task 6.0) contains profiles of socioeconomic conditions in three Nevada Native American communities: the Moapa Indian Reservation; Yomba Shoshone Reservation; and the Duckwater Shoshone Reservation. Each profile describes the reservation history, economic-demographic and housing conditions, economic opportunities, educational background of the residents, community facilities and services (such as health and other social services, fire protection, police, schools, utilities, etc.), and the governmental structure of the reservation.

The section on the Moapa Indian Reservation also contains a brief discussion of residents' perceptions of the quality of life on the reservation, tribal issues, and attitudes toward the federal and state government. This data was collected as part of a risk perception questionnaire that was implemented in mid-1988. A copy of the survey instrument is included. More extensive data from the survey can be found in MRDB ID# NA0009. Other reports prepared for NWPO on Native Americans in southern Nevada can be found in MRDB ID#s: NA0001-NA0006, NA0008, NA0013-NA0016, and NA0018.

RA0049 Shrader-Frechette, K. Expert Judgment in Assessing RADWASTE Risks: What Nevadans Should Know About Yucca Mountain Yucca Mountain Socioeconomic Project 06/01/92

This report, prepared as part of the NWPO Yucca Mountain Socioeconomic Project (Phase IVC, Task 9.3.7), evaluates instances of methodological value judgments and inferences that have occurred in DOEs risk work on the proposed Yucca Mountain repository. The author finds that questionable methodological value judgments and inferences have occurred, that questionable judgments and inferences have also occurred in similar work for other radiation-related facilities and that the risk conclusions of some Yucca Mountain analyses are, at best, uncertain. To improve the scientific methodology of Yucca Mountain risk work, the author recommends that assessors admit the methodological uncertainties in their work and attempt to take account of probabilistic bias, human error, inappropriate use of probabilistic language, social amplification of risk, and the lack of public trust in the DOE.

RA0056 Shrader-Frechette, K. Expert Judgment and the Frame Problem: Analysis of the Early Site Suitability Evaluation (ESSE) for the Proposed Yucca Mountain Site 06/01/92

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IVC, Task 9.3.8) examines some of the methodological frameworks used by the DOE in the ESSE. The ESSE reported at least lower-level site-suitability findings for every condition specified for the proposed Yucca Mountain repository. Although the 14 ESSE peer reviewers affirmed the revised ESSE, nevertheless they warned that much of it contains "substantial uncertainties". Why did the peer reviewers both affirm the report yet warn of its "substantial uncertainties"? One answer is that the ESSE authors, alone, framed the site-suitability questions, whereas the peer reviewers had little control over how to frame the ESSE questions. They answered the questions only in the frames provided by the ESSE and the DOE, frames that predispose one to support at least lower-level suitability findings. These "frames" prescribe the context for evaluating Yucca Mountain site suitability.

The most serious frame problem of the ESSE includes use of a two-valued logic that is not typically employed in science. The two-valued logic forced both ESSE authors and reviewers to choose either that the site was suitable or unsuitable; they were not allowed to choose a third option, that the current data and methods are inadequate to make a determination about site suitability. A second frame problem of the ESSE is use of appeals to ignorance, a deductive fallacy in reasoning that consists of the presumption that, if the site has not been shown unsuitable, therefore it is suitable. The obvious problem, however, is that one may not be able, at present, to show suitability or unsuitability. Other frame problems that undercut the validity of ESSE conclusions are begging the question, another deductive fallacy in reasoning; use of many subjective judgments; reliance on a number of apriori, rather than empirical, conclusions; and the assumption that, despite their uncertainty, the methods of probabilistic risk assessment are adequate for repository regulation.

RP0012 Slovic, P. Preliminary Findings: Tourism and Migration Imagery Survey Yucca Mountain Socioeconomic Project 06/01/88

This document presents preliminary findings from the tourism and migration imagery survey conducted during April, May and June of 1988 as part of the NWPO Yucca Mountain Socioeconomic Project (Phase III, Task 8.4.5). The purpose of the survey was to demonstrate the relationship between people's images of places and their choice of a vacation or retirement site; and more specifically, to understand images that Nevada and Las Vegas evoke and how the repository will effect those images and consequently vacation and retirement plans. Two telephone questionnaires were developed for the study. Questions on the two instruments were nearly identical. The cities questionnaire ask respondents to provide images for San Diego, Las Vegas, Denver and Los Angeles. The states questionnaire elicits imagery for California, Nevada, Colorado and New Mexico.

This report also discusses the development and methodology of the questionnaires. The interviews were conducted in Phoenix, AZ on a representive sample of residents - approximately 800 total. Preliminary results from the cities survey are discussed, including various tables and graphs comparing the four cities to each other. The raw results of both imagery surveys are contained in a series of 12 data disks (document RP0021) and in a two volume computer printout (document RP0022). See document RP0056 for the final report on the findings of the tourism and migration imagery surveys.

RP0002 Slovic, P., and Kraus, N. Inventory of Concerns and Issues Yucca Mountain Socioeocnomic Project 11/25/86

This report, prepared as part of Task 6.1 of the Yucca Mountain Socioeconomic Study (Phase II), identifies issues and concerns expressed about the repository by Nevada residents and state officials. Source materials included: Nevada newspapers, DOE environmental assessments, Nevada respose to environmental studies, proceedings of a 1976 conference on Public Policy Issues in Nuclear Waste Management, and published news reports of non-Nevada origin. Each source item was reviewed and coded in terms of its repository-relevant content, and the issues and concerns expressed were then organized into an inventory of social, economic, and political concerns revolving around the risks of siting a HLNW repository at Yucca Mountain (this inventory is found in the appendix of this document). This initial list of concerns and issues was used as input to the focus group meetings held in several Nevada locations and was used as a guide for designing the risk perception surveys to be conducted during Phase II. The focus group meetings and telephone risk perception surveys are reported on in other documents (see ID#'s RP0006 and RP0003, respectively).

RP0118 Slovic, P., Layman, M. and Flynn, J. Risk Perception, Trust, and Nuclear Waste: Lessons from Yucca Mountain 04/01/91

This article (prepared as part of the NWPO Socioeconomic Study: Task 8.2) discusses the role of risk perception and trust in government in nuclear waste management. The problems encountered in the DOE efforts to site a HLNW repository at Yucca Mountain are discussed. The authors feel that understanding public perceptions of risk from radiation, nuclear power and nuclear waste is essential for resolving the current impasse over the waste management problem. A study was implemented (through the NWPO program) to provide insight into risk perceptions by employing mental imagery as a focal point for analysis. Specifically, the technique of using word associations to evoke the images, perception, attitudes, and emotions associated with a nuclear waste repository was used. The findings of this study are addressed in this article.

The study findings and their implications for nuclear waste management and specifically the role of trust in the managing agency are examined. The fear and revulsion of the US public toward the concept of a nuclear waste repository stand in contrast to the confidence that most technical analysts have regarding the safe handling and disposal of radioactive materials. A profound breakdown of public trust in the scientific, governmental, and industrial managers of nuclear technologies has occurred. The restoration and preservation of public trust in risk management must be given priority, even though a solution to the problem of mistrust is not immediately apparent. The problem is not public ignorance or irrationality but the adversarial nature of the social, institutional, legal, and political systems of risk management in the US. Aggressive and competent government regulation, coupled with increased public involvment in the decision making process is seen as a starting point.

RP0105 Slovic, P., Layman, M., and Flynn, J. What Comes to Mind When You Hear The Words "Nuclear Waste Repository"?: A Study of 10,000 Images Yucca Mountain Socioeconomic Project 09/01/90

This paper (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Tasks 8.5 and 8.6) is about the images and perceptions associated with a nuclear-waste repository in the minds of the American public. Previous research has demonstrated that imagery associated with an "underground nuclear waste storage facility" is remarkably negative and people who associated nuclear imagery with Nevada also tended to express much lower preference for Nevada as a place to vacation (see MRDB ID# RP0056 for report on previous research). In light of the potential for repository images to infiltrate the images of Las Vegas, other Nevada cities, and the State of Nevada itself, the present study was conducted to determine the precise nature of these images among people throughout the U.S., including Nevada. The approach used in this study employed word associations to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with the concept of a nuclear-waste repository. (See MRDB ID# RP0103 for research findings on imagery and its relationship to vacation preferences.)

The data analyzed in this paper is from four surveys conducted in the Fall, 1989 on: Nevada, Southern California, Phoenix, and the nation as a whole. The respondents produced a combined total of exactly 10,000 word-association images to the repository stimulus. The content of these associations were examined and a classification scheme developed to assign them to categories. The most obvious and most important finding was the extreme negative quality of these images across all the surveys. The negativity of repository images was found to be remarkably consistent across people of different ages, incomes, education levels, and political persuasions. The perceptions and emotions associated with a repository are psychologically, politically, socially, and economically important. In particular, the mechanisms of the human mind make it quite possible that places that become repositories for nuclear waste will also become stigmatized through associations with that dread substance. Decisions regarding the siting and management of nuclear waste storage facilities must be sensitive to these perceptions and emotions.

RP0103	Slovic, P., Layman, M., and Flynn, J.	Images of a Place and Vacation Preferences: Implications of the 1989 Surveys for Assessing the Econ. Impacts of a Nuclear Waste Repository in NV	11/01/90

This document (prepared as part of the NWPO Yucca Mountain Socioeconomic Project: Phase IV-B, Tasks 8.5 and 8.6) analyzes imagery data from three surveys conducted during 1989. The 1989 research was based on telephone surveys conducted in Phoenix, AZ during Spring of 1988 in order to gain insight into how nuclear images might trigger adverse effects on tourism, migration, and business development in Nevada (the 1988 research is reported by Slovic et al. in MRDB ID# RP0056). The 1989 surveys: (1) re-tested the original Phoenix respondents to determine the stability of their images across an 18-month time period and to determine whether their vacation choices subsequent to the first survey were predictable from the images they produced in the original survey; and (2) replicated the results from the Phoenix surveys using samples from other populations that contribute to tourism, migration, and development in Nevada (samples included populations from Nevada, Southern California, and the U.S. as a whole). (MRDB ID# RP0105 focuses on study findings regarding images of a "nuclear waste repository."

The report focuses on images of various cities and states and the links between the affective quality of these images and both stated rankings of these places as vacation sites and actual vacationing in these places. Image scores derived from word associations were found to predict the probability that a person had vacationed in a place during the previous 16-18 months. Image scores were also predictive of a person's preference rankings of places to vacation. Most important, data from the Phoenix Re-Test demonstrated that images predicted future vacation choices as well as past vacations. The authors also investigated a method of assessing imagery based on rating the strength of association between image concepts and places. These ratings had face validity and predicted previous vacations and vacation preference rankings almost as well as did images derived from word associations. The authors found that a) the rating technique is more sensitive for detecting weak images than is the word-association technique and b) Las Vegas is more closely linked to things nuclear than any of the other states included in the surveys.

RP0056	Slovic, P., Layman, M., Kraus, N., Chalmers, J., Gesell, G. and Flynn, J.	Perceived Risk, Stigma, and Potential Economic Impacts of a High-level Nuclear Waste Repository in Nevada Yucca Mountain Socioeconomic Project	07/17/89

This paper describes a program of research designed to assess the potential impacts of a HLNW repository at Yucca Mountain, Nevada upon tourism, retirement and job-related migration, and business development in Las Vegas and the state. This research was funded by the NWPO Yucca Mountain Socioeconomic Project (Phase IVA, Tasks 8.1.5 and 8.1.6). Adverse economic impacts may be expected to result from two related social processes. One has to do with perceptions of risk and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The second process that may trigger significant adverse impacts is that of stigmatization. The conceptual underpinnings of risk perception, social amplification, and stigmatization are discussed in this paper and empirical data are presented to demonstrate how nuclear images associated with Las Vegas and the State of Nevada might trigger adverse effects on tourism, migration, and business development.

The raw results of the tourism and migration imagery surveys are contained in a series of 12 data disks (ID# RP0021) and in a two-volume computer printout (ID# RP0022). Preliminary findings are reported in an earlier report (ID# RP0012). The raw data for the corporate decision-makers survey are contained on 3 diskettes (ID# RP0031) and in a computer printout (ID# RP0032).

RP0001 Slovic, P., Kraus, N., Desvousges, W., Kunreuther, H., Kasperson, R., Greenwood, M., Schulze, W.,& McClelland, G. — Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) — 06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

Another focus of the risk perception studies is on estimating the economic damages resulting from risk-induced behaviors. Four techniques for estimating such economic damages are discussed. They are: 1) direct costing method; 2) hedonic price method; 3) travel cost method; and 4) contingent valuation method. Also discussed are the factors involved in making migration decisions and the approach being developed for the study of migration decision making, with particular emphasis on retirement decisions. This report was prepared from earlier draft documents, which contain essentially the same data with the following differences. The draft report for Task 6.5.1 discusses the ANOVA technique in more detail and the draft for Task 6.5.2 includes a section on investment impacts. The other major risk perception research conducted during Phase II was the telephone survey conducted nationally and in Nevada. This research is discussed in another document (ID# RP0003).

RA0039 Snedeker, D. — Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) — 07/12/90

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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RA0067 Spiegler, P. Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) 05/21/97

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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SC0008 Stewart, K. Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) 09/01/88

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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SC0002 Titus, A. Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) 06/05/87

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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SC0003 Titus, A. Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) 06/01/88

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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RA0011	Tuler, S., Kasperson, R. and Ratick, S.	Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6)	06/01/88

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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TR0039	Van Lenten, C.	Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6)	02/16/95

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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TR0045 Williams, J. Risk Perception, Risk-Induced Behavior & Potential Adverse Economic Impacts from a Repository at Yucca Mt., NV Yucca Mountain Socioeconomic Project, First Year Socioeconomic Progress Report (Appendix A.2.6) 09/12/95

This document is part of a series of appendices to the Yucca Mountain Socioeconomic Project, First Year Progress Report prepared for NWPO (Phase II, Tasks 6.5.1, 6.5.2, and 9.0). One important aspect of these studies is assessing the potential for the perceived risks associated with a HLNW repository at Yucca Mountain to produce adverse economic effects on the regional and state economy. The focus of Phase II risk perception research has been on developing the theory and methods necessary to make an evaluation of these impacts. Adverse economic impacts are expected to result from two related social processes: social amplification of risk events and stigmatization. One approach to forecasting social amplification and stigma effects is patterned after psychometric studies of risk perception. Decision Research used this approach in conducting a pretest during March, 1987 on 37 noxious environmental features (including four nuclear features). They also conducted a pretest for assessing environmental stigma using the word-association method to evoke the imagery, knowledge, attitudes, beliefs, and affective states associated with four states (New Jersey, Nevada, Colorado and California) and four cities (San Francisco, Las Vegas, Atlanta and Pittsburgh). Both studies are discussed in this document.

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APPENDIX II

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STATE OF NEVADA YUCCA MOUNTAIN SOCIOECONOMIC IMPACT ASSESSMENT PROGRAM RESEARCH FINDINGS 1986 - 1997

Summary of Socioeconomic Findings

> ***The greatest potential socioeconomic threat from the proposed repository stems from what has been termed the "special effects" of the project. Because of the high profile nature of the whole nuclear waste disposal program, the potential exists for Nevada to become associated with these negative perceptions to the detriment of its ability to attract tourists, conventions, migrants, and diversified new industry to the state.***

The federal high-level waste program presented the State of Nevada's Yucca Mountain socioeconomic research team[1] with many unique challenges. The unique nature of a repository facility; the potential for stigmatization and its implications; the uncertain schedules; public risk perceptions and consequent behavioral responses; the highly charged political atmosphere; and the need to develop new and innovative research approaches had to be addressed and dealt with in the design and implementation of research at every step in the process. The Agency's work assessed social and economic impacts not only by collecting and analyzing data, but by developing new ways of understanding the factors that motivate responses to high-level radioactive waste and the repository program. The research effort strongly argues for the recognition of the critical importance of socioeconomic factors and impacts in evaluating the nation's efforts to site a repository. The overall conclusion is that the federal government is not prepared at the present time to address the effects of such a project on society, and that it will have to become prepared in new and effective ways to solve the nuclear waste problems presented by public opposition and resistance to such facilities.

The Agency's research has developed a convincing body of evidence that indicates the greatest potential socioeconomic threat from the proposed repository stems from what has been termed the "special effects" of the project. These are impacts related to intense negative perceptions and stigma associated by the public with a high-level radioactive waste repository, combined with the vulnerability of Nevada's economy to changes in its public image. Because of the high profile nature of the whole nuclear waste disposal program, the potential exists for Nevada to become

[1] The study team for the State socioeconomic program is comprised of respected academic researchers and consultants from around the country. The team was originally put together as a result of the extensive planning process that preceded the awarding of the contract. While members have been added and deleted over the years, the core group of researchers has remained with the program. Represented on the team are experts in an array of socioeconomic disciplines from the Nevada universities, the Wharton School of the University of Pennsylvania, Clark University, Arizona State University, University of Oregon, University of South Florida, Utah State University, and consultants from the private sector.

384 associated with these negative perceptions to the detriment of its ability to attract tourists, conventions, migrants, and diversified new industry to the state. This would be especially troublesome in the event of a nuclear waste accident in or near Las Vegas that might stigmatize the area and cause visitors to stay away in significant numbers. The work to date demonstrates that Nevada is uniquely vulnerable to such stigmatizing effects because of its tourism-dependent economy and State revenue structure.

The following sections describe some of the key findings of the Agency's socioeconomic research. A complete and in-depth treatment of the impact studies and their findings can be found in the three major summary reports on the Nevada socioeconomic studies published in 1989, 1993, and 1995, respectively.[2] In addition, two major books dealing with the policy implications of the findings of Nevada's socioeconomic research have been published by the Agency's study team.[3] The Agency's Technical Review Committee has also issued two reports of its findings with respect to the studies, and a summary of the Nevada research was published in the ***Proceedings*** of the National Academy of Sciences.[4]

Significant Economic Impact Findings

- The primary economic concern for Nevada is the potential for stigma impacts on the tourist and visitor industry. Such impacts could produce significant losses to an economy dominated by visitor-based revenues. The unique importance of the visitor and tourist industry for Nevada and Las Vegas required a major effort in order to understand the potential for stigma impacts.

- Studies carried out to date indicate that populations important to Nevada's economic well being may be highly sensitive to the radioactive risks associated with a repository and spent fuel/HLW transportation, and that the attractiveness of the state as a place to visit, move to, or invest in could be negatively impacted.

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[2] Ref. (1) "An Interim Report on the State of Nevada Socioeconomic Studies," (June, 1989); (2)"State of Nevada Socioeconomic Studies of Yucca Mountain 1986 - 1992: An Annotated Guide and Research Summary," (June 1993); and (3) "State of Nevada Socioeconomic Studies Biannual Report: 1993 - 1995," (June, 1995).

[3] Ref. One Hundred Centuries of Solitude, by James Flynn, et al., Westview Press, Boulder, Colorado (1995); and The Dilemma of Siting a High-Level Nuclear Waste Repository, by D. Easterling and H. Kunreuther, Kluwer Academic Publishers (1995).

[4] Ref. "Interim Statement of the Technical Review Committee on the Yucca Mountain Socioeconomic Project," by G. F. White, et al. (January, 1990); "Nuclear Waste's Human Dimension," by K. Erikson, et al., in Forum for Applied Research and Public Policy, Fall, 1994; and "Socioeconomic Studies of High-Level Nuclear Waste Disposal," in Proceedings of the National Academy of Sciences, Vol. 91, pp. 10786 - 10789, November, 1994.

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- These stigma effects are potentially of significant magnitude. In the event of a radioactive waste accident or incident that caused Las Vegas to become commonly and negatively associated with radioactive imagery, behavioral responses in terms of the visitor economy, inmigration, and economic development could result in substantial negative impacts. Estimates of 5, 10, and 20 percent or larger reductions in key economic sectors are not inconsistent with the empirical evidence gathered.

- A one percent drop in visitors in the year 2010[5] would result in a decline of about $155 million in spending in the Las Vegas area; a five percent decline would mean a decline of more than $775 million; and a ten percent decline would mean a decline of over $1.5 billion. (For comparison, the recessions of 1980 and 1981 resulted in Las Vegas visitor declines of about 1% for 1980 and 1.5% for 1981.)

- The research suggests that for each one percent drop in tourism, State revenues would be reduced by approximately $7 million and employment in Clark County would drop by approximately 7,000 jobs.[6]

- Under current State tax laws, repository-related increases in population cost the State and local governments more for providing public services than they provide in revenues. This difference is between $670 and $1,000 per person, per year.[7] This is a consequence of the "standard effects" of the project and is separate from any stigma-induced economic effects that may occur during the life of the program.

Risk Perception and Behavior Findings

- People perceive the potential risks from a HLW repository to be serious, the likelihood of accidents high, and the character of the risks to be dreaded by those living nearby and along transportation routes. Risk perceptions are similar for respondents in both the national and Nevada surveys.

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[5] The year 2010 was used in the modeling exercise since it is a point in time when the risks from transportation, packaging, handling, and storage will all be present.

[6] These figures are expressed in terms of 1989 dollars and use 1988 employment baseline projections. It is likely that projections would result in larger losses/reductions if calculated and expressed using more recent data.

[7] The dependence of Nevada state and local jurisdictions on revenue contributions of visitors is unique and results from the fiscal structure of the state. Other economic developments, private or public, that do not expand the contributions of visitor spending also will have negative fiscal impacts. Public expenditures per person would have to be provided for repository-related population in excess of the revenues that these people would contributed through taxes, fees, etc. This means that, in the absence of payments made by DOE for mitigation or compensation or changes in the Nevada tax/revenue structure, the repository program will consistently produce significant negative fiscal impacts even without negative stigma-related effects.

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- Public attitudes toward a repository are correlated with a number of perceptions, including the perceived seriousness of risks, trust in the program, project managers, and proponents, issues of equity and fairness, and potential economic, community, and social effects. In all cases, the research found a strong aversion to siting HLW facilities.

- The research found that a majority of all respondents (nationally, in the southwest, and in Nevada) think that the HLW repository would make an area a less desirable place to live - either for retiring or starting a new business. A majority believed that a repository would also make an area a less desirable place to take a vacation.

- Retirement decisions were also strongly influenced. For example, a majority of respondents in the national surveys said they would pay higher housing costs—in some cases, up to $3,000 a year—to retire in an area away from a repository.

- The survey data collected during 1987-1994 document a profound lack of trust in the scientific, government, and industrial managers of nuclear waste technologies. This distrust is correlated with beliefs that a nuclear waste repository poses high and unacceptable degrees of risk.

- Convention planners are averse to holding a convention in a city near a HLW repository. Even under a benign (e.g., no accident) condition, one third of the planners surveyed reduced their preference for Las Vegas. This figure increased when planners were presented with scenarios in which the repository program experienced a series of accidents.

- A HLW repository could reduce the propensity to attend a convention. One-fourth (25 percent) of the attendees sampled reported they would not attend a convention if a repository were located 100 miles away, compared to only 1 percent who would avoid a city near a prison.

- Trust and confidence in repository management was highly correlated with perceptions of risk from the HLW program. Structural model analysis survey data suggest that lack of trust increases people's perceptions of risk and opposition to the repository program.

- Experimental studies of the psychological processes underlying migration decisions found that younger people were particularly likely to give weight to technological hazards associated with a nuclear waste facility, providing some evidence that a repository could influence people's choices in selecting job locations.

- Women tended to be much more sensitive to repository risks than men. These findings are similar to those reported for many technological and societal hazards.

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- Results from the studies of stigma and imagery provided indirect evidence that a repository could have an adverse impact on Nevada's tourism economy. First, a number of individuals associated "special" facilities with the places they are located. For example, subjects in a number of surveys mentioned the nuclear-weapons test site (or related nuclear imagery) when they thought of Nevada. This suggests that the repository might also become associated with Nevada and/or Las Vegas if it is located at Yucca Mountain. Second, the thought of a nuclear-waste storage facility consistently evoked extremely negative imagery. Third, the presence of negative imagery has a dampening effect on a person's propensity to visit a place. Respondents reported lower preferences for vacationing, attending conventions, moving, or starting a business when the target place had lower imagery scores. Fourth, the presence of nuclear-related imagery produced a much lower preference for Nevada as a vacation site.

- The behavioral processes described as possible responses to intense negative imagery appear relevant as well (although different in degree) to the social impact assessment of any proposed facility that produces, uses, transports, or disposes of hazardous materials.

- The findings of Agency research suggest that focusing solely on the probability and magnitude of physical consequences may greatly underestimate the actual socioeconomic impact of an event.[8] A full and complete understanding of the role of public risk perceptions and behaviors must account for the "social amplification of risk" (the effects of the media and societal communication processes) if accurate estimates are to be made for the future impacts from a HLW repository program.

- The processing of risk events by the media, cultural and social groups, institutions, and individuals profoundly shapes the societal experience with risk and plays a crucial role in determining the overall societal impacts of particular hazard events.

Risk Assessment Findings

- ***Site characterization risks***: The initial activities designed to characterize the Yucca Mountain site are not risk-free, although they do not pose the level of public health risk of subsequent stages of repository development and operation. In particular, test drilling and underground studies pose some limited environmental risks, while operational and transportation accidents present other risk possibilities. These risks and the potential presence of limited amounts of tracer or experimental radioactive materials could, however, trigger events that affect public perceptions and amplify broader social impacts.

[8] Ref. "Social Amplification of Risk: An Empirical Study," by W. Burn, P. Slovic, R. Kasperson, J. Kasperson, O. Renn, and S. Emani , September 1990 (NWPO-SE-027-90).

384 ... • ***Repository pre-closure risks***: Accidents will certainly occur during pre-closure activities at the repository in both the construction and operation phases. Construction risks are apt to resemble those of other large industrial and mining operations, because radiological materials will not be present. During pre-closure operations, particularly close attention should be paid to accidents involving the potential for radioactive releases, resulting in exposure of workers and the public. Various accident scenarios have been identified, but it is important to ensure that these scenarios embrace the full range of possible accidents. Potential radioactive releases must also be related to local weather conditions to assess whether the projected estimates of off-site risks are sufficiently conservative.

- ***Repository post-closure risks***: The long-term risks posed by the repository depend heavily on the adequacy of the engineered and geologic barriers. These risks include both the period of so-called fission-product hazard, extending perhaps 500-700 years into the future, and the much longer term actinide-dominated hazard period continuing for thousands of years into the future. The fact that both nearby and distant future generations face risks raises important questions of equity that will affect planning for mitigation and compensation.

- ***Retrieval risks***: It is required that wastes be retrievable for at least 50 years after closure of the repository. Retrieval, if it proves necessary, would pose risks to workers, to the nearby public, to transportation corridor communities, and to the environment. These risks have received only very limited attention by DOE and need further assessment.

- ***The conduct of risk assessment***: Risk analysis is a comprehensive group of methodologies that can address all five risk clusters. The methods are time-consuming, costly, and demanding of technical expertise. In practice, risk assessments performed until 1988 under the auspices of DOE, including the assessment of the proposed Yucca Mountain repository, tended to concentrate almost exclusively on short- and long-term health impacts on the public. For the State of Nevada to extract the maximum benefit from the substantial amount of work performed in the DOE risk assessments without independently repeating this work involved two equally important needs. One was for Nevada to have a full, independent review of the soundness and comprehensiveness of the analysis for potential health impacts, with additions or corrections as needed. The second was for the analysis to be sufficiently disaggregated and sufficiently sensitive to broader effects to permit assessments of the risks and opportunities for preventing or mitigating related socioeconomic harms.

- ***Overall adequacy***: The assessment of risks conducted by DOE has been uneven and incomplete, most notably in its inadequate conceptualization of risk problems; its failure to assess the social contributors to and ramifications of risk and risk events; its uneven attention to low-probability, interactive risks; its failure to give sufficient attention to human error, quality assurance failures, and acts of sabotage and terrorism; and the lack of a comprehensive systems approach that interrelates and compares the major types of risk

384 associated with characterizing candidate sites and developing and operating a HLW repository.

- *Human factors*: Risk studies have not devoted sufficient attention to the issues of human error, quality assurance failures, and intentional acts to disrupt the transportation, handling, and disposal of high-level radioactive wastes, all of which could initiate events and subsystem and system failure, often with probabilities difficult or impossible to estimate. The Agency's subsequent review of the conduct of federal risk assessments in 1991 found a continuing neglect of human error as a risk contributor.

- *Narrowness of assessment*: The most striking weakness of DOE risk assessments for the proposed Yucca Mountain repository is the failure to address the social amplification of risk. The interaction between risk and risk events on the one hand and social structures on the other hand carries substantial potential for producing adverse social and economic impacts in Nevada. It is certain that operational accidents will happen during site characterization, waste transportation, and pre-closure activities. High public concern, organized opposition, and intense media attention might well amplify minor risk events or management burdens.

- *Flawed frameworks*: DOE's early conclusions concerning the site suitability of Yucca Mountain sometimes relied on deductively invalid inferences. The most serious of these flawed frameworks arose from the use of a two-valued logic not normally employed in science. This logic required that analysts evaluate site suitability in terms of only two options—that the site is either suitable or unsuitable. A third option—that the data were inadequate to assess site suitability or that site suitability is currently uncertain—was not allowed. Such a methodology created a situation in which if analysts found no disqualifying condition, then the failure to do so produced an assumption of suitability.

Survey Research Findings

- The survey research carried out as part of the State's Yucca Mountain socioeconomic study provided a unique set of databases for understanding public response to the federal HLW program. The concerns expressed are most acute in Nevada, where the Yucca Mountain project has been a high profile project for over a decade. However, the perceptions of high risk from such a program are widely shared by the public nationwide, and concerns with the issues of spent fuel and high-level waste handling and transportation will become increasingly salient national issues if the federal program moves forward toward implementation. These surveys provided some insight into the nature of the issues and the types and levels of concerns the public has about management of nuclear wastes.

- National, regional, and Nevada respondents all perceive high risks associated with a repository program and react negatively to the location of HLW functions or storage.

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- Three-quarters of the respondents surveyed nationally believe it is unfair for one state to be asked to serve as the site for a repository for nuclear waste generated by the other states.

- Important data on images, risk perceptions, and trust in waste managers and the federal program are linked to subsequent support or opposition to the repository by Nevada

  respondents. Nevadans are concerned that the repository would cause a loss of tourism, an evaluation supported by respondents in the national and regional surveys.

- Consistently over three-quarters of the Nevada respondents oppose the Yucca Mountain project in repeated surveys taken since 1987. They support strong state opposition to the repository program even if this means giving up potential economic benefits. The research found that even direct cash payments would not induce respondents to support the repository.

- Nevada residents feel strongly that they should have a decisive role in making decisions about the repository project in their state, and they feel they have been excluded from meaningful participation. They express the highest trust ratings (which have increased between 1989 to 1994) for the Governor and State officials that have opposed the current program. Trust in federal government agencies and institutions declined during this period.

- Nevada residents strongly distrusted the promotional advertising campaign by the American Nuclear Energy Council in support of Yucca Mountain because they distrusted the motives of the sponsors. More than half the residents surveyed said the advertisements did not influence their position. For those who said the advertisements had some influence, almost a third (32.1%) said the presentations reduced their support for the repository while only 14.8 percent said the advertisements increased their support.

- Female respondents to the national, regional, and Nevada State surveys rated the repository risks more highly than did male respondents. In the case of Nevada residents, female respondents are more likely to oppose the repository project at Yucca Mountain than are male respondents, although strong majorities of both males and females register strong opposition overall.

- The belief that the repository is inevitable has declined over 6 years of survey research. While almost 90 percent thought in 1988 that the repository would be built regardless of opposition from Nevada, by 1994 this figure was closer to 50 percent.

Economic-Demographic and Fiscal Findings

- Standard economic information is necessary and useful but not sufficient to monitor and project visitor-gaming activities in the dimensions and geographies required for repository

384 assessment. Visitor-gaming is a complex activity not easily allocated to or identified within standard economic reporting structures. It has various manifestations in areas such as the famous Las Vegas strip, downtown Las Vegas, communities at Nevada's state borders, and intrastate travel corridors. Visitor-gaming activities increasingly draw on national and international markets of families, junket visitors, and conventioneers who choose southern Nevada over other vacation and short-visit options. Under Nevada law, a complex array of revenues are drawn from visitor-gaming activities (e.g., gross gaming proceeds and other gaming taxes, sales and motor vehicle taxes, cigarette and liquor taxes, and lodging room taxes) and make the state even more fiscally dependent on visitor-gaming than economically dependent and more vulnerable to negative effects of the federal nuclear waste program.

- Retirement migration is an increasing factor in the growth of urban and some rural communities in Nevada. These migrants can be separated into two principle groups, military and nonmilitary. The prospective pool of retirees is quite large due to aging trends and the propensity of households to move as they approach retirement age. Southern Nevada's appeal to this pool appears to have accelerated in the late 1980s because of attractions such as climate and tax structure, as well as certain special characteristics, such as Nellis Air Force Base facilities for military retirees. Although retirees bring new income to the area, they require numerous services, some of which Nevada communities are ill-equipped to provide, and the research has shown that they are vulnerable to potential stigmatizing impacts of the repository program.

- Based on the attractions of location, growth, and a favorable tax system, economic diversification is taking place in the state, especially in southern Nevada, but the visitor-gaming industry effectively subsidizes this activity. As a result, non-gaming economic diversification is vulnerable in two ways: first, as a result of risk effects that could reduce the attractiveness of southern Nevada to prospective new businesses; and second, from impacts to the visitor-gaming industry that reduce that sector's ability to help pay for growth.

- The Nevada Test Site is particularly important as a distinctive current economic activity in southern Nevada and as an analogous case that can provide insight into how the Yucca Mountain repository project could affect Nevada. NTS has the same operating agency (DOE), many of the same prime contractors, and similar project management policies and styles.

- Important economic linkages exist between Las Vegas and other regional centers in the southwest U.S. (e.g., the Los Angeles metroplex, Phoenix). While these linkages are strong and multi-dimensional, how they actually work in various sectors and under various economic conditions is not well understood. However, any negative impacts associated with the repository program that affect southern California and Arizona will have spill-over impacts for southern Nevada.

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- The demography of southern Nevada reflects its economic base, its settlement pattern, and its recent rapid growth and change. Demographic character has many implications for the economic prospects, attitudes toward local and federal government, and sense of community in southern Nevada—with or without the repository project. Agency research uncovered significant linkages between economic-demographic characteristics and the way in which different groups perceive the repository program, evaluate its risks, and weigh these risks with other factors. The research found distinctions by gender, age, length of residence, level of education, household characteristics, source of income, and/or reasons for moving to the area - all topics reflected in the demographic components of integrated Economic-Demographic/Fiscal (E-D/Fiscal) system (See Figure 1).

- Nevada collects significant revenues from nonresidents via various gaming, sales, cigarette, liquor, and motor fuels taxes. Thus, a repository effect that impacts one or more of these revenue bases (e.g., a stigma effect on visitor-gaming) could have wrenching effects at all government levels throughout the state.

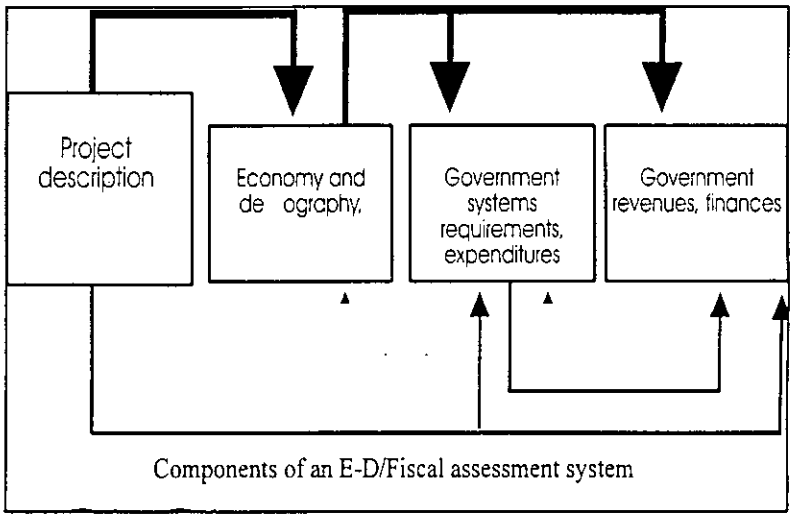

Figure 1

- Nevada's revenue structure is dominated by state-collected and/or state-distributed revenues. As a result, analysis and projection of revenues on an entity-by-entity basis has inherent limitations in Nevada, and reliable projections at the entity level must include a statewide dimension.

- Different economic activities in Nevada have widely diverse revenue-cost implications for municipal, county, and state government. Casino enterprises, for example, generally have positive impacts on government revenues versus costs. Due to the net mine proceeds tax, mining enterprises have positive impacts - if the mine is productive over the long term. Federal government enterprises generate sales and use tax revenues as well as payments in lieu of taxes, but generally these do not cover costs.

- The net, negative fiscal bias, which applies to particular basic industries in the state, are offset somewhat by the average earnings of employees, which are significantly higher among professional, technical, and crafts employees at DOE enterprises (NTS, Yucca Mountain)

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than among service employees at casinos and other visitor-oriented enterprises and much more stable than most mining employment. However, the revenue-cost effects of higher earnings are in turn offset by the facts that the revenues levied from local residents generally do not cover costs (since a large portion of the revenue base is collected from nonresidents), and that the revenues levied from residents are not progressive. They rely heavily on sales and excise taxes with no state or local income taxes.

- Nevada does not have a reliable tool for tracing the revenue consequences of alternative economic futures beyond the upcoming one or two year budget cycle. A major revenue study undertaken in 1989-1990 focused on other revenue issues and did not establish such a tool.[9] Without such a tool, it is difficult to trace the revenue consequences of changes in particular sectors potentially affected by the repository project (e.g., visitor-gaming, retirement migration, convention, federal service contractors, construction) for various revenue funds at state, county, and municipal levels. Given the existing capabilities, it is also difficult to calculate the net effects of revenues generated directly by an economic activity and those generated by employee spending.

Impacts on Government Agencies and Government Systems

- Repository-related stigma effects, depending on their scale and character, could have wrenching effects on Nevada's state and local government systems. Changes in the economic base (e.g., visitor-gaming), service population (e.g., residential and nonresidential land use and income), or population distribution could have significant effects on government facility and service systems and even on the institutional arrangements for delivery of public facilities and services. Government systems that depend on visitor-generated revenues and are geared for growth could find it particularly difficult to adapt to declining revenues, or even the potential for declining revenues associated with stigma effects. (Most state and local government systems in southern Nevada depend, to some degree, on visitor-generated revenues, and most are geared to accommodate to and catch up with growth; these government systems are not set up for stasis or decline.)

- Both standard and stigma effects of the repository project have broad effects on local government systems and requirements. Standard effects are relatively small and immediate, but stigma effects could be potentially large (although their scope and timing are not yet fully defined). Distributional issues are critical for both effects because their implication for various government entities and service areas with widely varying government service systems and capacities is extensive.

[9] The Urban Institute and Price Waterhouse, *A Study of the Fiscal Affairs of State and Local Government in Nevada*, Carson City, NV: November 18, 1988.

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- State agencies are not adequately prepared to deal with the presence of a HLW repository. In particular, the Office of Emergency Management, Nevada Department of Transportation, the Department of Motor Vehicles and Public Safety/Nevada Highway Patrol, and the Department of Conservation and Natural Resources would be significantly impacted. These agencies, as well as the Radiological Health section of the Department of Human Resources, would also require additional training, equipment, and personnel. The Nevada Department of Transportation and the Department of Motor Vehicles would experience major negative impacts because of transportation-related problems.

- The Agency's research confirmed that ambiguities exist among State agencies' organizational responsibilities that have implications for dealing with the impacts of a future repository. In particular, Nevada's somewhat fragmented emergency management system would be severely taxed to keep pace with the training, preparedness, and response needs associated with the Yucca Mountain facility and the thousands of radioactive waste shipments associated with it. The increasing importance of a state emergency communication system, and determining which agency would be responsible for it, was partially stimulated by the repository issue. This has been a divisive issue affecting both State and local agencies.

- The repository project, even if it were not accompanied by risk/stigma effects, would act as a net drain on the State General Fund. The positive revenue effects would derive chiefly from the state sales and use tax. On the average, General Fund revenues under the standard effects future would increase by about $1.8 million annually during site characterization, about $5 million annually during repository construction, and about $1.5 million annually during emplacement. However, economic modeling done as part of the Agency's research in 1989 found that additional General Fund expenditures required as a result of the repository-related population increases would be approximately $4 million during site characterization, $9.6 million during construction, and about $3.1 million during emplacement, with almost half of the additional expenditures made for educational purposes (primarily the Distributive School Fund). The net projected fiscal shortfall is estimated at about $21.7 million during site characterization, $27.3 million during construction, and $40.5 million during emplacement.

- The estimated costs outlined for a sample of state agencies identified as potentially most affected by the repository project, <u>excluding</u> the Department of Transportation, total from about $85 million to over $156 million through the year 2010 of the repository time schedule. The costs to the Department of Transportation could reach over $800 million when all necessary route segments are included.[10] Other state agencies still need to be

[10] This analysis was initially done in 1989 and updated for certain agencies in 1990 and 1992. Subsequent changes in the proposed federal program (such as the addition of heavy-haul transport along state highways) will

384 ... studied, the repository project description needs to be more clearly and specifically articulated by DOE, agency responses need to be clarified, and management strategies need to be developed before a final impact assessment can be completed.

- Transportation risks and impacts are a major concern. The ability to respond to transportation impacts, the potential for transportation to become a disruptive issue, and the strain that transportation concerns would place on cooperation between officials and agencies were all cited as potential problems in the research.

Social-Cultural Findings: Urban Area Effects

- Opposition to the repository project in the Las Vegas metro area has consistently been very strong for a public issue, with over two-thirds (usually about 70 percent) opposed. The Yucca Mountain repository is a major issue. Less than 10 percent of metro area residents do not have an opinion for or against the repository project.

- The potential stigma impacts are widely recognized by urban area residents, who have concerns that visitors and tourists will be deterred from coming to Las Vegas because of the repository.

- Transportation risks were considered very high by urban residents, who felt that the urban area is most vulnerable to the consequences of accidents, given its role as a transportation center and the fact that a large population is at risk.

- There is little trust and confidence in the federal government's repository program, and substantially more confidence in the state and local officials to represent the urban area public. The problem of trust and confidence in managers of the program has been found repeatedly in the research effort.

Social-Cultural Findings: Rural Community Effects

- Rural Nevada cannot be treated as a single entity but must be examined on a community-by-community basis to understand responses to the Yucca Mountain repository and the social-cultural impacts. While several of the communities studied appeared similar in terms of geography, demography, and history, numerous important differences exist among them. Many of the community differences point to factors important for understanding responses to the proposed Yucca Mountain repository.

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likely substantially increase the costs to State agencies from the figures reported here.

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- Data clearly support the premise that community context is an important element in understanding responses to the repository. Even communities with generally similar historical, social, and economic development trends (such as Caliente and Beatty) differ significantly in their acceptance of or support for the repository. For example, one major factor explaining this difference may be the extent to which residents of the communities were exposed to nuclear fallout from atmospheric weapons-testing during the 1950s and 1960s. Caliente and Mesquite residents, many of whom experienced nuclear fallout, were far less supportive of the repository than respondents of any of the other study sites except Goldfield. The strongest support for the facility was found in Amargosa Valley, Beatty, and Indian Springs, the three communities nearest the proposed facility, yet not regularly exposed to nuclear fallout.

- In addition to the empirical evidence provided by the social-cultural study, one very important theoretical consequence emerged. The findings cast serious doubt on the validity and/or utility of two frequently used explanatory concepts: the NIMBY (Not in My Backyard) syndrome and risk perception shadows. While these two concepts would predict that support for the repository would be greatest in communities furthest from the site, study evidence demonstrated that support for the repository was strongest in communities nearest to the project. Communities further from the site were the most opposed to it and the most concerned about potential risks.

- In refining the focus of the research towards communities at risk with respect to the repository program and repository-related waste transportation (given current assumptions about what the project will look like should it go forward), the Agency's studies identified rural communities along potential highway and rail shipping routes as potentially most vulnerable. These include Caliente (Lincoln County); Indian Springs (Clark County); Amargosa Valley, Beatty, and Tonopah (Nye County); Goldfield (Esmeralda County); Ely (White Pine County); and Wendover (Elko County).

Social-Cultural Findings: Native American Communities

- Native American tribes in the area around Yucca Mountain and along transportation routes have unique governments. As independent federally recognized entities, tribal governments have a role equivalent to states in most federal undertakings. They also have a special status according to various environmental and cultural protection acts and in the Nuclear Waste Policy Act of 1982. To date, none of the tribes in the study area has been granted "affected Indian Tribe" status under the NWPA, although several have applied. The repository project has also spilled over into the campaign by the Western Shoshone National Council, a political entity made up of representatives from many Western Shoshone tribes, to reclaim lands under the Treaty of Ruby Valley of 1863. This has brought the Western Shoshone and other tribal governmental entities into conflict with DOE as well as other federal and state

384 .. agencies. Because of the unique governmental position of tribes, their interests are not likely to be well protected or even properly represented in deliberations over the repository. They may also come into conflict with neighboring local governments over differences in positions regarding the repository, thus increasing their isolation from intergovernmental interaction.

- Most Native Americans in Nevada see the unwanted disturbance of cultural resources as the inevitable outcome of the Yucca Mountain project. Mitigation of disturbed archaeological sites is seen by some as a marginally acceptable alternative. They would prefer that no disturbance take place at all.

- The Native American tribes in the immediate vicinity of the Yucca Mountain project area and along potential transportation routes are, for the most part, economically disadvantaged. Reservations and communities in Nye, Lincoln, and Inyo counties are rural and isolated, and either lack a land base or have land bases too small to support their populations by ranching or other locally common means. A large number of people are unemployed, underemployed, and/or are living below the poverty level. Educational levels have improved in recent years, but without job opportunities in local communities, people must leave to take advantage of their training. Any negative statewide economic impacts associated with or caused by the repository or repository-related nuclear waste transportation will have a disproportionate impact on such communities because of these depressed baseline conditions.

Compensation and Mitigation Findings

- The literature research suggests many cases in which compensation produced or at least contributed to successful siting of unwanted facilities, but there are also a number of cases where benefits failed to overcome opposition of local residents. Compensation has been particularly ineffective in gaining support in the case of radioactive waste facilities. This is true of low-level and high-level facilities. This does not appear to be merely a problem of the level of compensation; it suggests that radioactive waste facilities raise objections that cannot be offset by compensation.

- Survey research that investigated the impact compensation has on people's willingness to accept the development of an unwanted facility at a local site found that offering compensation doubled the proportion of respondents who would "accept" facilities such as landfills, prisons, and incinerators. However, the positive impact of compensation was not replicated when the facility to be sited was a radioactive waste repository. In none of five surveys did the introduction of benefits (e.g., tax rebates of up to $5000 per year over 20 years) produce a significant increase in acceptance. This finding was also made by University of Nevada researchers in an independent study funded by DOE.
- The Agency's research also found that compensation will not increase public acceptance of radioactive waste facilities that are perceived as being forced on an unwilling population.

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Compensation can be an effective siting tool, but only under conditions where people have the voluntary choice to accept the facility or not.

Conclusion

In summary, the analyses undertaken from 1986 through 1997 indicate that the development of the Yucca Mountain repository represents a significant gamble for Nevada's future economy and that potential impacts could be substantial and long lasting. The research has demonstrated that these impacts would pervade the Nevada socioeconomic context and would be manifested most dramatically in loses to the visitor economy, the retirement economy, and the business economy.

APPENDIX III

NEPA AND THE YUCCA MOUNTAIN PROJECT

Charles R. Malone

Discussed and reviewed here are important aspects of the U.S. Department of Energy (DOE) 1999 Draft Environmental Impact Statement (DEIS) for the Yucca Mountain Project (YMP) [DOE 1999. Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250D. US DOE, Washington, DC. July 1999]. Recognized and accepted sources of information and insights regarding environmental documentation under the National Environmental Policy Act (NEPA) have been drawn upon as standards for judging the YMP DEIS. The sources of the standards are listed at the end of these document.

Some seeming redundancies occur among the discussion and comments below. This is because various issues are related and occur at different places throughout the DEIS. Additionally, some issues raised would yield to the common solution of DOE's adopting the tenants of ecosystem management for the Final EIS.

Discussion and Review Comments

385 **1. Procedural and coordination course:** NEPA is a policy act containing both procedural and substantive provisions and intents. The Act sets a course for government action and, despite its action-forcing features, the Act is not considered a regulatory statute in a quantitative sense regarding individual components of the environment such as air and water. The Act establishes national environmental policy and is meant to coordinate responses to environmental issues by bringing together other environmental legislation and policy for all environmental media regarding an individual major action. Typically, most federal agencies succeed in doing this. Where the YMP DEIS falls short is in regard to joint regional land use planning with other
398 agencies, citizens, and private stakeholders. Additionally, there has been no effort on DOE's part to integrate environmental documentation for the YMP with other anticipated or ongoing federal activities. In this context, DOE should address relationships between short-term uses of environmental resources and long-term productivity into the future.

399... **2. The overall environment** The difference between NEPA and other laws is in regards to focus, scope, and emphasis. NEPA is distinguished by comprehensively addressing the overall environment rather than single media such as air, water, and protected natural resources. The

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...399 task of addressing the overall environment in an integrated sense often is not achieved in NEPA documentation. Environmental components are addressed in a piecemeal fashion. This particularly is true for the ecological hierarchy. In the case of the Yucca Mountain DEIS, only biota and soils were addressed, the former only at the population and community levels. Ecosystems were avoided as was their role in the regional landscape. The entire YMP DEIS is at fault in not using interdisciplinary Environmental Impact Assessment (EIA) for the NEPA process.

400 **3. Not self-executing**: NEPA is not self-executing in that it does not alone determine the outcome expressed by a preferred course of action. Outcomes are influenced by many other considerations including the biases of an agency and organized interests. NEPA is a procedural policy act rather than a substantive act, and it alone does not determine the outcome of an action. In the case of the YMP, the outcome will be influenced by biased interests inside and outside DOE, such as the nuclear industry. Thus, public stakeholders such as the citizens of Nevada may not substantially affect the outcome of the YMP through their comments on the DEIS. Speaking on behalf of the citizens, the influence of the State government in this respect may be more effective but still may be outside the final decision making regarding execution and form of the Proposed Action for the YMP. This is a shortcoming on the part of DOE.

4. Federal sustainability policy: NEPA provides a foundation for environmental policy to be integrated into federal missions consistent with the scope of environmental and ethical values. However, not all agencies have met this need by implementing the Act's intent to meet the challenges imposed upon the environment by growth and development. In this regard, agencies have not risen to the aims of the Federal Ecosystem Management Initiative to foster sustainability through the ecosystem-based approach to managing the environment and its natural resources. Such should be among the goals of the NEPA process through well-executed EIA. Achieving this level of quality through NEPA means that government agencies must take
401 the Act as it was intended and not merely as a procedural and administrative hurdle. The White House policy on sustainable environmental resources and economies supports NEPA's foundation of national policy. This fact is not recognized in the YMP DEIS. DOE has not met the intent of the NEPA process to meet the environmental challenges posed by growth and development. Sustainable development depends on reliable EIA, which is lacking for the YMP. To fulfill the present need, DOE must take NEPA as intended and not a mere set of procedural requirements.

402 **5. Ethics and principles:** Actions proposed and taken by the U.S. government often are contrary to the aims and intent of NEPA. Among the reasons is the indifference of civil servants and agency bureaucrats to matters of ethics and principles. Another reason is ignorance of the environment, the concepts of sustainability and ecosystem management, and the pervasiveness of pollution. Most important is the lack in some federal agencies of unifying goals and strategies for perceiving, pursuing, and realizing NEPA's principles and long-range purposes. The bureaucrats within federal agencies need to be seriously and effectively committed to assuring that high qualities for the environment and for productive and healthful personal and civic life are achieved and sustained. This includes a responsibility to inform the public and interest groups of what is at stake and how adverse environmental consequences can be averted over time. Above all, it means that government agencies and bureaucrats need to be honest with the public about the true nature and ultimate balance of costs and benefits from proposed actions.

445 The YMP DEIS is indifferent to the principles of environmental and professional ethics expressed in NEPA. Also lacking is a unifying environmental goal and a strategy for DOE to fulfill NEPA for the YMP. A commitment on the part of DOE is needed to meet ethical principles and to assure the protection of the environment. This includes openness and informing all of the stakeholders in the YMP and related regional activities about the full nature of costs and benefits of the Yucca Mountain program.

403 **6. Unbiased and comprehensive EIA:** The procedural requirements of NEPA are meant to force attention to the Act's purpose of producing environmental documents for the NEPA process through application of the discipline of EIA. Thus, EIA is to be conducted by federal agencies before strategic decisions about a project have been made and not simply tailored to fit the project once a decision has been made to proceed with the action. In this context, NEPA is better served if environmental documentation is based on life-cycle EIA. This approach addresses a project's full life cycle from cradle to grave, including the fate of all pollutants and residuals and the full social, economic, and resource implications. NEPA also is better served when EIA is conducted in a strategic format that coordinates similar actions over time in a regional context. The intent of the NEPA process is that unbiased environmental documents be prepared before a proposed action is tailored. The information and insights resulting from the EIA process is meant to be integrated into the final design and implementation of the action. Because of the legislative nature of the YMP and its exposure to powerful external and internal interests, this intent of NEPA has not been possible. In particular, DOE has violated the ethical principle of avoiding biases in the conduct of EIA for the YMP. To avoid these faults, the YMP DEIS should adopt both life cycle EIA and strategic EIA on a regional basis.

404 **7. Environmental values:** NEPA is meant to further environmental values and ethics present in our society that are supported by a majority of citizens. The values reflect concern about long-term physical environmental quality and the quality of the human environment in the face of material growth. Under NEPA, the process of EIA also is meant to enhance the congruence of future actions with broad environmental goals that protect the environment for future generations. This means providing assurance of the widest range of beneficial uses of the environment without degradation, risk to health, and other undesirable consequences. A particular loser in the NEPA process for the YMP has been long-term quality of the human environment regarding future generations. The DEIS in particular condones sacrificing the Yucca Mountain region for the future. The inherent biases of those responsible for the DEIS weigh heavy on the project because independent outside review of the EIA process was limited. Those opposed to the YMP were viewed by DOE with a lack of confidence when the opposite situation was in fact the case. This also was true of the contractors who executed EIA for the YMP and compromised their ethics and objectivity on behalf of DOE.

8. Ethics, indifference, and openness: To achieve good EIA as intended by NEPA, expertise must be assembled and allowed by agency bureaucrats to remain involved throughout the entire process and to participate as part of an interdisciplinary team. An agency's legal staff also should be part of the team and should be involved from start to finish with the NEPA process. Strategies and tactics taken by one component of the team must be understood and agreed to by the entire team. Participants must be educated in the substantive purposes of NEPA as well as in the procedural ones, and they must be trained properly to write satisfactory impact statements that all stakeholder groups can understand. Above all else, a good sense of professional ethics must be practiced by all participants in the EIA process. As a whole, DOE has a poor record regarding environmental ethics, an indifference to environmental quality, and lacks openness to the public. The YMP is being conducted in this characteristic manner, where civil servants and bureaucrats ignore the higher precept of NEPA and environmental ethics. The DEIS includes no sense of unifying goals and strategies for achieving national environmental policy and informing and educating people about DOE's objectives which remain hidden and unopen.

9. Post-project correction: An important intent of NEPA is that post-project monitoring of the environmental effects of major projects be performed because of the inherent difficulty of accurately predicting the behavior of ecosystems. A corollary of this is that post-project mitigation of impacts be carried out when monitoring reveals the need, even though an impact statement did not anticipate the need. The reason for this is that EIA for complex projects is likely to incorrectly prejudge the impacts that are most serious and significant. Implicit in the

NEPA process is that EIA for project approval does not end once environmental documentation is completed. Post-project analysis is important to ensure that development occurs as anticipated
405 and that all resulting impacts were predicted. In situations such as the YMP where uncertainties are large and extend far into the future, continued monitoring and assessment are vital for managing risks. Such plans should be clearly outlined in the YMP DEIS.

10. Connectivity and carrying capacity: Another important principle of NEPA is that the scope of EIA be sufficiently comprehensive to accurately reflect the complexities of environmental interconnectivity and interactions involved. Included are joint planning processes, research, public interactions, and integrating environmental documentation among various levels of government. Conflicts with land use plans, policies, and controls at different levels are to be avoided and the relationships between short-term uses of the environment and long-term productivity must be addressed. These goals also require applying the concept of interdisciplinary ecological and ecosystem planning over a region. This means that impact analysis should constitute a holistic approach to human-ecosystem interactions in the context of regional plans that have assessed the carrying capacity of the region's resources and the cumulative effects that could occur. This issue concerns comprehensive and integrated EIA at
406 the ecosystem and regional levels. An interdisciplinary as opposed to a multiple disciplinary framework for protecting the environment is essential to EIA under NEPA. Only by understanding interconnectivity and the interactions of humans and the ecosystem can the concept of future carrying capacity of the human environment in the Yucca Mountain region be addressed. This is missing from the YMP DEIS and constitutes a significant oversight because of uncertainties about the long-term consequences for future generations of humans in the region.

11. Significant effects: To determine impact significance during EIA for NEPA, relevant considerations of the environment are to be evaluated for severity of impact caused by the intensity of the action undertaken. For example, the concept of a *threshold* for effects to occur is used in judging cumulative impacts. This is important in a regional context where similar or interrelated environmental threats may be posed by a federal agency or by several agencies over time. In these cases, single actions and impacts must be considered cumulatively and thresholds for effects that occur over long periods of time become important. Here the issue of "reasonably foreseeable" becomes important in terms of how much time must be involved before a future action can be undertaken safely. For ecosystem-level impacts, it is important to consider effects that can become cumulative over time. Also important is that mitigation measures for long-term impacts be addressed. Agencies are required to consider the degree to which environmental
407... effects are uncertain or involve unique, unknown, and cumulative risks. The issue of significant

...407 effects is problematic for the YMP because of the complexities involved. Among these are the context and intensity of an action and the threshold of disturbance to result in an environmental impact. Additional considerations include the degree of controversy involved, unknown risks associated with human health, and impacts being reasonably foreseeable. Considerations such as thresholds, context, intensity, and long periods of time for effects to occur have not been articulated in the DEIS. Consideration of the spectrum of hazards and risks of impacts and the feasibility of mitigation measures over long frames of time also is absent from the YMP DEIS.

408 **12. Future environmental quality**: Apprehension for future environmental quality has been aroused by concerns such as global warming and accumulations of radioactivity. Adverse consequences of increased environmental perturbations, however, have not always been recognized by the public. Government agencies should educate the public rather than fostering further development at the risk of unexpected environmental impacts. Accomplishing this is a role of the federal government. Means must be found to bring the political will and the missions of agencies closer to implementing the values expressed in NEPA's intent. NEPA is meant to assure achievement of high environmental quality far into the future. The full range of uncertain adverse impacts of the YMP that are meaningful in the context of future generations is missing from the DEIS and must be corrected to meet NEPA's purpose for sufficient EIA. This applies in particular to the interactions between global climate change and future releases of radionuclides into the regional and global environment from the YMP.

13. Substantive integration: In large part, complying with NEPA is a symptom of obsession with procedure over substance. NEPA can involve different kinds of reports and in each case substance often suffers. Often overlooked is NEPA's intent that coordinating and integrating major programs impacting the environment and land use plans be addressed. These issues arise from the fact that impact assessment is meant to be a learning process. Thus, the environmental documentation provision of NEPA is meant to force the gathering, analysis, and reporting of substantive information for the purpose of improving the substance, economy, efficiency, and
409 effectiveness of deciding and administering environmental policies and projects. Impact assessment under NEPA is meant to be a substantive learning process such that agencies can see how to coordinate and integrate proposed actions. The Yucca Mountain DEIS fails to accomplish this in one notably significant instance, the so called Five-Party Interagency Agreement. This interagency agreement calls for integrated and coordinated land use planning in accordance with the tenants of ecosystem management in the Yucca Mountain region. This is missing from the DEIS, setting the Yucca Mountain site apart from all contiguous land use plans.

410 **14. Avoiding NEPA:** Agencies and their bureaucrats often look at the informational substance of NEPA as an imposition that encumbers and delays the agency's mission and statutory responsibilities. These same bureaucrats are hostile to having the agency's expertise and preordained decisions open to scrutiny by NEPA. Agencies also are tempted to reveal as little as possible about their intentions to outsiders and the public. The full-disclosure provisions of NEPA are meant to avoid deception involving an agency's technical expertise, full intent, and the true cost of projects. Related to the issue of avoiding deception is that NEPA and environmental protection are seen by some agency bureaucrats as being viewed too sentimentally and impractically by the public and other outsiders. Such bureaucratic misconceptions lead to the attitude that NEPA and its documents are too costly and impose unnecessary burdens on moving forward with "serving" the public, as an agency believes it knows best how to do without interference. In the YMP DEIS, DOE has failed to achieve NEPA's intent that proposed actions be treated with full disclosure and openness. This reflects a reluctance of the bureaucrats involved with the project to have their full intent, costs, and preordained decisions revealed to the public and other outside interests. This holds also for revealing the expertise of those responsible for the EIA process and the DEIS, which these review comments show to be lacking in accordance with standard environmental practice in the private sector.

411 **15. Systematic interdisciplinary focus:** A particularly onerous aspect of NEPA for government agencies is the Act's mandate to use systematic interdisciplinary approaches to integrate science, socioeconomics, and environmental design arts in the EIA process. Many bureaucrats and agency personnel fail to understand the difference between interdisciplinary integration and the common multiple-disciplinary approach which fails to integrate the separate disciplines involved in the EIA process. Moreover, humans are to be considered as part of ecosystems and the environment but most often are not included except in socioeconomic and public health considerations. The DOE is one of several federal agencies that typically fail to realize that NEPA mandates a comprehensive interdisciplinary to EIA. This is the case with the YMP DEIS, where multiple disciplines worked independently. There was no overall integration to bring them together into a sum that is greater than the parts. The failure to adopt an ecosystem management approach for the DEIS and to consider humans a part of the holistic environment are the prime indications of this shortcoming for the YMP.

...412 **16. Ecosystem framework:** Accomplishing integration among different stakeholders and within federal agencies often is resisted by agency personnel. Failure to do so diminishes environmental quality. In the NEPA and EIA processes, agencies should adopt a progressive attitude toward environmental management that includes all interested and affected stakeholder

...412 groups, not just sister federal agencies. Goals consistent with the Federal Ecosystem Management Initiative should be part of every agency's mission objectives and land use policies. In fact, many integrative and other aspects of NEPA are complimented by the Federal Ecosystem Management Initiative. Among these are the responsibility of government agencies to build human environmental values into their missions and to integrate them into EIA and their mission programs. Policy integration is meant to foster more effective and sustainable programs by such means as stakeholder collaboration in planning and decision making. Accomplishing this requires greater agency learning and reorientation than recognized before ecosystem management was included in federal environmental policies. Now, agencies need to strive more than ever to achieve coherent and broader-based public administration and service in the context of ecosystem management. The Federal Ecosystem Management Initiative, which DOE has agreed to, should have been applied to the YMP. Several reasons for this are commented on above, and additional reasons have to do with (a) the nature of the program needing a progressive attitude toward EIA, and (b) the need for the program to be fully open to stakeholder involvement, in present and future terms. DOE has refused to adopt these and other aspects of ecosystem management for the YMP, which renders the DEIS inadequate.

17. Ecosystem-based management: While the EIS process and its required documentation have improved federal planning and general environmental quality, EISs in general have not achieved the intent declared by NEPA. If NEPA is to be realized, consistent with its goals, federal agencies must commit to and hold themselves to higher standards of ethics than are generally achieved. This is important to the future and depends upon the government and the people understanding the nature of environmental quality and the problems posed to it by unlimited growth and development. Accomplishing NEPA's ultimate goals of sustainable development through the ecosystem-based approach means that the principles declared in NEPA must become a practiced reality. Sustainable yield of resources for maintaining development means that ecosystem processes and life-supporting environmental systems must be addressed in
413 the EIA process. NEPA infers that a goal of national environmental policy is to work toward sustainable resources and economies through ecosystem management. This policy also has been declared by the White House in a multiple-agency agreement with which DOE has agreed and established a departmental order for achieving. Such an approach has been taken by DOE at the Nevada Test Site, but the YMP has steadfastly refused to adopt an ecosystem approach to managing the environment. Consequently, policy-relevant EIA and decision making in the context of holistic environmental and human dimensions cannot be conducted for the YMP. This failure is at the root of one of the DEIS' fundamental insufficiencies.

18. Science and uncertainty: The framers of NEPA intended that interdisciplinary EIA be conducted that includes the human environment in the context of sustaining development, ecosystems, and natural resources. Sound scientific and technical information was meant to be drawn upon in the course of environmental documentation for learning and as a base for corrective measures. Information often is applied in an absolute sense of certainty rather than in the degrees of probabilities characteristic of the scientific process. Probabilistic science itself is inconsistent with legal questions that require a "yes" or "no" answer. Thus, the uncertainty associated with any scientific issues can becomess lost in the decision making process stemming from the EIA process. This especially is the case in instances where insufficient information
414 exists to describe environmental baseline conditions prior to performing EIA. Interdisciplinary EIA for NEPA means that the use of sound scientific information must be maximized in order to minimize the dependence on so-called 'best professional judgement.' A purpose of this approach is to reduce the degree of uncertainty in environmental documents such as the Yucca Mountain DEIS. In this respect, DOE has failed throughout the YMP, particularly regarding a holistic environmental approach. The DEIS fails to indicate where scientific information is incomplete and repeatedly subjective judgement is substituted. In such instances, indications of the degree of uncertainty created or how the uncertainty ultimately can be compensated for or resolved should be addressed. A prime example of this weakness in the YMP DEIS is the lack of information regarding the nature of the pre-disturbed environmental baseline conditions. This and other uncertainties throughout the DEIS render it insufficient.

19. Biased interest groups: Uncertainty also results when science is used, but in a limited sense, to support an agency's particular objective. Thus, narrowly and selectively focused scientific information often is skewed toward the biases of outside interests and of the agency. Decision making often becomes encumbered with such hidden doubts. Injection of faulty information complicates already complex administrative procedures not designed to deal with scientific uncertainty. To this devil's mix of superficially scientific and technically derived base of information comes powerful political influence and the opinion of influential interest groups.
415 Biased intentions of DOE and its interest groups play a large role in the uncertainty throughout the YMP DEIS. Under these influences, inadequate information is used for EIA. This renders the DEIS as the servant of development and economic growth at the expense of environmental quality.

416... **20. Adaptive management**: Despite state-of-the-art science, uncertainties remain regarding the consequences of most proposed actions because critical factors associated with risks remain unknown. For example, unexpected environmental trends may affect the outcome of impacts.

...416 For reasons such as these, a one-time assessment may not suffice as a reliable indicator of outcome. To compensate for such unknown risks, long-term monitoring and revisiting predictions and cumulative impacts are necessary for reliable and effective EIA. This is known as "adaptive environmental management," a modern-day component of responsible EIA, and is meant to be based on the concept and practice of ecosystem management that includes the human environment. Often uncertainty can be reduced through environmental monitoring and adaptive management based on the resulting information. Such a tact should be followed during development and the useful lifetime of the YMP, as well as far into the future. This is because initial assumptions about an action change due to new knowledge, social values and human needs change over time, and significant changes can occur in the environment. Intentions and plans for such changes, based on a framework of integrated EIA, should be included in the YMP DEIS, but are not. This is unacceptable given the certainty of long-term environmental and health consequences associated with the program.

21. Weak information: NEPA recognizes that environmental science may be inadequate for
417 resolving numerous issues. Valid EIA requires reliable scientific and technical methods and information not always present at the time. Identifying such shortcomings is a responsibility that is part of good environmental documentation. This enables subsequent study when and where needed to resolve important uncertainties within a reasonable time frame and circumstantial situations and to mediate unforseen consequences. Identifying where more information is needed is particularly relevant in cases of uncertainty arising from expert opinion where sufficient hard data and sound information are lacking for impact prediction. Agencies need to be clear about such issues and about the techniques used for predicting and assessing impacts in the face of uncertainty, especially regarding future cumulative impacts. This is a benefit from having scientists and other technical experts involved in EIA for NEPA that have been trained to fully comply with NEPA and not just to provide scientific information. In the numerous cases where sound information is missing from the YMP DEIS, the shortcomings should be recognized and a framework set forth for resolving the difficulties and uncertainties created. Included in the framework should be the concept of monitoring and mitigating unforeseen consequences. At times, uncertainty in EIA can be lessened if the methods and techniques followed for environmental documentation are clearly set forth. This is lacking in the YMP DEIS and should be resolved. Also needed is information regarding standard practices used for impact assessment and prediction. Lack of such insights is an indication in the DEIS that sound interdisciplinary expertise in EIA was not assembled for the YMP. Experts trained not just in their respective disciplines are needed, but sound training and experience in EIA also is essential.

22. Boundaries and planning: In carrying out ecosystem assessment studies and designing mitigation responses, it is important that the basic attributes of ecosystems be identified and focused upon. The ultimate landscape and regional goals of a proposed action also must be stated, such as optimizing resources yield or restoring natural ecosystem process, function, integrity, or biodiversity. Managing or manipulating ecosystems for different goals requires different strategies and techniques that need consideration in EIA for the NEPA process. Landscape planning according to natural boundaries rather than artificial institutional boundaries must be considered in the context of a proposed action that plausibly could affect the landscape
418 or natural region. The Yucca Mountain DEIS is deficient in terms of best professional practice for EIA because natural ecosystem and landscape boundaries were not adopted. Programs as important as the YMP in terms of long-lived contaminants and future human generations require region planning and execution in the context of ecosystems and regional landscape boundaries. Otherwise, long-term and cumulative impacts cannot be addressed adequately. In terms of holistic environmental quality and EIA, the YMP DEIS is deficient as a NEPA document.

419 **23. Ecosystem simulation modeling**: Understanding ecosystems is important for managing resources for human purposes. Ecosystems can be modified to yield some provisions and services, but their tendency is to return to the system's natural evolutionary form. Because of this, purposeful management requires sustained intervention. In cases where anticipated impacts may be unique because of the type of perturbation involved, ecosystem responses are almost impossible to predict. Whether the post-impact recover ecosystem will be satisfactory also cannot be predicted due to the lack of examples from which to draw information. In such cases, EIA must include simulation field studies and predictive modeling in the ecosystem type where real impacts will occur. The precedential nature of the YMP in terms of contamination far into the future will endanger the environment and render future natural resources unusable. A comprehensive and integrated holistic approach to EIA that considers humans within the natural environment should be applied to the Yucca Mountain natural region. Predictive simulation models of the natural ecosystem that consider global climate change and extend far into the future should be performed. Such tasks should be based on full ecosystem baseline information. The current DEIS fails in that respect and is deficient for the nature of the project. Details about such an EIA process are provided by the citations listed following these comments.

420... **24. Study design and analysis**: Where field studies are necessary, suitable experimental design, sampling, and data analysis must be carried out, with or without replication. Methods for ecosystem-level studies involve various assumptions about the system at hand that influence the design and execution of the study. If the ecosystem to be affected is a native one, duplication of

...420 it for purposes of statistical replication are problematic because no two ecosystems are alike. Extreme care must be taken to choose the appropriate experimental design and analytical model to be used during the EIA process. In most cases involving a single, unreplicated natural ecosystem, traditional statistical approaches are unsuitable and yield results that are highly questionable. The ecological study design and the methodology adopted for EIA analysis for the YMP were flawed due to the inability to conduct credible replication of the ecosystem. Standard statistical techniques based on reliable replicates and controls do not apply in such cases.

421 **25. Ecosystem integrity**: Caution also is needed in making assumptions about the underlying future biological diversity and integrity of an impacted ecosystem. Assuming that the original natural ecosystem is the system most likely to return after an impact has subsided cannot be counted on to be reliable. Uncertainty exists if the impact exists far into the future because environmental factors such as climate may have changed significantly over long spans of time. If relevant information exists for the anticipated ecological and environmental conditions, ecosystem simulation modeling must be included in the EIA process for NEPA. In cases such as the YMP, where adverse health and environmental impacts are likely to occur far into the future, reliable EIA must include considerations of long-term ecosystem function, integrity, and biodiversity. Such consideration are especially important regarding the likelihood for interactions between anticipated impacts from the YMP and long-term global climate change. Holistic EIA based on the concept and principles of ecosystem management are essential.

422... **26. Conflicting programs and projects**: Integration of policies within and among government agencies is necessary to prevent wasteful duplication. The NEPA process is meant to minimize conflicting goals by integrating related activities, legislation, and policies to avoid internal and interagency conflicts. Often, threats to the environment can be traced to unintended effects of conflicting federal efforts. Avoidance of this by integrating government activities is a direct purpose of NEPA for encouraging productive harmony between humans and their environment. Thus, the EIA process should reveal the need for integrated federal public works planning to minimize conflicting programs. However, much federal activity and related legislation is in response to particular considerations with little effort given to inadvertent consequences, environmental effects, socioeconomic impacts, or other consequences. In a pluralistic democratic society, each stakeholder group pushes its agenda with indifference to the values of other groups, and often federal agencies make no effort to avoid the shortcoming. Once again, in programs such as the YMP, it is necessary that potential conflicts between future projects be addressed in a reasonably foreseeable manner. The Yucca Mountain region in particular is susceptible to such long-term impacts that have to be addressed in a context of ecosystem

...422 management. Such is among the intents of the existing Five-Party Cooperative Agreement for the region that DOE has refused to adopt for the YMP.

27. Values and ethics: All of this points to the increasing recognition in federal agencies of the need for greater integration of environmental values into their programs, new and established alike. The integration required by NEPA plus that inherent in ecosystem management stems from increasing public expectations for more effective and efficient management practices. Opinion has swung in the last decade or so to the still growing belief that damage to the environment is not unavoidable in achieving the objectives of public service from government agencies. To achieve responsible, ethical environmental management, agencies need to assure their personnel understand ethics in terms of how the agency can conform with the intent of NEPA compliance based on integrated ecosystem management that includes values inherent to
423 humans in the environment. Environmental values and ethics inherent in NEPA are not reflected in the YMP DEIS. Sound integrity of EIA practice is fundamental for relevant policy decision making and must be evident in the DEIS for EIA to be credible. Ethical precepts are implicit when ecosystem management is used as a unifying theme for the NEPA process, and without that and outside review of EIA, a crippling ethical dilemma hangs over the YMP.

28. Long-term sustainability: Additionally, impact analysis and assessment will fall short of the reality meant to be achieved by NEPA unless agencies also learn to consider long-term sustainability of their public programs. The goal of achieving sustainable natural resources and economies is the purpose of the Federal Ecosystem Management Initiative. All federal land management agencies have adopted ecosystem management among their internal orders, but few agencies have incorporated the concept of striving toward sustainability through applying the concept and practice of ecosystem management in the NEPA and the EIA processes. Ecosystem management requires an interdisciplinary approach that has as its foundation addressing human
424 and economic development in a sustainable and environmentally sound manner. Implicit in NEPA is that environmental sustainability over the long term for future generations of humans is to be sought by the EIA process. The advantages and disadvantages of proposed actions regarding sustaining future generations in programs such as the YMP must be addressed by the NEPA process This also is the purpose of the Federal Ecosystem Management Initiative and the Five-Party Interagency Agreement for the Yucca Mountain region. The DEIS for the YMP is deficient in these regards.

425... **29. Global pollution**: Another important perspective is NEPA and the global environment. Global environmental issues affect all or nearly all countries, and the concept of "commons"

...425 applies to all areas of the environment outside the jurisdiction of any nation. These issues are meant to be addressed by the NEPA process in regards to our national intent not to jeopardize or irreparably damage the Earth's environment. Examples of such offensive actions are those that contribute to global climate change and others that increase the Earth's burden of radioactivity. The intent of NEPA is that contributions to global environmental problems be avoided. Global environmental 'commons' such as the atmosphere applies to the YMP in the context of radioactivity and must be addressed by competent EIA in the DEIS. This in particular is an issue regarding future cumulative impacts and future generations.

Sources of Standards

Bartlett, R.V. and C.R. Malone. 1993. Science and the National Environmental Policy Act. *The Environmental Professional* 15(1): 1-160.

Bass, R.E. and A.I. Herson. 1993. *Mastering NEPA.* Solano Press Books, Point Arena, CA.

Caldwell, L.K. 1998. *NEPA.* Indiana University Press, Bloomington.

Clark, R. and L. Canter. 1997. *Environmental Policy and NEPA.* St. Lucie Press, Boca Raton.

Committee on Environment and Natural Resources. 1995. A National Framework for Integrated Ecological Assessments. The White House, Washington, DC.

Fogleman, V.M. 1990. *Guide to the National Environmental Policy Act: Interpretations, Applications, and Compliance.* Quorum Books, Westport, CN.

Gilpin, A. 1995. *Environmental Impact Assessment: Cutting Edge for the Twenty-First Century.* Cambridge University Press, Cambridge, UK.

Interagency Ecosystem Management Task Force. 1995. The Ecosystem Approach: Healthy Ecosystems *and* Sustainable Economies. Volume I - Overview. White House Council on Environmental Quality, Washington, DC.

Jain, R. and L. Urban. 1993. *Environmental Assessment.* McGraw-Hill, Inc., New York.

Ortolano, L. 1997. *Environmental Regulation and Impact Assessment.* John Wiley, New York.

TKC (The Keystone Center). 1996. The Keystone National Policy Dialogue on Ecosystem Management. TKC, Keystone, CO.

Salk, M.S., V.R. Tolbert, and J.A.Dickerman. 1998. Guidelines and Techniques for Improving the NEPA Process. *Environmental Management* 23(4): 467-476.

Szaro, R.C., W.T. Sexton, and C.R. Malone. 1998. Ecosystem Management. *Landscape and Urban Planning* 40(1-3): 1-123.

Westman, W.E. 1985. *Ecology, Impact Assessment, and Environmental Planning.* John Wiley & Sons, Inc., New York, NY.

Wiesner, D. 1995. *The EIA Process.* Atrium Publishers, Santa Rosa, CA.

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STATE OF NEVADA COMMENTS ON THE U.S. DEPARTMENT OF ENERGY'S DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

Volume 2

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ATTACHMENT A

ENVIRONMENTAL REVIEW AND REGULATION FOR SITING A NUCLEAR WASTE REPOSITORY AT YUCCA MOUNTAIN, NEVADA

CHARLES R. MALONE

The U.S. Department of Energy (DOE) has proposed that the first geologic repository for high-level nuclear waste in the United States be sited at Yucca Mountain, Nevada. Repository siting was exempted by the Nuclear Waste Policy Act from the requirements for an environmental impact statement under the National Environmental Policy Act (NEPA) and, additionally, the DOE was prohibited by law from acquiring new empirical information for environmental assessment. Thus, no systematic, interdisciplinary evaluation of impacts based on site-specific data will occur before the Yucca Mountain environment is irreparably altered by site characterization. Exemption of siting activities for the nation's first geologic repository for high-level nuclear wastes from NEPA review is further evidence of the eclipse of NEPA in decision making, a trend that may foretell how controversial, technologically complex projects will be carried out in the future.

The policy that established the program for siting the nation's first geologic repository for disposing of high-level nuclear waste was initially set forth by the Nuclear Waste Policy Act (NWPA) of 1982. In 1987, NWPA was amended by the Nuclear Waste Policy Amendments Act (NWPAA), which reduced the number of prospective sites in the western United States for a first repository from three to one and postponed the component of the program aimed at developing a second repository in the Eastern United States. This move allowed the US Department of Energy (DOE), the agency responsible for implementing the program, to concentrate its resources on the site at Yucca Mountain, located on the southwestern border of the Nevada Test Site (NTS). There has been no discussion of the diversity of environmental regulations that apply to the program and the implications of some of the unique regulatory features that exist and continue to evolve. These matters are of interest because the nuclear repository

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program authorized by NWPA and NWPAA may foretell how environmental review and regulation for complex and controversial technological programs could be carried out in the decades ahead.

The environmental compliance requirements that policymakers crafted for NWPA also provide insight to the eclipse of the National Environmental Policy Act (NEPA) in the decision-making process regarding environmental protection. Renwick (1988) contends that comprehensive, integrated environmental review has become secondary to statutory-specific environmental regulation of individual classes of pollutants or components of the environment. This situation has been characterized by a lessening of emphasis on the substance of NEPA policy to the extent that the law has evolved into a procedural one focusing on the environmental impact statement (EIS). What is particularly notable about the current high-level nuclear waste program in this respect is that NWPA exempts significant portions of it from even the procedural elements of NEPA. While there are provisions in NWPA to compensate in part for the fact that site characterization activities for a repository do not require an EIS and full NEPA review, this mandate has potentially far-reaching implications for the future of environmental management in the face of a continued weakening of NEPA, both substantively and procedurally. The principal issue analyzed in the present paper is the extent to which the environmental provisions in NWPA, coupled with other environmental regulations, compensate for the eclipsed effectiveness of NEPA for siting the nation's first geologic repository for high-level nuclear waste. This issue is important in light of Renwick's (1988) view that the eclipse of NEPA by other laws probably affords more environmental protection than was previously the case.

The spectrum of environmental compliance requirements that pertain to the DOE nuclear waste repository siting program includes unique, program-specific provisions set forth by NWPA, as well as the range of environmental statutes and regulations that apply to typical government actions. These requirements will in turn be reviewed below, but in order to evaluate them, it helps first to understand the general nature of the actions involved in siting a repository.

The Proposed Action

Although the conception of a geologic repository for nuclear wastes preceeded the enactment of NWPA in early 1983, that milestone is an adequate one to depart from for this analysis. A reasonably complete view of what repository siting would entail was provided in a set of environmental assessments (EAs) issued by the DOE in the 1986, as statutorily called for by NWPA. Initially, in 1984, the DOE had issued draft EAs for nine candidate repository sites. By the time the final EAs were completed in 1986, the range of potential sites had been narrowed to three, ie, one each in the states of Texas, Washington, and Nevada. Of interest here is the EA for the Yucca Mountain site in Nevada (DOE

1986), which, like the other EAs, described a two-stage repository program in accord with the site selection procedures specified by NWPA. The siting stage, involving site characterization activities intended to determine site suitability for a repository, is to be followed by a second stage consisting of construction and operation.

The Yucca Mountain site is located wholly on federal land, the eastern third of which is on NTS and controlled by the DOE. The remaining two-thirds of the site is on either public trust land or military land under the administrative control of the Bureau of Land Management (BLM). Site characterization activities that are to be conducted away from the site largely will be on BLM land, but some ground-water monitoring wells and seismic refraction surveys are planned in Death Valley National Monument in California (DOE 1988a), which is controlled by the National Park Service (NPS). These matters are important in terms of which federal agency is responsible for environmental protection of the site, details of which will be addressed in a later section. It is also important to note that Yucca Mountain is located within the transitional zone (ecotone) between the Mohave Desert and the Great Basin Desert in a little-known, localized, and unique area situated on volcanic as opposed to sedimentary substrate, as is the remainder of the so-called "Transitional Desert" (Beatley 1980; Collins et al. 1981).

Some preliminary siting activities such as drilling, trenching, and seismic testing already have occurred at Yucca Mountain, even though field activities for site characterization as defined by NWPA have not formally commenced. The site has been studied by the DOE since the late 1970s and exploratory investigations were conducted up to 1986. These activities are described in the DOE (1988a) Site Characterization Plan (SCP) in context with the work that remains to be done in accordance with NWPA siting procedures. The remaining work involves additional geologic and hydrologic investigation, plus construction of an exploratory shaft facility (ESF) that will be used for underground testing of conditions in the repository horizon at Yucca Mountain. All of these activities and associated tests are discussed in the SCP. Of interest here are the actions that will be covered by environmental regulations, and most of these occur on the surface, where drilling, trenching, hydrologic testing, and construction of the ESF will cause disturbance.

Table 1, compiled from the SCP, summarizes individual aspects of site characterization that will be subject to environmental review and regulation. The types of activities to be undertaken include shallow and deep drilling, geologic trenching, infiltration studies, geophysical surveys, construction of the ESF, and construction of roadways for access to the study sites. Of primary interest from the perspective of environmental compliance are activities that involve disturbance of the surface, generation of dust and emission of potential pollutants, drilling and testing in the saturated zone, effluent discharges to the surface, use of water resources, regulated utility services, and disposal of wastes, including

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TABLE 1. Proposed Site Characterization Activities for the Yucca Mountain Project

Activity	Description	Number/area	Environmental attributes
Major drill holes	Several hundred to over 1000 m deep for water table and geologic testing; will need drill pads and use drilling fluids	45–80	Surface disturbance of 1 ha/site; drilling foam and wastes; radioactive materials; hydrogeologic testing and surface discharges
Other drill holes	15–46 m deep for unsaturated zone exploration and geophysical testing; little or no surface preparation needed	300–350	Limited surface disturbance up to 600 m^2/site
Trenching	1–3 m deep by 2–4 m wide by 150 m long for geologic exploration and soil sampling	20	Surface disturbance of 0.1 ha/site
Infiltration studies	Shallow drilling to 15 m, pond construction, regolith removal to investigate water movement in the unsaturated zone	80 plots	Surface disturbance of 0.1 ha and various numbers of shallow holes and ponds/site
Geophysical surveys	Seismic reflection and refraction, gravity, and magnetic surveys	300–350 km of lines	Surface disturbance by vibrator trucks and dynamite charges
Exploratory shaft facility	Surface support facilities for underground testing; will include prefabricated buildings and trailers, dormitories, concrete r...r, utility and sanitary facilities, rock storage pile, and related facilities	13 ha	Surface disturbance; mining waste discharges and emissions; municipal, sanitary, and hazardous wastes; water supply
Access roads	Double oil-and-chip roadway to ESF plus bladed roads to outlying facilities, drill holes, trenches, and other study areas	0.4 km paved and 65 km dirt	Surface disturbance of up to 700 hectares and floodplain modifications

sewage and solid and hazardous materials. Almost all activities involve a degree of distrubance of the soil surface, biotic communities, and any cultural resources that might occur. Additionally, many of the exploratory activities will be located in floodplains where some of the most favorable ecological habitat at Yucca Mountain occurs. The EA estimates that up to 320 hectares of land could be disturbed during site characterization.

Dust emissions during surface disturbance will be controlled by sprinkling with water, and water also is required for drilling and mining activities. It is estimated that site characterization will require appropriation of water rights to about 500,000 cubic meters of ground water per year for 5 years, to be obtained from an existing well on the NTS. Use of radioactive materials and chemical tracers to study ground-water movement is also of regulatory concern, as is the generation and disposal of all wastes during site characterization. No unusual hazardous wastes are expected to be generated and, overall, the wastes involved in the project will be typical of those of any large construction and mining operation. Mined materials will be placed in a lined rock storage area and mining effluents will be discharged to the rock pile. Sanitary wastes will be disposed of via a septic tank and leach field. Both solid and hazardous wastes are to be stored on-site and ultimately disposed of off-site. A domestic water supply system will be installed, as will an electric utility system consisting of a substation supplied by an extension of an existing overhead power line. The types of environmental requirements to be involved in these activities are discussed in a later section.

Framework for Environmental Review and Regulation

A complex array of environmental requirements apply to the repository siting program. These requirements involve environmental compliance with regard to guidelines and implementing regulations that typically apply to large federal projects and unique features established by NWPA that address only the high-level nuclear waste program. The program-specific environmental requirements that must be complied with are set forth by NWPA in the context of procedures that the DOE must follow for siting the repository and ultimately gaining authorization from the Nuclear Regulatory Commission (NRC) for construction. The requirements stem essentially from modifications made by NWPA to NEPA, and they affect how the DOE is to conduct environmental review for the siting project. Although the NRC is involved in authorizing construction and licensing the operation of a repository, it has no regulatory role during siting. While defense nuclear facilities constructed and operated by the DOE typically are exempt from regulation by the NRC, NWPA requires that high-level waste repositories be authorized and licensed because they are to be used for commercial as well as for defense purposes. Accordingly, NEPA applies to the regulatory actions taken by the NRC once a decision is made to construct a repository.

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In addition to the environmental requirements and implementing regulations set forth by NWPA, including the modifications to NEPA, federal and state regulations that routinely apply to all projects help govern the DOE repository program. These include the unexempted portions of NEPA along with the specific requirements and regulations eminating from NWPA, all of which are discussed below.

Environmental Requirements Established by NWPA

The most significant aspects of NWPA from the environmental perspective are the partial exemptions from NEPA review provided to site characterization activities. There are two such provisions, in Section 112(e) and in Section 113(d), that exempt preliminary siting activities and all aspects of the site characterization program from preparation of an environmental EIS as called for by NEPA Section 102(2)(C) and from environmental review at international, state, and local levels under Sections 102(2)(E) and (F). In lieu of an EIS for site characterization, NWPA Section 112(b) requires that an EA be prepared for each site nominated for consideration as a candidate repository site. Such an EA has come to be known as a "statutory" EA (ie, specific to NWPA statutes) to distinguish it from an NEPA EA (Burton 1984). In a public statement (Mussler 1984), the DOE specifically noted that regulations for NEPA (40 CFR 1500-1508) do not apply to the statutory EAs.

The only guidance provided by NWPA for the EAs was that evaluations of site suitability were to follow a set of guidelines to be developed for recommending sites for repositories. These siting guidelines, mandated by NWPA section 112(a), were to address valuable natural resources, hydrology, geology, geophysics, seismic activity, effects on users of water rights, and proximity to atomic energy defense facilities, water supplies, populations, and to resource areas such as national parks, wildlife refuges, rivers, wildernesses, and national forests protected by federal law. Although it could be inferred that systematic, interdisciplinary environmental considerations in the NEPA sense should be included in the siting guidelines, they were not specifically called for by NWPA and subsequently were not included in the guidelines issued by the DOE under 10 CFR 960. It is important to note that NWPA Section 112(b)(3) prevents the DOE from undertaking new investigations for the EA and restricts preparation of the document to the use of existing information. This limitation upon acquisition of further empirical information for the EA had to be taken into account by the DOE when it prepared the siting guidelines, against which the statutory EAs would be evaluated. Because the candidate repository sites and the data base available for each of them were known to the DOE before the guidelines were prepared, it was natural for the DOE to develop guidance consistent with what was known about the sites. To have done otherwise by adopting criteria for which incomplete evaluative data were available could have led to a priori

disqualification of some if not all of the preselected sites. Deficiencies in site-specific information were called to the attention of Congress by federal agencies other than the DOE, but were ignored during hearings held on NWPA prior to its passage (Kraft 1988)

It also should be noted that the customary role of the NRC in evaluating environmental impacts for siting non-defense nuclear facilities was not provided for by NWPA during site characterization. In accordance with Section 114(d), NRC involvement in the high-level waste program was deferred until the repository-development phase, when construction authorization by the NRC is required. Licensing by the NRC of a constructed repository prior to its operation also is required by NWPA in Section 114(f), the section that declares repository development to be a major federal action requiring the DOE to prepare a NEPA EIS. Typically, the NRC role in authorizing and licensing nuclear facilities also is considered to be an action requiring NEPA compliance and preparation of an EIS. To accomodate this circumstance, the framers of NWPA sought to ease the demands of NEPA on the repository program by facilitating NRC environmental review requirements. This was accomplished through NWPA Section 114(f), which provides for the NRC to adopt the DOE EIS to the extent practicable. Such an action is the subject of proposed rule making by the NRC (1988) for NEPA review that has the effect of removing the NRC's obligation for environmental review of repository construction authorization by relying almost totally on the DOE's procedures for NEPA compliance. The ultimate significance of this issue will be pursued further in the next section.

Three other environmental provisions in NWPA Section 113 also affect how the DOE repository siting program is to be conducted. First, Section 113(a) calls on the DOE to minimize significant adverse environmental impacts identified either in comments on the DOE's SCP or in further assessments of the environment submitted as part of the SCP. Second, Section 113(b)(1)(A)(iii) requires that the SCP include plans for decontaminating and decommissioning a characterized site and for mitigating significant adverse environmental impacts if the site consequently is not used for a repository. Third, the theme of impact minimization, mitigation, and reclamation was carried forth to Section 113(c)(4), which required that the DOE take reasonable steps to reclaim the site and to mitigate environmental impacts from site characterization if the site ultimately is found unsuitable for repository construction. This provision was modified slightly by NWPAA in 1987 to provide for reclamation and mitigation of environmental impacts caused by site characterization "at any time" that a decision is made not to proceed with repository development at Yucca Mountain. Taken together, these three provisions of Sections 113 constitute the fundamental directions to the DOE for conducting environmental review for site characterization subsequent to issuance of the statutory EAs.

Another provision of NWPA having implications pertaining to environmental concerns is Section 116, as amended by NWPAA, which provides a role for the

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State of Nevada, as an affected government, relative to monitoring and reviewing repository site characterization. Funding made available under the nuclear waste legislation for independent oversight of DOE activities can be used for environmental review and protection. For example, Section 116(c)(2)(B) of NWPA allows affected governments to submit a report that includes assessment of potential environmental impacts and provides the basis for requesting assistance for mitigating impacts. No guidance is provided by NWPA as amended for how this function is to be carried out and no plans currently are available that would allow insight into how effective the process might be.

NEPA Requirements

Despite the partial exemptions from NEPA that NWPA provides for site characterization, there are requirements remaining that must be met by the DOE. All substantive provisions of NEPA remain in force, as well as the Council on Environmental Quality (CEQ) implementing regulations other than those concerning EIS preparation. Additionally, the DOE itself has a NEPA compliance regulation (10 CFR 1021) that reinforces the CEQ regulations by adopting them in whole.

Most notable among the environmental review requirements that remain applicable to DOE site characterization are those of 40 CFR 1501, 1505, and 1506 in the CEQ implementing regulations for NEPA. Among other things, these regulations require early planning that effectively integrates the objectives of NEPA policies into agency programs. An objective of this requirement is to assure that a systematic, interdisciplinary approach is taken that integrates environmental and social sciences into decisions affecting the environment. The intent of this unique statutory provision is that environmental effects and values will be sufficiently identified to allow their comparison to economic and technical analyses. To accomplish these goals, the DOE must follow procedures that ensure its decisions are made in accordance with the policies and purposes of NEPA.

As previously noted in the discussion of NWPA Section 114(f), the full force of NEPA environmental review applies to repository development, and the DOE is required to comply with NEPA and the CEQ regulations that establish generic contents for an EIS. In the past, nuclear facilities requiring licensing by the NRC have adhered to NRC guidance for preparing environmental documents. Under the NRC requirements for environmental review that existed when NWPA was passed, the procedures set forth in 10 CFR 60 and 10 CFR 51 for NEPA review and compliance pertaining to licensing a high-level nuclear waste repository would have required that a detailed environmental report on the project be prepared by the applicant, in this case the DOE. From this document, the NRC then would have prepared and EIS to fulfill its obligations under NEPA. A virtue of this arrangement is that it would assure that the DOE follows a reasonably rigorous set of guidelines for preparing the environmental report, as opposed to

the generic and far less detailed guidance set forth for EISs by CEQ under 40 CFR 1502. This would assure that, ultimately, an environmental review tailored to nuclear projects would be performed by the DOE for the Yucca Mountain site, albeit after the impacts of site characterization have occurred.

The NRC, however, has used the provision in NWPA Section 114(f) allowing it to adopt the DOE EIS to justify proposing revisions to its NEPA review procedures (NRC 1988). If adopted, the revisions would release the NRC from its traditional NEPA review obligation by allowing it to rely on the DOE procedures and EIS rather than conduct an independent environmental review. Additionally, the DOE would not be required to prepare an environmental report and the 10 CFR 51 guidance for detailed environmental documentation would cease to apply to the repository program. In effect, the EIS prepared by the DOE would constitute the only environmental review procedure for repository construction and there would be no specific guidance for the EIS other than the siting guidelines under 10 CFR 960 which, as noted earlier, were prepared to accommodate an EA effort that could not be supplemented by newly acquired data and information where gaps in knowledge about the site existed.

This is the situation as it stands, up to the granting of an authorization by the NRC for construction of a repository by the DOE. It is possible, as is the case with other licensable nuclear facilities, that further environmental review and EIS preparation subsequent to construction would be required for repository operation. The NRC has yet to decide how it will proceed in matters beyond construction authorization with regards to NEPA review and environmental compliance for all aspects of repository development, and doubtlessly is awaiting the outcome of its proposed revisions to the NEPA review regulations. Clearly, however, the NRC intends to avoid rigorous environmental review of the Yucca Mountain Project if possible.

Other Environmental Statutes and Regulations

Federal and state environmental compliance requirements that apply to repository siting are derived from the nature of the proposed action described in a preceding section. Individual activities to be undertaken during site characterization render certain statutes and regulations applicable to the project, as shown in Tables 2 and 3 for federal and state environmental compliance requirements, respectively. The state requirements listed are specific to Nevada because NWPAA confined repository siting to the Yucca Mountain site.

For the most part, the federal environmental regulatory framework that applies to the repository program (Table 2) is similar to that for typical government projects. Consideration of air quality, water quality, hazardous wastes, threatened and endangered species, and cultural resources is provided by specific statutes and regulations. There are additional environmental requirements posed in this instance, however, that are potentially significant in light of the NEPA exemp-

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TABLE 2. Principal Federal Environmental Statues and Regulations that Apply to the Yucca Mountain Project

Federal Land Policy and Management Act of 1976, 43 USC Section 1701-1784 (43 CFR Parts 2300 and 2800).
Organic Act of the National Park Service, 16 USC Section 1, and, National Park System Mining Regulation Act, 16 USC Sections 1901-1912 (36 CFR Part 9).
Floodplain Executive Order, E.O. 11988 (10 CFR Part 1022).
Endangered Species Act of 1973, 16 USC Sections 1531-1543 (50 CFR Sections 17.11, 17.12, 17.94, 17.95, and 17.96; 50 CFR Parts 222, 226, 227, 402, 424, 450, 451, 452, and 452; DOE/EP-0058).
National Historic Preservation Act of 1966, as amended, 16 USC Sections 470-470w-6.
American Indian Religious Freedom Act, 42 USC Section 1996 (36 CFR Part 296; 43 CFR Part 7).
Clean Air Act, as amended, 42 USC Sections 7401-7642 (40 CFR Parts 50, 51, 52, 58, 60, 61, and 124; Sections 81.300 and 81.400; DOE/EP-0062 and 0065; E.O. 12088).
Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 and the Hazardous and Solid Waste Amendments of 1984, 42 USC Sections 6901-6991 (40 CFR Parts 124, 240-247, 260-264, 266, 270-271, and 280; E.O. 12088; State regulations).
Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 and the Water Quality Control Act of 1987, 33 USC Sections 1251-1376; (33 CFR Parts 209, 320, 323-327, and 330; 40 CFR Parts 110, 116, 117, 121, 122, 123, 124, 125, 129, 133-136, 230, 233, 401, and 403; DOE/EP-0060 and 0061; E.O. 12088).
Safe Drinking Water Act, 42 USC Sections 300f-300j-10 (40 CFR Parts 124, 141, 142, 143, 144, 145, 146, 147, and 149; E.O. 12088).

tions provided by NWPA to site characterization. Some of the characterization activities occur on lands controlled by the BLM or NPS. In these instances, statutes and regulations under the Federal Land Policy and Management Act (FLPMA) and the Organic Act of the National Park Service became applicable, requiring in turn that the BLM and NPS apply NEPA review to those activities. Only a small number of activities, principally geophysical surveys, are proposed on NPS land in Death Valley National Monument, but a major portion of site characterization will be carried out on BLM-controlled land adjacent to the NTS.

Under the terms of both the NPS Organic Act and FLPMA, the DOE must obtain authorization from the controlling agency to utilize land not under the jurisdiction of the DOE itself. This requirement will mean that the NPS and BLM must conduct environmental review under NEPA and the CEQ regulations for the granting of permission to the DOE to utilize the land. Accordingly, for the activities that these requirements apply to, traditional EIA should be performed.

A significant number of proposed site characterization activities, principally bore holes and geophysical surveys, will occur in floodplains. The DOE implementing regulations for floodplain protection (10 CFR 1022) require that an

TABLE 3. Principal State Environmental Statutes and Codes that Apply to the Yucca Mountain Project

Utility Environmenatl Protection Act, NRS 704.820 to 704.900 (Permit Requirements Proposed as Amendments to NAC 703.415 *et seq.*).
Appropriation of Public Waters, NRS 533.325 to 533.435 (Permit Requirements Covered by Administrative Procedure and "Regulations Concerning Preparation of Maps Under Application to Appropriate Water and Proofs of Appropriation", State Engineer, 1977).
Underground Water and Wells, NRS 534.010 *et seq.* (Regulations for Drilling Water Wells, NAC 534.010 *et seq.*).
Air Pollution, NRS 445.401 to 445.710 (Permit Requirements, NAC 445.430 to 445.716).
Nevada Water Pollution Control Law, NRS 445.131 to 445.354 (Discharge Permit, NAC 445.140 to NAC 445.170; Treatment Works, NAC 445.170; Diffuse Sources and Permit to Construct or Grade, NAC 445.199 to 445.234; Temporary Underground Injection Control Regulations, NAC 445).
Public Water Systems, NRS 445.361 to 445.399 (Water Quality, NAC 445.244 to 445.262; Water Supply, NAC 445.370 to 445.420).
Collection and Disposal of Solid Waste, NRS 444.440 to 444.630 (Solid Waste Disposal, NAC 444.570 to 444.748).
Disposal of Hazardous Materials, NRS 459.400 to 459.600 (Hazardous Waste Disposal, NAC 444.8500 to 444.9335).

environmental assessment be conducted for such activities. While this requirement is far from comprehensive in its coverage of the DOE project, if complied with, it will nonetheless help assure that some activities on DOE-controlled land receive environmental review that otherwise may escape coverage.

Most of the important environmental regulations for the State of Nevada (Table 3) that apply to the DOE project are derived from delegated federal authority. Specifically involved are compliance requirements associated with the Clean Air Act, the Clean Water Act, the Resources Conservation and Recovery Act, and the Safe Drinking Water Act. For the protection of biological and cultural resources, Nevada relies primarily on federal statutes and has no significant requirements of interest in the context of the repository program. Neither does the state have a comprehensive environmental review law that can compensate for the NEPA exemptions provided by NWPA. One state statute is of interest in this respect, and that is the Utility Environmental Protection Act. This statute requires that an EA be performed for new utilities, and it likely will apply to those proposed for site characterization and for repository construction.

Site characterization activities proposed in Death Valley, California, by the DOE include geophysical exploration and installation of up to 30 ground-water monitoring wells. Although these activities will occur on NPS land, environmental statutes of the State of California will apply; these include the California Environmental Quality Act (CEQA), the state's equivalent of NEPA. Unless California agrees to transfer lead agency status and liability to the federal gov-

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ernment, CEQA will apply to the activities in Death Valley and will encompass an array of specific state requirements. The California Energy Commission is handling affairs relative to the DOE repository siting that impinge upon the state, and how state environmental requirements will be applied has not been determined.

Outlook for Environmental Review and Regulation

There are at least two ways to gain insight into how effective the regulatory framework that applies to the Yucca Mountain Project might be for protecting the environment. One approach is to evaluate the actions already taken to implement NWPA, NWPAA, NEPA, and their various specific environmental requirements. This will indicate the extent to which the intentions of various environmental requirements are being achieved by the implementing agencies. Another tactic is to assess the potential effectiveness of the regulatory requirements that have yet to be implemented, and to evaluate the historic record that is analogous to the present situation. Institutionally, there are four entities that have roles in environmental protection at Yucca Mountain: the DOE, the NRC, the BLM, and the State of Nevada. The NPS is responsible for protecting portions of Death Valley National Monument from the limited site characterization activities planned to occur there. The State of California could become involved in Death Valley via CEQA, but the likelihood of this occurring is not known, and the extent of site characterization activities planned in California is relatively minor with respect to the overall DOE siting program.

Implementation of Environmental Requirements by the DOE

The principal responsibility for assuring that the regulatory framework provided by NWPA is developed and implemented rests with the DOE. To this end, the DOE has approached fulfilling its environmental requirements in a stepwise manner, consistent with actions called for in NWPA.

In accordance with NWPA, the initial step taken by the DOE was promulgation of the siting guidelines. These guidelines fell short of compensating for the NEPA exemptions because they did not address the environment in a comprehensive, interdisciplinary sense, but instead equated protection of the environment to compliance with single-medium environmental statutes. Although legally moot in this context, the US Supreme Court ruled in the landmark Calvert Cliffs case that compliance with specific laws does not substitute for a systematic, interdisciplinary perspective on environmental review and assessment meant to be taken in complying with NEPA (Rogers 1977; Jain et al. 1981). It must be noted, however, that the trend is to rely increasingly on laws other than NEPA for environmental protection while retaining the EIS procedures for advocacy purposes (Renwick 1988).

The next environmental step taken by the DOE was preparation of the statutory EAs. There were two handicaps imposed upon these documents. First, because the assessment process was not undertaken in the context of NEPA, no standard guidance such as CEQ and NRC regulations for NEPA environmental review applied. Instead, the DOE adapted the siting guidelines that had been developed knowing that incomplete information would be available for the EA process. This precluded the agency from taking a comprehensive, interdisciplinary approach to environmental protection and was a serious deficiency imposed upon the Yucca Mountain EA because little site-specific information existed for the area, making it impossible to carry out a comprehensive environmental review. In this respect, concerns that had been expressed earlier during Congressional hearings on NWPA about the lack of a sufficient base of empirical information for the EAs to succeed were realized (Kraft 1988).

In the end, the statutory EA for Yucca Mountain (DOE 1986) was recognized by the State of Nevada as an ineffective document for environmental review and was contested in a case yet to be heard by the courts (*Nevada v. Herrington*, No. 86-7307, 9the Circuit of Appeals). The DOE has sought to uphold the efficacy of the statutory EA and has continued to use it as the basis for all subsequent environmental planning decisions. To this end, the DOE has used the finding of no significant impacts to justify a decision not to obtain comprehensive, site-specific environmental baseline information at Yucca Mountain prior to initiating site characterization. The DOE's policy is that comprehensive monitoring for detecting adverse environmental impacts is unnecessary, and instead of demonstrating that it will minimize impacts to all segments of the environment, has tailored a piecemeal program to comply with individual requirements based upon the findings in the statutory EA (DOE 1988b, c). Nowhere does the DOE recognize the unique ecological nature of the Yucca Mountain site and the fact that it occurs on an inadequately studied ecotone (Beatley, 1980; Collins et al. 1981). Plans have been issued by the DOE that include compliance with parts of such laws as the Clean Air Act, the Endangered Species Act, and the National Historic Preservation Act (DOE 1988d), but that fail to address ecological integrity and resources protection. There is no comprehensive environmental program that integrates all aspects of the Yucca Mountain environment into a systematic, interdisciplinary environmental review prior to site characterization activities being undertaken and before potentially irreversibly altering the unique and fragile desert environment at Yucca Mountain. However, after site characterization has been initiated and impacts incurred, the DOE plans to establish an environmental baseline for use in preparing the repository EIS mandated by NWPA for NEPA compliance. This actions will come too late to describe the environment before it is significantly altered by site characterization, an acknowledgement made by DOE (State of Nevada 1987).

The absence of an environmental baseline prior to site characterization can be expected to preclude effective reclamation planning as viewed by NWPA and

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NWPAA. In the preliminary SCP (1988a), the DOE has presented no reclamation plans as called for under NWPA Section 113(b) as part of planning for site characterization. Thus, as the DOE program now stands, it cannot be expected to fulfill the requirements of NWPA and NWPAA to reclaim the Yucca Mountain site in the event that the site is not used for repository development. Of even more fundamental importance to state government and the provisions of NWPA and NWPAA that provide for environmental oversight and impact assistance, the actions planned by the DOE to alter the site before baseline information is available will preclude others from making an accurate assessment of impact potential and resources needed to mitigate the inevitable impacts associated with site characterization.

Consideration of environmental protection by the DOE next can turn to the extent to which it is likely to comply with specific federal and state environmental regulation. To this end, the State of Nevada (1988) reviewed the DOE record for complying with state and federal environmental requirements at Yucca Mountain prior to 1986. It was found that between 1976 and 1986, the DOE complied with no state regulations and with only the Endangered Species Act and the National Historic Preservation Act among the federal requirements that applied. During this time, a total of 98 drilling operations were conducted, 20 of which were major holes requiring drill pads, use of drilling fluids, and access roads of several kilometers' length each. Additionally, 21 geologic trenches were constructed, up to 160 kilometers of seismic lines were run, and numerous semi-permanent seismic, hydrologic, and meterologic monitoring stations with roads to them were installed. It was estimated that up to 200 hectares of land surface were disturbed for the activities undertaken by the DOE prior to 1986. These actions were not addressed by comprehensive NEPA review, and 11 of the drilling operations located in floodplains were not reviewed in accordance with the federal floodplain regulations (Table 2). Among the important state requirements that the DOE failed to comply with were drilling and water resources protection regulations and air quality requirements. To date, the DOE has made no attempt to reclaim disturbed sites that no longer are used for the repository siting program.

The results of its survey led the State of Nevada (1988) to critique the compliance record at the DOE nuclear facilities throughout the nation as well as operations at the NTS (DOE 1988e). It was found that the DOE typically had a poor environmental compliance record in Nevada and seldom adheres to state and local regulatory requirements. The State concluded that the DOE cannot be counted upon to protect the Yucca Mountain environment in accordance with specific statutes other than possibly the Endangered Species Act and the National Historical Preservation Act, which it seems that the DOE usually complies with. This finding is consistent with what has come to be known, even by the DOE's own admission, as a typically poor record with respect to health, safety, and environmental compliance (Walker 1987; DOE 1988f; General Accounting Office 1988; DOE 1988g) attributable to the traditionally self-regulatory nature of

the DOE and the correlary lax attitude generated toward environmental oversight and responsibility (US Senate 1987).

Implementation of Environmental Requirements by Other Agencies

In addition to the DOE, other federal agencies that are involved in the repository program include the NPS, BLM, and ultimately the NRC. The latter is involved in a regulatory role with respect to authorizing repository construction and licensing its operation. Because construction and operation are considered by NWPA to be major federal actions, NEPA applies to the NRC role in the repository program subsequent to site characterization. Historically, the NRC has exercised a responsible role in environmental review of nuclear projects, but because NWPA allows the NRC to adopt the DOE EIS for the repository, the NRC cannot be counted on to exercise independent environmental review in this instance. The action taken by the NRC (1988) to amend its NEPA review regulations to delete the requirement for an environmental review and an independent EIS confirms the intent by the NRC to avoid active involvement in environmental aspects of the repository program and instead to accept the DOE's actions.

The role to be played by the NPS in environmental review and regulation of repository siting activities is relatively minor because of the limited extent of activities to be undertaken by the DOE on land under NPS jurisdiction. Regulations governing environmental review for activities in national parks (Table 2) require that the review be documented. Accordingly, the NPS is expected to have an EA performed and documented for any drilling and seismic surveys conducted by the DOE for repository siting activities in Death Valley National Monument in California.

It seems that one of the best prospects for environmental review of DOE site characterization at Yucca Mountain ideally should rest with the responsibility that the BLM has to review proposed actions on land under its jurisdiction. This includes the site for the exploratory shafts planned by the DOE, as well as many of the other geologic and hydrologic studies based on the surface. In accordance with FLPMA regulations, the BLM should independently review the potential impact of the proposed DOE activities and conduct the review in pursuit of NEPA compliance. In its review of compliance actions for the Yucca Mountain Project prior to 1987, the State of Nevada (1988) found that in the past, the BLM has always adopted the DOE's documentation associated with environmental review, including the EA prepared for the Yucca Mountain site (DOE 1986). It is anticipated that for future site characterization activities planned by the DOE, the same procedure will be followed by the BLM, ie, adoption of existing DOE documents as opposed to independent review based on field studies and information gathered by the BLM itself. Thus, in fulfilling its obligations under FLPMA and NEPA, it seems unlikely that the BLM will conduct com-

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prehensive, interdisciplinary environmental review of repository siting activities based upon field information specific to Yucca Mountain.

Summary and Conclusions

The national program for disposal of high-level nuclear waste has progressed sufficiently since passage of enabling legislation (NWPA) in 1982 to provide insight to how effective provisions for environmental review and regulation are likely to be regarding siting a geologic repository and to the broader implications for environmental policymaking. With respect to the repository siting program now underway at Yucca Mountain, Nevada, there are three categories of requirements for environmental review and regulation: those set forth by NWPA that are specific to this program, the generic NEPA requirements not exempted by NWPA, and the traditional federal and state environmental statutes and regulations. Site characterization was exempted from regulation by the NRC and from the NEPA requirement for an EIS. Consequently, environmental review was relegated to the statutory EA mandated by NWPA and guided by the DOE's siting guidelines rather than by CEQ and NRC regulations. The siting guidelines were prepared in light of the prohibition imposed by NWPA on the acquisition of new data and information for preparation of the statutory EAs. As a result, there were no provisions in the guidelines for comprehensive, integrated EIA. Instead, assessments were based on the potential for compliance with traditional federal environmental statutes and regulations designed to protect individual components of the environment. The NEPA exemptions granted by NWPA thus excused the DOE site characterization program from the systematic, interdisciplinary review that is unique to NEPA. While the shortcoming could in part be compensated for by applicability of other environmental statutes, most notable by FLPMA, it is unlikely that the potential to replace what was sacrificed by the exemption granted by NWPA will be fulfilled. Unfortunately, NWPA and its indifferent attitude toward NEPA environmental policies signaled that political expediency is more important to policymakers than environmental rationality.

In the final analysis, it can only be concluded that both the procedural and the substantive intent of NEPA were compromised by NWPA with respect to DOE site characterization activities at Yucca Mountain. This is further evidence of the current eclipse of NEPA, which in this instance is more serious than that characterized by Renwich (1988), involving cases in which the compromising of NEPA's intent ultimately was compensated for by compliance with other federal environmental statutes and regulations. It is well recognized (Caldwell 1985; Bartlett 1986) that the substantive policies set forth by NEPA have been overshadowed by its procedural requirement for an EIS and that sight has been lost of the rationality NEPA sought to establish for environmental decision making. What is new with the advent of the nation's nuclear waste policy is the replacement of NEPA's procedural regulations with the self-regulatory authority

that traditionally has characterized DOE nuclear programs, resulting in environmental problems of immense proportion regarding waste management (US Senate 1987; General Accounting Office 1988; Walker 1987; DOE 1988g). This is a precedent of significant importance and implication to environmental policymaking.

While the framers of NWPA may have envisioned that NWPA requirements regarding impact monitoring, mitigation, and reclamation of site characterization activities would compensate for the NEPA exemption, that is not proving to be the case. This is because the DOE has based all of its environmental program for site characterization on the findings in the statutory EAs, which were fundamentally flawed by virtue of NWPA having prevented science from playing its proper role as an integral tool in policy analysis. The provision that no new field studies could be undertaken was a crippling one also directly related to the NEPA exemptions provided by NWPA. Thus, the lack of systematic, interdisciplinary assessment, the self-regulatory nature of the environmental program, and the absence of analysis based on empirical information stem from a deferrment of NEPA procedures granted to the DOE by Congress. Last, even the independent oversight role that is provided to the affected state government, in this case Nevada, has been compromised by the failure of the environmental assessment and analysis process for site characterization to be based on comprehensive, site-specific information subjected to integrated, interdisciplinary evaluation. This is because actions taken by the DOE in the course of implementing its environmental and site characterization programs, which are being based on incomplete site-specific information, potentially could exclude an option or alternative course of action that proper oversight might find more in accordance with appropriate analysis of empirical information.

Should characterization of the Yucca Mountain site lead to a decision in accordance with the siting policy in NWPA to proceed with repository development, the consequent environmental review implicit in NEPA for such major federal actions will once more be threatened by the provisions in NWPA, allowing the NRC to adopt the EIS prepared by the DOE. To this end, the NRC has proposed revisions to its NEPA compliance regulations that will excuse the DOE repository program from current NRC regulations pertaining to nuclear projects. The results will be that the DOE will not be required to prepare an environmental report and, rather than being guided by the traditional bevy of NRC environmental standards and guidelines pertaining to nuclear projects, will again follow its own siting guidelines that led to the deficient EA and the subsequently flawed environmental program based on it. The deficiencies stemming from the prohibition on gathering empirical data for the statutory EA that in turn led to weak siting guidelines again will be evident in the repository EIS prepared to those same guidelines instead of to the traditional guidance required by the NRC for nuclear projects. Once more, the substantive intent of NEPA that comprehensive interdisciplinary assessment be conducted for federal actions will have been thwarted,

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forcing the environmental review process to rely on the strength of traditional environmental statutes that address single components of the environment rather than providing an integrated approach to EIA. Renwick (1988) stated that the shift to laws other than NEPA probably protects the environment more than would be the case under NEPA. This may be so where at least the procedural requirements of NEPA remain unimpaired and where statutes apply that address ecological integrity. However, in the case of siting a geologic repository for high-level nuclear waste, NEPA's procedural foundation was set aside and subsequently replaced by flawed practices that clearly fail to assure adequate protection of the environment. This is a new and threatening twist to the demise of NEPA, resulting from the failure of policymakers to see that the potential of NEPA is fulfilled. There soon must be a resolution of the issue with respect to whether or not the public preference for environmental protection is being served by the trend away from the concepts of environmental rationality, ecosystem integrity, and ecological resource values represented by NEPA.

References

Bartlett, R. W. 1986. Rationality and logic of the National Environmental Policy Act. *Environmental Professional* 8:105–111.

Beatley, J.C. 1980. Fluctuations and stability in climax shrub and woodland vegetation of the Mojave, Great Basin, and Transition deserts of southern Nevada. *Israel Journal of Botany* 28:149–168.

Burton, E. S. 1984. Statutory environmental assessments under the Nuclear Waste Policy Act of 1982: Process, content, and status. In *Proceedings of the 1983 Civilian Radioactive Waste Management Information Meeting*, pg. 245–247, CONF-831217, February, Washington D.C.: Department of Energy.

Caldwell, L. K. 1985. NEPA's unfulfilled potential. *The Environmental Forum* 2(1):38–41.

Carter, L. J. 1987. *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste*. Washington, DC: Resources for the Future, Inc.

Collins, E., O'Farrell T. P., and Rhoads, W. A. 1981. *Annotated Bibliography for Biologic Overview for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada*. Report No. EGG 1183-2419, Goleta, California: EG&G Santa Barbara Operations.

Davenport, J. H. 1986. The law of high-level nuclear waste. *Tennessee Law Review* 53(3):481–526.

Jain, R. K., Urban, L. V., and Stacey, G. S. 1981. *Environmental Impact Analysis: A New Dimension in Decision Making*. New York: Van Nostrand Reinhold Co.

Kraft, M. E. 1988. Evaluating technology through public participation: The nuclear waste disposal controversy. In *Technology and Politics*, M. E. Kraft and N. J. Vig (eds). Durham, NC: Duke University Press.

Mussler, R. M. 1984. Environmental assessments required to support nomination of sites. In *Proceedings of the 1983 Civilian Radioactive Waste Management Information Meeting*. pp. 243–244, CONF-831217, February, Washington, DC: Department of Energy.

Renwick, W. H. 1988. The eclipse of NEPA as environmental policy. *Environmental Management* 12(3):267–272.

Rogers, W. H., Jr. 1977. *Environmental Law*. St. Paul, West Publishing Co.

State of Nevada. 1987. *Environmental Program Planning for the Proposed High-Level Nuclear Waste Repository at Yucca Mountain, Nevada*. NWPO-TR-001-87. Carson City, NV: Nuclear Waste Project Office.

State of Nevada. 1988. *A Role in Environmental Compliance for the State of Nevada During Site Characterization of the Proposed High-Level Nuclear Waste Repository Site at Yucca Mountain, Nevada*. NWPO-TR-008-88. Carson City, NV: Nuclear Waste Project Office

US Department of Energy. 1986. *Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, Vols. 1-3*. May, DOE/RW-0073. Washington, DC: OCRWM.

US Department of Energy. 1988a. *Site Characterization Plan*. December, DOE/RW-0199. Washington, DC: OCRWM.

US Department of Energy. 1988b. *Environmental Monitoring and Mitigation Plan for Site Characterization*. December, DOE/RW-0208. Las Vegas, NV: NVO.

US Department of Energy. 1988c. *Environmental Regulatory Compliance Plan for Site Characterization*. December, DOE/RW-0209. Las Vegas, NV: NVO.

US Department of Energy. 1988d. *Draft Environmental Program Review*. December, DOE/RW-0207. Washington, DC: OCRWM.

US Department of Energy. 1988e. *Environmental Survey Preliminary Report: Nevada Test Side, Mercury, Nevada*. April, DOE/EH/OEV-15-P, Washington, DC: ES&H/OEA.

US Department of Energy. 1988f. *Environmental Survey Summary*. September, DOE/EH-0072. Washington, DC: ES&H/OEA.

US Department of Energy. 1988g. *Environment, Safety, and Health Needs of the US Department of Energy: Volume 1: Assessment of Needs*. December, DOE/EH-0079. Washington, DC: ES&H.

US General Accounting Office. 1988. *Energy Issues*. November GAO/OCG-89-16TR. Washington, DC: GAO.

US Nuclear Regulatory Commission. 1988. NEPA review procedures for geologic repositories for high-level waste: Proposed rule. *Federal Register* 53(87):16131–16147.

US Senate. 1987. *Nuclear Protection and Safety Act of 1987 (S. 1085) and Accompanying Report 100-1073 (Calendar No. 334)*. September 24, Washington, DC: 100th Congress, 1st Session.

Walker, M. L. 1987. *Statement of the US Department of Energy Assistant Secretary for Environment, Health, and Safety, M. L. Walker*. 10 February, Serial No. 100-8, p. 64–67. Washington, DC: Congressional Record, 100th Congress, 1st Session.

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ATTACHMENT B

Siting America's Geologic Repository for High-Level Nuclear Waste: Implications for Environmental Policy

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ABSTRACT / Siting a geologic repository for isolating high-level nuclear waste up to 10,000 years is a controversial undertaking never before attempted in the United States. The Nuclear Waste Policy Act of 1982 exempted repository siting from important requirements for environmental review under the National Environmental Policy Act. In December 1987, the Nuclear Waste Policy Amendments Act identified Yucca Mountain as the first site to be characterized for a high-level nuclear waste repository. In light of the unproven nature of the technology being evaluated, the scientific uncertainties associated with Yucca Mountain, and the lack of proven methods for risk evaluation, the environmental policies for repository siting represent a significant departure from more traditional, comprehensive, and interdisciplinary environmental review for siting nuclear projects. The policies warrant further study by those interested in how present as well as future decisions about complex technologies may be made.

Deciding where to locate a geologic repository for disposing of high-level nuclear wastes in the United States is a complex issue. The policy that dictates the siting program was set forth by the Nuclear Waste Policy Act of 1982 (NWPA), which subsequently was amended by the Nuclear Waste Policy Amendments Act of 1987 (NWPAA). Davenport (1986) and Frishman (1986) reviewed the intricate legal matters concerning high-level nuclear wastes, and Carter (1987) and Cooper (1988) provided accounts of the multitudinous policy-making considerations and involved history leading to the current program. Others discuss the wide range of technical issues involved in developing a repository (Roxburg 1987, Chapman and McKinley 1987) and the myriad socioeconomic considerations associated with facility siting (Colglazier 1982, Walker and others 1983). Missing from these reviews is a perspective on the normative implications of the present nuclear waste program to environmental policy. Such a perspective is important because the program has generated numerous but inadequately studied controversies regarding standards of environmental review for complex technologies.

While the issues faced by the nation in disposing of as much as 50–100 tons of commercial and defense high-level nuclear wastes by the year 2000 or shortly thereafter are of considerable importance, relatively stringent and comprehensive environmental review called forth by the National Environmental Policy Act (NEPA) has been compromised by NWPA and NWPAA of the sake of political expediency (Carter 1987, Cooper 1988, Clary and Kraft 1988). In light of what is generally perceived as the prevailing public attitude in favor of vigilant environmental protection and the contradictory eclipse of and unfulfilled potential of NEPA, it is important to be aware of how current nuclear waste policy is evolving and what its potential implications are to the future of decision making for protecting the environment (Caldwell 1983, Bartlett 1986, Renwick 1988).

KEY WORDS: Environmental policy; Nuclear wastes; National Environmental Policy Act; Nuclear Waste Policy Act; Yucca Mountain

The Repository Siting Program

Background History

A detailed history of events leading to passage of NWPA in early 1983 is provided by Carter (1987), who shows that, simply put, nuclear weapons and nuclear energy are examples of technologies that have created large quantities of wastes for which a proven and acceptable management solution does not exist. When the United States adopted nuclear technology, it was believed that reprocessing of high-level radioactive wastes would be a significant component of the management scheme ultimately adopted by the federal government. The failure of recycling as an option for waste management resulted in consideration of various alternative permanent disposal methods with the prevailing view being that disposal in deep geologic repositories was the preferred alternative. This is

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the concept that was adopted and incorporated into NWPA, which authorized the Department of Energy (DOE) to undertake a program for developing two repositories, one in the western United States and a second in the eastern portion of the nation.

Because the decision to pursue the repository solution had been evident as early as 1979 and was formally made by the president in 1980, the DOE had initiated its repository siting program in advance of passage of NWPA. In so doing, it was natural that the agency should seek sites on its own reservations that held the promise of being acceptable from the standpoint of waste containment. However, technical and advisory studies pointed to salt deposits as a preferred medium for geologic disposal and none of DOE's reservations was underlaid by salt beds or domes. For this reason DOE initiated investigations to locate suitable salt deposits in addition to undertaking studies on lands it controlled. Thus, before NWPA was conceived, DOE had identified potential repository sites: in basalt at the Hanford Reservation, Washington; in welded tuff at Yucca Mountain, Nevada, which borders the Nevada Test Site (NTS); and at seven locations underlaid by salt deposits in Louisiana, Mississippi, Texas, and Utah.

Once DOE started considering sites on land it did not control, it became clear that the agency faced significant difficulties in dealing institutionally with other federal agencies and with state governments. States often questioned the technical adequacy of sites, and they demanded a strong voice in repository decisions. Consequentially, DOE turned to congressional support for the repository siting program and worked to create national legislation for establishing siting procedures and dealing with states' rights (Carter 1987). This effort resulted in passage of NWPA, which was signed into law in early January 1983.

Environmental Review under the Nuclear Waste Policy Act

The procedures set forth in NWPA for selecting a suitable repository site were complex, intricately crafted, and reflected a delicate balance between technical and political considerations. Primacy in selecting repository sites was to be given to technical factors, even though the NWPA specified that a first repository would be located in the west and a second one in the eastern United States. This concession to regional politics and equity was essential and constituted a significant compromise to repository siting procedures. A role was also provided for state and local governments to participate in the siting process. However, this role eventually was compromised as DOE increasingly asserted its authority over states in the face of public opposition and controversy surrounding the site selection process (Carter 1987, Gervers 1987, Kraft 1988, Clary and Kraft 1988).

The NWPA contained several provisions that guided environmental review of potential repository sites, and that served to eclipse NEPA as a comprehensive policy act for environmental protection. Sections 112(f) and 114(f) limit the analysis of alternatives that normally would be addressed under NEPA. Section 112(f) represents congressional premises that: (1) a repository is needed, (2) the appropriate timing for construction of the repository is as specified in the statute, and (3) deep underground burial is the desirable means to dispose of high-level radioactive waste and spent nuclear fuel. These premises are presumably not subject to litigation (Montagne 1985). Section 114(f) states:

> "compliance with the procedures and requirements of this [Act] shall be deemed adequate consideration of the need for a repository, the time of the initial availability of a repository, and all alternatives to the isolation of high-level radioactive waste and spent nuclear fuel in a repository."

Sections 112(e) and 113(d) exempted DOE from major environmental reviews required by NEPA Sections 102(2)(c) and 102(2)(E), which require preparation of comprehensive environmental impact statements (EISs) and consideration of alternative courses of action that might involve conflicting uses of the same resources. The NWPA also exempted DOE from NEPA Section 102(2)(F), which requires recognition of the worldwide and long-range consequences of decisions. Lastly, Section 112(b)(3) required DOE to use available data for environmental assessments (EAs) rather than acquiring more empirical information needed for comprehensive evaluation of each site. An important consequence of the exemptions to NEPA is that less emphasis was given to considerations of alternative actions, which is the heart of the EIS as per Council of Environmental Quality (CEQ) regulations 40 CFR 1502.14.

The NWPA Sections 114(d) and 114(f) limit the customary role of the Nuclear Regulatory Commission (NRC) in evaluating environmental impacts for siting of nuclear facilities by restricting involvement to licensing once a construction site is selected and by requiring the agency to utilize DOE's EIS to the extent practicable. This, in effect, let DOE identify potential repository sites while being exempt from the stringent environmental regulations typically enforced by NRC in siting America's nuclear facilities.

Lastly, three western and three eastern sites were to be recommended for site characterization studies by

1985 and 1989, respectively. Consequently, NWPA defined a rapid schedule of tasks for DOE, even though the scientific community concluded that insufficient time would be available to obtain necessary scientific and technical information by established deadlines (Clary and Kraft 1988).

Narrowing the Number of Sites for Characterization

During the same time that DOE was focusing on the nine preselected sites for the first repository, it was also developing the siting guidelines and preparing the statutory EAs required by NWPA. The simultaneous development of the guidelines and the EAs assured that no undue problems with evaluating a site would arise. In accord with NWPA procedures, once the EAs were prepared for the nine sites, DOE selected three for intensive site characterization that was to involve both surface and underground investigations of geology, hydrology, and other environmental conditions. In May 1986, DOE released the EAs and announced that sites at Hanford, Yucca Mountain, and Deaf Smith County, Texas, were the choices for characterization (Department of Energy 1986a).

Because of the absence of comprehensive site-specific environmental information and the lack of completed site characterization plans for describing proposed actions, the EAs were not well received by the affected states and the public (Clary and Kraft 1988). Moreover, the DOE analysis that ranked the sites in order of suitability for repository siting revealed that DOE had not designated the top three for characterization but instead had chosen the fifth in rank (Hanford, Washington) over the second (Richton, Mississippi) (Department of Energy 1986b). This was seen as a victory for the State of Mississippi, which had vigorously opposed being a host state to a DOE repository (Carter 1987, Gervers 1987). It subsequently was learned in congressional investigations and elsewhere that DOE had shown a bias in favor of the sites associated with DOE reservations and had suppressed unfavorable environmental and geological information reflecting adversely on the Hanford and Yucca Mountain sites (US House of Representatives 1986, US General Accounting Office 1988, Johnson 1988, Crowe and others 1988, Wells and others 1988, Szymanski in press).

Additional controversies also developed during this stage of the site selection process. The DOE did not completely share information it possessed with either affected states or the public (Clary and Kraft 1988). Questions arose concerning technical considerations affecting site suitability (Carter 1987, Brown 1987a, Strolin 1987). Moreover, DOE's consultation process became controversial because of the perception that environmental review was not adequately addressed in the siting process (Kraft 1988, Clary and Kraft 1988). As a result of these perceived or real problems, initial openness to the nuclear waste program turned to opposition (Gervers 1987).

Designation of Yucca Mountain for Characterization: Questions of Technical Adequacy

Controversy and opposition to the DOE siting program resulted in political stalemate. Congress therefore concluded that the program was flawed and redirected it (Brown 1987a, Cooper 1988). Thus, in late 1987 the NWPAA was passed. The act mandated that only one repository be constructed instead of two and that Yucca Mountain be the only site to be characterized for suitability.

Issues of technical adequacy for a geologic repository at Yucca Mountain have immense consequences because of the requirement that the site be suitable for containing highly radioactive wastes for 10,000 years. Safely isolating wastes for such a period of time is a unique and ambitious undertaking never before attempted. This challenge makes geologic repository siting and development entirely different from all previously undertaken large-scale efforts. The geologic and hydrologic histories and characteristics of the host setting must be better known than any geologic area ever studied. An unprecedented demand thus is being placed upon science and technology to identify a primary geologic barrier that will protect nuclear wastes from interaction with the natural geohydrologic setting. Projections of the performance of the geologic barrier require an understanding of the interaction of the various geologic factors and processes within the natural repository setting. Geohydrologic, geochemical, thermal, and mechanical factors and processes, as well as tectonic behavior, all relate to one another. Their coupled effects on waste isolation and integrity of the repository must be clearly understood if the repository performance is to be predicted.

There is a growing body of information that is providing insights to the geologic and geophysical setting of the area (e.g., *Journal of Geophysical Research* 1987, Johnson 1988, Center for Neotectonic Studies 1988, Center for Volcanic and Tectonic Studies 1988, State of Nevada 1985). These studies concern structural relationships within a regional framework and have, among other things, delineated zones of weakness affecting the stability of the Yucca Mountain area. Ongoing research has identified six major site suitability issues for the evaluation of the site for a potential high-level nuclear waste repository:

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(1) effects of future tectonic events on site integrity,
(2) effects of future volcanism on site integrity,
(3) potential for contamination of the regional aquifer beneath the site,
(4) effects of future climatic variation on the hydrological regime and integrity of the site,
(5) the nature of moisture and gas movement through the unsaturated zone at the site, and
(6) the nature of extractable natural resources at the site and the consequent potential for future human intrusion that could compromise site integrity.

Resolving these and other issues of similar significance that will arise as more is learned about the science of siting a geologic repository will challenge the state of the art of science itself (Johnson 1988). Already, available geophysical testing technologies have been found inadequate for delineation of the subsurface and stratigraphy to the degree of refinement required. Additionally, the science of hydrology in the unsaturated zone is in its infancy, and there is little agreement regarding validation of existing and new computer modeling techniques for analysis of existing conditions and for predicting hydrologic response to other geologic processes such as tectonism and variable heat flow. Such problems become critical in view of the philosophy behind deep geologic waste disposal: that the geological system in which the repository is developed is the primary barrier for waste isolation.

Effective waste containment relies upon the known geologic and hydrologic characteristics of the site and the setting, an ability to predict how future processes and events will alter the known characteristics, and means of evaluating the risks involved. Consequently, effective waste containment requires complex but inadequately developed capabilities (Kraft 1988). The concept of performance assessment for a repository and the information needed to accomplish it involve intricate problems whose solutions are constrained by the primitive nature of risk assessment and evaluation methods (Freudenburg 1988).

There are other reasons for concern over the siting program, one of the most significant being the DOE decision to rely on the statutory EA for the Yucca Mountain site as evidence that adverse impacts are unlikely to result from site characterization (Department of Energy 1986c). Accordingly, DOE does not intend to conduct comprehensive environmental baseline investigations before the site is disturbed by characterization activities (Department of Energy 1988a). Limited monitoring for impacts once characterization is underway may occur for sensitive biota at the site, archeological resources that would be directly disturbed, total suspended particulates in the atmosphere, and limited parameters for groundwater resources at Yucca Mountain. There will be no measures of ecosystem integrity, no basis for comprehensive environmental review and evaluation, and the gaps in information existing in the EA with regards to air and water quality, land, use, soils, ecosystems, noise, and aesthetics will remain unfilled prior to site disturbance (State of Nevada 1987).

An example of the potential environmental problems that can arise as a result of inadequate information and evaluations in the statutory EA is the issue of threatened and endangered species and critical habitat at Devil's Hole and Ash Meadows in California and Nevada. The statutory EA mentions these protected resources but fails to provide any useful information into potential impacts from site characterization activities at Yucca Mountain, about 50 km to the north. During recent studies of Devil's Hole, Ash Meadows, and the associated groundwater basin, on which Yucca Mountain borders to the west, evaluation of existing information illustrated that groundwater impacts at Yucca Mountain can be expected to affect Devil's Hole and Ash Meadows (Winograd and others 1988). On the strength of such concerns, the US National Park Service filed a protest over DOE's application for water rights at Yucca Mountain (Williams 1989). This action almost certainly will bring the US Fish and Wildlife Service and the Endangered Species Act into consideration because of the number of protected species and habitats involved and the recognition of the criticality of groundwater in a basin already experiencing excessive consumption (Fish and Wildlife Service 1983, 1985). Issues such as these were not resolved by the statutory EA because it did not contain results of a more rigorous environmental review.

Discussion and Conclusions

The program for siting a geologic repository for disposing of America's high-level nuclear waste and its implementation by DOE involve a number of considerations with respect to how environmental policy should be conceived and implemented for technologically complex and controversial projects. These include issues such as the federal policy for environmental review with respect to the role of NEPA, the role of organizations and individuals in technological review, the technical adequacy of the repository program, and assessments of the risks involved.

Environmental review for the siting program was guided by several important statutory provisions of

NWPA. Extensive site-specific scientific information, based upon systematic interdisciplinary methods, was not required for each potential repository site. Sections 112(f) and 114(f) limited the discussion of the full range of alternatives that would normally be applied to the first repository under the full force of NEPA. Sections 112(e) and 113(d) exempted DOE from environmental reviews required by NEPA Sections 102(2)(C), (E), and (F). The requirement for an EIS in accord with CEQ regulation 40 CFR 1500-1508 was replaced by a NWPA-mandated statutory environmental assessment designed to evaluate siting guidelines promulgated by DOE itself (Mussler 1984). The adequacy of environmental review was also constrained by the deadlines established by NWPA (Kraft 1988).

The NWPA Section 112(b)(3) hastened preparation of the statutory EAs by requiring DOE to use available data for the assessments rather than acquiring the comprehensive, empirical information needed for evaluating each site. This meant that the siting guidelines developed and applied in the statutory EAs could not call for evaluation of criteria for which data failed to exist. If such evaluation were called for, the consequence would be that some of the nine predetermined sites would be disqualified a priori. To accommodate this situation with respect to potential environmental impacts in the absence of full scientific information, DOE equated environmental protection with the intent to comply with individual federal environmental laws. Merely by expressing the intent to comply, and without conducting full regulatory reviews, DOE was able to conclude in the statutory EAs that no significant impacts would occur as a result of site characterization activities. Because of the NEPA exemptions granted by NWPA, the ruling reached by the courts in the landmark Calvert Cliffs case stating that compliance with environmental regulations does not relieve an agency from the necessity of performing a comprehensive, integrated review of potential impacts, does not apply to the DOE position (Rogers 1977).

The NWPA also limited environmental review of the DOE siting program by the NRC. Under 10 CFR 51, the NRC typically requires strict environmental review for siting nuclear facilities, but Congress reduced NRC involvement in the siting process. By rendering CEQ and NRC regulations for NEPA review inapplicable to site characterization, NWPA assured that the statutory EAs to be prepared by DOE would be governed only by the siting guidelines subsequently to be prepared by DOE itself under 10 CFR 960.

The exemptions from NEPA review granted to repository site characterization studies by NWPA, coupled with the prohibition on new studies to provide empirical information needed for comprehensive environmental evaluation, must be assessed by those interested in the future of environmental policy. Scholars of NEPA have observed that the potential of NEPA has yet to be realized (Caldwell 1985, 1987), that the rationality embodied by NEPA is unique among environmental laws (Bartlett 1986), and that the current trend is toward an eclipse of NEPA by other laws (Renwick 1988). The eclipse of NEPA is especially of concern because it is the only legislation that calls for the systematic, interdisciplinary assessment of environmental consequences in the repository siting program. In the case of repository siting, regulations requiring NEPA review were replaced by a set of evaluative guidelines conceived by the same agency that was to follow them and with full knowledge of where the gaps in information existed that could impede the evaluation. This regulatory approach is basically one of self-regulation. Numerous studies have attributed environmental, health, and safety problems at DOE facilities to similar forms of self-regulation (US Government Accounting Office 1986, US Senate 1987, Department of Energy 1988b, National Academy of Sciences 1988).

The fact that complete environmental information was not obtained before Yucca Mountain was designated as the only site to be characterized for suitability as a repository has additional implications. Examination of the legislative history indicates that NWPAA contains the presumption that Yucca Mountain is qualified until there are adequate data that would clearly disqualify it. However, this presumption works in concert with the fact that DOE has used only existing or available data for the siting process. These guidelines, combined with the fact that alternative sites are not being characterized, do not ensure that the best or safest available site is selected. Once Congress made the decision to only characterize the Yucca Mountain site under provisions of NWPAA, no other site could be substituted without clear demonstration that Yucca Mountain is unacceptable for compelling scientific reasons (Cooper 1988). The burden of proof for determining whether Yucca Mountain is unacceptable is placed on DOE. As shown by Brown (1987b), it is difficult for the party with the burden of proof to sustain that burden if challenged by others who assert that the burden has not yet been met. In part, this difficulty is due to the fact that environmental problems are complex, and environmental assessments often are not able to predict impacts with reasonable certainty (Lemons 1986, Freudenburg 1988). The placement of the burden of proof on DOE, combined with the fact

that neither DOE nor Congress is willing to consider characterization of alternative sites at this time or in the forseeable future, increases the likelihood of a final decision being made to develop a repository at Yucca Mountain (Cooper 1988).

In terms of what policy best guides environmental review, there is the implication here that Congress was wrong to eclipse statutes and concepts embodied in NEPA and that the action may establish a precedent for future complex, controversial programs. What must be recognized is that the final decision concerning where to locate the geologic repository for high-level nuclear wastes is one of the most technically and ethically complex decisions that the nation faces. The potential consequences of a repository are far-reaching because the risk of an ultimate failure will be borne by future generations over the next 10,000 years. In the context of politics, such a vast period of time and the concept of future generations are beyond the capacity of many to understand and deal with in a meaningful way (Bishop and others 1978, Partridge 1981). Inadequacies in scientific understanding of the Yucca Mountain site due to a lack of comprehensive information thus imply unknown and unperceived risks to the distant future. Because of the complexity of the issues, the highly uncertain consequences associated with siting a geologic repository for high-level nuclear wastes, and the primitive nature of risk assessment and risk evaluation procedures, it is impractical that any individual or even one federal agency can know what constitutes the best or most acceptable consequences.

Given the fact that there is room for judgment in the face of uncertainty about repository decisions in general, and Yucca Mountain specifically, the question remains whether the best national policy is one that sets aside portions of NEPA that recognize the need for systematic, interdisciplinary review of environmental decisions. Such a policy discounts the very type of information and procedures necessary to make more open and fully informed decisions about complex technologies. Thus, it seems that a full analysis is needed of the implications of the nation's current nuclear waste policy on the future of policy making for environmental review and protection.

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Literature Cited

Bartlett, R. V. 1986. Rationality and the logic of the National Environmental Policy Act. *The Environmental Professional* 8:105–111.

Bishop, W. P., D. H. Frazier, I. R. Hoos, P. E. McGrath, F. S. Metlay, W. C. Stoneman, and R. A. Watson. 1978. Proposed goals for radioactive waste management. NUREG-0300. US Nuclear Regulatory Commission, Washington, DC. 22 pp.

Brown, G. E., Jr. 1987a. US nuclear waste policy: Flawed but feasible. *Environment* 29:6–7, 25.

Brown, D. A. 1987b. Ethics, science, and environmental regulation. *Environmental Ethics* 9:331–350.

Caldwell, L. K. 1985. NEPA's unfulfilled potential. *The Environmental Forum* 2(1):38–41.

Caldwell, L. K. 1987. The contextual basis for environmental decisionmaking: Assumptions are predeterminants of choice. *The Environmental Professional* 9:302–308.

Carter, L. J. 1987. Nuclear imperatives and public trust: Dealing with radioactive waste. Resources for the Future, Inc., Washington, DC, 473 pp.

Center for Neotectonic Studies. 1988. Evaluation of the geologic relations and seismotectonic stability of the Yucca Mountain area. October, 1988. Mackay School of Mines, University of Nevada, Reno, 156 pp.

Center for Volcanic and Tectonic Studies. 1988. Regional importance of post-6 m.y. old volcanism in the Southern Great Basin: Implications of risk assessment of volcanism at the proposed nuclear waste repository at Yucca Mountain, Nevada. September 1, 1988. Report Number 10, University of Nevada, Las Vegas, 39 pp.

Chapman, N. A., and I. G. McKinley. 1987. The geologic disposal of nuclear waste. John Wiley & Sons, New York, 280 pp.

Clary, B. B., and M. E. Kraft. 1988. Impact assessment, policy failure, and the Nuclear Waste Policy Act. 10–12 March 1988. Western Political Science Association, San Francisco, California, 35 pp.

Colglazier, E. W. 1982. The politics of nuclear waste. Pergamon Press, New York, 264 pp.

Cooper, B. 1988. Legislative redirection of the nuclear waste program. 28 February 1988. Symposium, Waste Management 1988. University of Arizona, Tucson, Arizona, 12 pp.

Crowe, B. M., F. W. Perry, B. D. Turrin, S. G. Wells, and L. D. McFadden. 1988. Volcanic hazard assessment for storage of high-level radioactive waste at Yucca Mountain, Nevada. Paper Number 6372. Page 153 *in* Abstracts with program—1988, 84th annual meeting, Cordilleran Section, Geological Society of America, 29–31 March 1988, Las Vegas, Nevada.

Davenport, J. H. 1986. The law of high-level nuclear waste. *Tennessee Law Review* 53:481–526.

Department of Energy. 1986a. Recommendation by the Secretary of Energy of candidate sites for site characterization for the first radioactive-waste repository. DOE/S-0048. US DOE, Washington, DC, 9 pp.

Department of Energy. 1986b. A multiattribute utility analysis of sites nominated for characterization for the first radioactive-waste repository: A decision-aiding methodology. DOE/RW-0074. US DOE, Washington, DC, 129 pp.

Department of Energy. 1986c. Environmental assessment:

Yucca Mountain Site. Nevada Research and Development Area, Nevada. DOE/RW-0073. US DOE, Washington, DC. 902 pp.

Department of Energy. 1988a. Environmental program overview. DOE/RW-0207. US DOE, Washington, DC. 52 pp.

Department of Energy. 1988b. Environment, safety, and health needs of the US Department of Energy, Volume I: Assessment of needs. DOE/EH-0079. US DOE, Washington, DC. 40 pp.

Fish and Wildlife Service. 1983. Determination of endangered status and critical habitats for two fish species in Ash Meadows, Nevada. *Federal Register* 48(172):40178–40186.

Fish and Wildlife Service. 1985. Determination of threatened status with critical habitat for six plants and one insect in Ash Meadows, Nevada and California and endangered status with critical habitat for one plant in Ash Meadows, Nevada and California. *Federal Register* 50(97):20777–20794.

Freudenburg, W. R. 1988. Perceived risk, real risk: Social science and the art of probabilistic risk assessment. *Science* 242:44–49.

Frishman, S. 1986. High-level waste repository siting: A state perspective. *Tennessee Law Review* 53:527–540.

Gervers, J. H. 1987. The NIMBY syndrome: Is it inevitable? *Environment* 29(8):18–20, 39–43.

Johnson, C. A. 1988. Oversight—a key ingredient in the high-level waste repository program. 4 November 1988. American Nuclear Society International Conference, Washington, DC. 5 pp.

Journal of Geophysical Research. 1987. Geophysical investigations of radioactive waste disposal sites in the western United States. *Journal of Geophysical Research* 92(B8):7783–7864.

Kraft, M. E. 1988. Evaluating technology through public participation: The nuclear waste disposal controversy. Pages 253–277 *in* M. E. Kraft and N. J. Vigs (eds.), Technology and politics. Duke University Press, Durham, North Carolina.

Lemons, J. 1986. Ecological stress phenomena and holistic environmental ethics: A viewpoint. *The International Journal of Environmental Studies* 27:9–30.

Montagne, C. H. 1985. The initial environmental assessments for the nuclear waste repository under Section 112 of the Nuclear Waste Policy Act. *Journal of Environmental Law* 4:187–229.

Mussler, R. M. 1984. Environmental assessments required to support nomination of sites. Pages 243–244 *in* Proceedings of the 1983 civilian radioactive waste management information meeting. CONF-831217, US Department of Energy, Washington, DC.

National Academy of Sciences. 1988. Safety issues at the defense production reactors: A report to the Department of Energy. National Academy Press, Washington, DC. 68 pp.

Partridge, E. (ed.). 1981. Responsibilities to future generations. Prometheus Books, Buffalo, New York.

Renwick, W. H. 1988. The eclipse of NEPA as environmental policy. *Environmental Management* 12:267–272.

Rogers, W. H., Jr. 1977. Environmental law. West Publishing Company, St. Paul, Minnesota. 281 pp.

Roxburg, I. S. 1987. Geology of high-level nuclear waste disposal: An introduction. Chapman and Hall, New York. 229 pp.

State of Nevada. 1985. Comments on the US Department of Energy Draft Environmental Assessment for the Yucca Mountain Site: Volume I. March 1985. Nuclear Waste Project Office, Carson City, Nevada. 212 pp.

State of Nevada. 1987. Environmental program planning for the proposed high-level nuclear waste repository at Yucca Mountain, Nevada. NWPO-TR-001-87. Nuclear Waste Project Office, Carson City, Nevada. 127 pp.

Strolin, J. C. 1987. Nuclear waste disposal: A national dilemma with significant implications for Nevada. *Nevada Public Affairs Review—Legislative Issues* 1:78–83.

Szymanski, J. S. Conceptual considerations of the Death Valley groundwater system with special emphasis on Yucca Mountain, Nevada. DOE/RW-0000. US Department of Energy, Las Vegas, Nevada (in press).

US General Accounting Office. 1988. Nuclear waste: DOE's handling of Hanford Reservation iodine information. GAO/RCED-88-158. US GAO, Washington, DC. 27 pp.

US House of Representatives. 1986. Staff investigations into DOE's selection of three sites for characterization as the nation's first repository for high-level radioactive waste. Subcommittee on General Oversite, Northwest Power, and Forest Management and subcommittee on Energy Conservation and Power, 99th Congress, 2nd Session, October 1986. Washington, DC.

US Senate. 1987. Nuclear Protections and Safety Act of 1987 (S. 1085) and Accompanying Report 100-1073 (Calendar Number 334). 100th Congress, 1st Session, 24 September 1987, Washington, DC. 48 pp.

Walker, C. A., L. C. Gould, and E. J. Woodhouse. 1983. Too hot to handle: Social and policy issues in the management of radioactive waste. Yale Press, New Haven, Connecticut.

Wells, S. G., L. D. McFadden, C. Renault, B. D. Turin, and B. M. Crowe. 1988. A geomorphic assessment of quaternary volcanism in the Yucca Mountain area. Paper Number 2266. Page 242 *in* Abstracts with program—1988, 84th annual meeting, Cordilleran Section, Geological Society of America, 29–31 March 1988, Las Vegas, Nevada.

Williams, O. R. 1989. Protest to water application number 52338: Filed with the Nevada State Engineer, 3 January 1989. US National Park Service, Denver, Colorado, 1 pg.

Winograd, I. J., B. J. Szabo, T. B. Coplen, and A. C. Riggs. 1988. A 250,000-year climatic record from Great Basin vein calcite: Implications for Milankovitch theory. *Science* 242:1275–1280.

ATTACHMENT C

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FRAMEWORKS FOR DECISIONS ABOUT NUCLEAR WASTE DISPOSAL

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Recent decisions have established Yucca Mountain, Nevada, as America's first characterization site for a high-level nuclear waste repository. The decision remains controversial because it generated numerous understudied and unresolved value-laden public policy issues. This paper describes several alternative frameworks for assessing decisions about nuclear waste disposal, and is intended to supplement our previous study on the Yucca Mountain repository.

KEY WORDS: Nuclear waste, environmental ethics.

INTRODUCTION

In a previous paper, we describe how America's policies for disposal of high-level commercial and defense nuclear wastes are governed by national legislation such as the National Environmental Policy Act (NEPA), the Nuclear Waste Policy Act (NWPA), and the Nuclear Waste Policy Amendments Act (NWPAA).[1] The NWPAA recently established Yucca Mountain, Nevada, as the nation's first characterization site for a high-level nuclear waste repository. In our aforementioned paper, we show how NWPA, NWPAA and decisions made by the Department of Energy (DOE) have generated controversial but understudied value-laden public policy issues.

Examples of such issues include the following: First, NEPA is considered to be one of the most important pieces of national legislation calling for protection of environmental values. The NWPA exempted the repository site selection process from important NEPA requirements. This reduced the rigor of environmental assessments, and made it appear that debates should be focused primarily on technical and economic factors rather than on more broad environmental values described in NEPA. Second, NWPA originally required open participation, consultation, and cooperation between people with different interests and values. However, many DOE decisions and Congressional actions were consistent with more narrow technological perspectives regarding repository site selection, and therefore did not sufficiently allow for public participation as mandated by NWPA.[2] In addition, DOE did not foster cooperation and consultation with Nevada nor compliance with state

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environmental regulations as required by NWPA.[3] Third, many DOE decisions were based upon scientifically inadequate environmental assessments.[2] This violated the ideals of science that call for open discussion, dialogue, and debate regarding scientific issues. Fourth, NWPAA established Yucca Mountain as the only site for characterization and therefore disregarded the concern for an equitable sharing of risks between different parts of the country as originally mandated by NWPA. Fifth, NWPAA provides compensation to Nevada for being repository host, but also imposes restrictions upon the state in order for it to receive said compensation. Nevada contends that the compensation is manipulative because of the requirement that basic and existing rights and duties be relinquished.[4] Sixth, many people distrust decisions made by government and corporate experts in the nuclear industry because of perceptions that the public has not been fully informed of risks or allowed to participate in decisionmaking, and because protection of the environment, health, and safety of people has been inadequate under existing legislation and administrative decisions.[5,6]

The Yucca Mountain siting decision remains controversial. In addition, the General Accounting Office's (GAO) recent report documents that the nation's cleanup of nuclear wastes may cost more than $130 billion.[6] In comparison, the federal government spent $160 billion last year on all domestic discretionary programs. These budgetary demands will intensify pressure to do something about the nuclear waste cleanup issue. However, a lasting solution to the nuclear waste problem requires that adequate scientific information, as well as open debate and discussion of controversial value-laden public policy issues be part of the decisionmaking process. Such a solution is not likely to be forthcoming unless frameworks for assessing public policy decisions are better understood.[5,7]

In the remainder of this article we discuss alternative perspectives and frameworks for assessing value-laden decisions about nuclear waste disposal. This paper supplements our previous paper on the Yucca Mountain siting decision, which contains an in-depth analysis of events leading to the decision and a discussion of public policy issues which it generated.[1]

FRAMEWORKS FOR MAKING DECISIONS

A fundamental dilemma surrounding nuclear wastes concerns the tension that exists between: (a) our knowledge of the long-term effects of nuclear waste, and (b) our awareness of the fact that the longevity of nuclear wastes gives rise to both scientific, political, and ethical uncertainty in our assessment of its practical consequences. Given this dilemma, what decisionmaking frameworks exist that can guide decisionmaking?

1. *Citizen Participation and Acceptability of Nuclear Waste Siting Decisions*

An important component in public policies involving siting nuclear waste repositories is the determination of risk and the level of risk that is deemed to be acceptable. Following environmental assessments that provide an indication of the probability and magnitude of environmental and public health risks, decisions are made that in effect declare a certain level of risk to be acceptable.

The nuclear waste repository issue historically has been controversial, in part, for the technical reason that although a nuclear energy program exists it cannot be considered safe in the absence of a repository, and for the political reason that a

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repository has yet to be developed. The controversy involves several fundamental perspectives that influence decisionmaking about nuclear wastes.

The technological perspective is most common in decisions about nuclear waste disposal. It is highly analytical, and includes tools such a probability theory, decision and cost-benefit analysis, systems dynamics, and econometrics. Proponents of the technological perspective hold that the technical and organizational problems of managing a problem as large and complex as nuclear wastes are enormous. They maintain that the public cannot be expected to grasp the many scientific and technical issues. Further, they perceive that fundamental differences people have about how nuclear wastes should be handled generate endless debate and controversy. The technological perspective holds that if an agency such as DOE is given responsibility to accomplish tasks according to a specific schedule, then it must be given authority to manage and guide the program. This implies that while people and state representatives with different interests may review and comment on DOE documents, they would not be brought into the actual working or decisionmaking process. Also inherent in the technological perspective is the view that DOE can correct some conflicts through public relations activities, but ultimately Congress will need to exert the federal authority over states. This is, of course, exactly what happened in the passage of NWPAA.[1]

Decisions about complex technical issues that contain value-laden questions are typically made by technical/scientific experts who have a technological perspective. Such experts analyze value-laden questions in separate fact-value terms.[8] This type of analysis results from three factors: (a) Such decisionmakers have primarily scientific/technical backgrounds and therefore do not always understand the application of moral reasoning to ethical questions, (b) Much administrative discretion exists for rule-making, and (c) A lack of conceptual clarity of relevant words/phrases for ethically based decisions exists, as for example in the NEPA statement of purpose. A consequence is that science is given the role of assessing environmental impacts and risks, and evaluation of acceptability of impacts/risks is left to the political process or whatever ethical process might exist.[9] This solution isolates questions of epistemological and methodological uncertainty from influence by environmental ethics. Doubts about the validity and authority of scientific analyses and their resolutions are left to members of the scientific/technical community, in this case DOE. For purposes of ethical analysis, what remains after internal review by DOE scientific/technical experts is usually regarded as definitive. The fact that impact/risk assessment and uncertainty arguments regarding theory and method are largely confined to the DOE scientific/technical community prevents them from being a part of broader forms of ethical and public policy arguments that may undermine the legitimacy of an information gathering and decisionmaking process controlled primarily by scientific/technical experts.

Bella *et al.* discuss the democratic perspective, which maintains that the fundamental issue of nuclear waste management is the relationship of citizenry to institutions of power.[5] Is the relationship to be based upon trust or force, cooperation or manipulation? Repository siting decisions involve issues of citizen participation, distributive justice, concepts of freedom, and centralized versus decentralized decisionmaking.[5,10] Consistent with fundamental ideals of a democratic society, what is required is that institutions of power attempt to resolve conflicts in ways that are accountable to the public trust and not dominated by these institutions themselves.

In contrast to the technological perspective, the democratic perspective strives to develop procedures to integrate science and ethics in the formulation of public policy, so that they are not dealt with as separate fact-value issues in decisionmaking.

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One approach is to demand that the general public or policy-making representatives become literate in the basic epistemological issues of evidence, uncertainty, and hypothesis, while simultaneously demanding that scientists learn to make concise, articulate defenses of why the best available evidence supports one conclusion instead of another.[8] The ethical validity of a particular decision is determined less by the particular values or goals that the decision may serve than it is by the incorporation of epistemological and ethical criteria into the decision process itself. It is the method of policy formation that is subject to moral critique, and if it is found to be adequate, then the moral justification of a particular decision consists in having been derived through valid procedures. The democratic perspective requires a high level of citizen participation in decisionmaking that is not controlled by federal agencies with a disproportionate amount of power. It also requires a relationship of trust between agencies and the public insofar as environmental protection is concerned.

The organizational and personal perspectives have been studied less than other perspectives, but are nevertheless relevant. The organizational perspective perceives technology from the point of view of affected and affecting organizations.[7] People with an organizational perspective are cognizant of parochial priorities and interests that are distinctive to his or her organizations, and tend to reinterpret information about technology in a way favorable to organizational goals. The most subtle and elusive perspective is the personal, which sees the world through the eyes of the individual, often in an intuitive manner. Technology is primarily evaluated in a way which relates individuals to the technology and its impacts.

Linstone *et al.* describe how perspectives on assessments such as nuclear waste depend on various assumptions which people have about the world and the questions they ask.[7] The researchers examine different modes of thought and paradigms for assessing decisions about technology. These include: (a) problem-solving, where an assumption exists that there is a solution to the problem; (b) cost-benefit analysis and related techniques, which search for an "optimal" solution; (c) reductionism, which assumes that subdividing and simplifying complex systems will lead to better understanding; (d) use of data and various models, which contain different assumptions about the nature of reality and hence lead to different modes of inquiry and conclusions: (e) quantitative and qualitative analysis, which defines the relationship and importance of measurables and immeasurables; (f) importance of the individual, which defines the role of the individual in the aggregrate view of things; (g) perception of time, which defines the time horizons in which different people or organizations make assessments about the future.

The differences in these modes of inquiry and paradigms are then used to classify similarities and differences between perspectives concerning, say, nuclear waste technology. Traits studied include Weltanschauung, characteristics of each perspective (e.g. product vs. process, rational vs. intuition, efficiency vs. creativity, analysis vs. experience, objective vs. subjective, etc.), preferred system of inquiry for problem-solving, and concepts of time used for assessments. Application of the different perspectives to assessments of technology such as nuclear waste can narrow the gap between models and reality in decisionmaking and therefore reduce controversy about public policy issues.

However, most assessments about nuclear waste reflect the technical perspective to the neglect of other perspectives discussed.[5,7] Accordingly, such assessments do not reflect the full benefit which could be gained by comparison with other perspectives. More importantly, few comparisions between different perspectives include consideration of an "ethical" perspective. For example, Shrader-Frechette documents how environmental assessments of nuclear power reflect a narrow technical

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and economic focus to the exclusion of important value-laden issues requiring ethical analysis.[11] We are not aware that any assessments have been made about nuclear waste disposal under NWPAA that include a comparison of ethical with other perspectives.

An ethical perspective is based upon the fact that many people believe decisions and actions should be predicated upon sound moral principles. Environmental ethicists have identified several criteria on which decisions about high-level nuclear waste storage need to be based in order for them to be more ethical and, hence, less controversial. These include principles of moral reasoning, normative ethics, and forms of rationality appropriate for environmentally-ethical decisionmaking.

The goal of moral reasoning is to develop the interest in and skills necessary for thinking carefully about questions of right and wrong, good and bad, justice and injustice, duty and obligation. As stated in Regan, requirements that should be met to make an ideal moral judgment might include the following: (1) Conceptual clarity, (2) Valid information, (3) Rationality, (4) Impartiality, and (5) Use of valid moral principles.[12]

Philosophers engaged in normative ethics attempt to go beyond the aforementioned principles of moral reasoning; they attempt to determine what moral principles are valid. While it is beyond the scope of this paper to discuss in detail theories of normative ethics, several criteria inherent in such theories include: (a) environmental compatibility, (b) utilitarianism, (c) distributive justice, (d) concepts of freedom, (e) citizen participation in decisionmaking, and (f) decentralized decisionmaking. Excellent discussions of normative ethics and environmental problems are found in Regan[12] and Attfield.[13]

2. *Congress and Nuclear Waste Policymaking*

Congress has played a major policy role on nuclear waste disposal, in funding the implementation of policy, and in overseeing policy implementation by the DOE and other federal agencies. Several criteria need to be applied to assess the role of Congress in the Yucca Mountain siting decision.

One important criteria for assessing Congressional actions is that of political legitimacy, which is a major ethical issue in the policy process. Political legitimacy usually refers to decisionmaking that is constitutional and acceptable to relevant political actors. These may be the general public, regulated groups or other actors (e.g. environmental groups or public utilities), legislators, and administrative officials. The focus is on procedural criteria that can lead to an agreed upon definition of the public interest, such as whether adequate opportunity is given for articulation of the issues, arguments by supporters and opponents of the policy, public involvement, interaction among policy actors, and consideration of technical information.

Applied to the Yucca Mountain siting decision, the question of political legitimacy allows consideration of important questions such as: (a) whether and to what extent pertinent scientific information (and uncertainty) was used, (b) whether states such as Nevada were given sufficient opportunity to express their concerns, and (c) whether the decisionmaking process itself was sufficiently open to allow a full airing of policy arguments.

Political legitimacy needs to be evaluated within different contexts of rationality to more fully assess Congressional decisions about nuclear waste siting.[14] Rationality is required for making good public policy decisions and moral judgments. Rationality is the ability to recognize the connection between different ideas, and to recognize that if some statements are true, then some other statements must be true while

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others must be false. It is in logic that rules are set forth that specify which statements follow from others, and it is because of this that a person who is rational often is said to be logical. To reach an ideal moral judgment, one must not only strive to make a judgment against a background of information and conceptual clarity, but must also explore how beliefs and facts are logically related to other things that are believed or not believed.[12]

Rationality is emphasized as a necessary trait to make ethically informed decisions. However, several forms of rationality exist which can serve as a basis for evaluation of the political legitimacy of Congressional decisions about nuclear waste disposal. It is important to understand the different forms of rationality and to make them explicit so that we can discern whether one form of rationality should have precedence over others.

Caldwell[14] and Bartlett[15] present an excellent discussion of different forms of rationality used in policy formulation and decisionmaking. Substantial rationality applies to individual decisions. Such rationality takes into account the possibilities and limitations of a given situation and reorganizes it so as to produce, increase, or preserve some good according to the goals of the particular individual. Functional rationality is characteristic of organizations that are structured to produce, increase, or preserve some good in a consistent and dependable fashion. Principles of order underlie both substantial and functional rationality. This implies that decisions are made according to principles and from organized structures which embody principles of order. Substantial and functional rationality therefore entail more than technical information, the efficient achievement of a single goal, or economic efficiency; the maximum achievement of a plurality of goals is a desired outcome.

Technological rationality refers to the systematic application of large-scale technology to most levels of human activity, including governmental and economic policies which have growth as their central aim. Technological rationality emphasizes uniformity, efficiency, impersonality, and centralized decisionmaking. Economic rationality views humans, as opposed to nature, as the basic unit of rational analysis; it also emphasizes the material welfare of humans and their mastery over nature. Economic rationality is applicable to tangible and commensurable values, but often disregards important ecosystem components with little economic value. In addition, economic rationality focuses on short-term instead of long-term benefits.

Social rationality is based on standards and principles other than efficiency, such as interpersonal relations, independence and freedom, and social action. Legal rationality refers to rationality appropriate to the fundamental rules of a society, the rationality of preventing disputes and providing solutions through a system of rules that are clear, consistent, detailed, and technical. Such rationality informs people/agencies about what resources are available to them, what persons/agencies can count on to perform actions, and what actions each person/agency must perform. Political rationality refers to decisionmaking structures in terms of order of discussion and decision. It reflects adequate provision for gathering and checking information, adequate provision for inventing and checking suggestions, and adequate procedures for combining suggestions into a decision. Lastly, ecological rationality may be thought of as pertaining to living systems which includes the relationships among human and nonhuman living systems and their environments in a holistic manner. Ecological rationality also stresses long-term benefits over short-term gains. Such rationality draws extensively from the science of ecology. However, the foundations for ecological reasoning include ethical, religious, literary, and experiential foundations as well as the scientific.[16]

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Practical consequences occur if different forms of rationality are not made explicit by decisionmakers in the decisionmaking process and if they are not fully understood by them. Rationality is an important concept in policy-making, yet many decisions are controversial because they are based on different forms of rationality. For example, economic and legal rationality often conflict with ecological rationality. Fundamentally, environmental ethics is concerned with whether and on what bases ecological rationality is said to have precedence over other forms of rationality in environmental decisionmaking.

CONCLUSION

Decisions about nuclear waste disposal are made within a context of scientific, ethical, and political uncertainty. Scientific uncertainty exists about suitability of geological sites, engineering design of repositories, and geohydrologic modelling. Ethical uncertainty exists, for example, concerning how to spatially and temporally distribute burdens created by nuclear waste disposal. There is no consensus on what perspectives about technology or decisionmaking frameworks should apply to nuclear waste disposal, and none fits the policy problems precisely. This creates uncertainty about public policy, which means that decisionmakers are, to an extent, feeling their way as they attempt to resolve a novel kind of public goods problem. The fact that most decisionmaking perspectives are imperfectly applied to nuclear waste disposal means that substantive environmental goals, uncertainty, and the use of power have a relatively more important role to play in decisions and therefore require additional study and public discourse. Although the most obvious characteristic of the different decisionmaking perspectives is that they often conflict with each other, it is through their interaction and conflict resolution that they lead to insights about the assessment of nuclear waste disposal that will not emerge otherwise.

In closing, we ask whether consideration of a perspective based upon environmental ethics can really be counted on to help guide environmental scientists and policy-makers in decisionmaking? It seems doubtful that ethical precepts can, at this time, provide decisive guidance to the environmental conscience where large, complex, multiple interest issues like nuclear waste disposal are involved. Hargrove, on the other hand, draws a hopeful conclusion from the dilemma by stating that ethics can help environmental professionals by assuring that facts and other input to decisions are brought into the open to influence policy makers.[17] The results, Hargrove believes, will be not that decisions are easier to make but that they will be made in a more honest, ethical, and straightforward manner than typically is the case and that the environmental scientist will have played a proper role in the process.

References

1. J. Lemons and C. Malone, "America's high-level nuclear waste repository: A case study of environmental science and public policy" *Int. J. Environmental Studies* (in press, 1989).
2. B. B. Clary and M. E. Kraft, "Environmental assessment, science, and policy failure: The politics of nuclear waste disposal" In: *Policy Through Impact Assessment* (ed. R. V. Barlett). In press.
3. State of Nevada, *A Role of Environmental Compliance for the State of Nevada During Site Characterization of the Proposed High-Level Nuclear Waste Repository Site at Yucca Mountain, Nevada*, NWPO-TR-008-88 (State of Nevada, Agency for Nuclear Projects, Carson City, NV, 1988).
4. R. H. Bryan, "The politics and promises of nuclear waste disposal: The view from Nevada" *Environment* 29(8), 14–17, 32–38 (1987).
5. D. A. Bella, C. D. Mosher and S. N. Calvo, "Technocracy and trust: Nuclear waste controversy" *J. Professional Issues in Engineering* 114, 27–39 (1988).

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6. US General Accounting Office, *Nuclear Health and Safety, Dealing with Problems in the Nuclear* Defense Complex Expected to Cost Over $100 Billion, GAO/RCED-88-197BR (Washington, DC, 1988).
7. H. A. Linstone, A. Meltsner, M. Adelson, A. Mysior, L. Umbdenstock, B. Clary, D. Wagner and J. Schuman, "The multiple perspective concept with applications to technology assessment and other decision areas" *Technology Forecasting and Social Change* 20, 275–325 (1981).
8. P. Thompson, "Uncertainty arguments in environmental issues" *Environmental Ethics* 8, 59–76 (1986).
9. W. D. Ruchleshaus, "Science, risk, and public perception" *Science* 221, 1026–1028 (1983).
10. R. A. Watson, *Goals for Nuclear Waste Management, NUREG-0412* (US Nuclear Regulatory Commission, Washington, DC, 1978).
11. K. S. Shrader-Frechette, "Environmental impact assessment and the fallacy of unfinished business" *Environmental Ethics* 4, 37–47 (1982).
12. T. Regan (ed.), *Earthbound* (Random House, NY, 1984).
13. R. Attfield, *The Ethics of Environmental Concern* (Columbia University Press, NY, 1983).
14. L. K. Caldwell, "The contextual basis for environmental decisionmaking: Assumptions are predeterminants of choice" *The Environmental Professional* 9, 302–308 (1987).
15. R. V. Barlett, "Rationality and the logic of the National Environmental Policy Act" *The Environmental Professional* 8, 105–111.
16. I. G. Barbour, *Technology, Environmental and Human Values* (Praeger, NY, 1980).
17. E. C. Hargrove, "The value of environmental ethics" *The Environmental Professional* 9, 289–294.

ATTACHMENT D

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STATE OF NEVADA PERSPECTIVE ON ENVIRONMENTAL PROGRAM PLANNING FOR THE YUCCA MOUNTAIN PROJECT

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Abstract. The state of Nevada is authorized by the Nuclear Waste Policy Act, as amended, to review the U.S. Department of Energy (DOE) program for siting a nuclear waste repository at Yucca Mountain, Nevada. This paper reports on the results and status of the State's environmental review program and concludes that the DOE program is deficient because it fails to include: (1) comprehensive baseline studies prior to site disturbance, (2) identification of impact avoidance criteria to guide monitoring of all components of the environment while site evaluation is being carried out, (3) assessment of cumulative impacts throughout the Yucca Mountain Project, and (4) direction under the aegis of defined resource management objectives. An alternative program developed by Nevada is presented that embodies principles of environmental resource management and other concepts reflective of accepted standards of environmental practice.

INTRODUCTION

This paper presents an approach to environmental program planning for the proposed national high-level nuclear waste (HLW) repository at Yucca Mountain, Nevada. The approach is proposed as an alternative to the environmental program identified as part of the U.S. Department of Energy (DOE) Civilian Radioactive Waste Management Program (CRWMP) (Parker *et al.*, 1990). The approach proposed here would address environmental issues effectively and better serve the substance of the National Environmental Policy Act of 1969 (NEPA) than does the DOE's program. This paper presents a framework for accomplishing that objective based on the pursuit of such a program at Yucca Mountain by the state of Nevada.

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BACKGROUND AND PURPOSE

Since 1976, the Department of Energy (DOE) has conducted preliminary technical suitability studies related to nominating a site for the HLW repository at Yucca Mountain, located about 176 kilometers (110 miles) northwest of Las Vegas, Nevada, adjacent to the Nevada Test Site (NTS). The DOE's mission was formally defined by the Nuclear Waste Policy Act of 1982 (NWPA). The NWPA identified an objective of developing mined geologic repositories for permanent deposition of commercial HLW and established a process of site selection that was to include comprehensive investigations by the DOE of site technical suitability, and protection of public health, safety, and the environment.

The history of the DOE's progress in the program is well documented. Briefly stated, the DOE first carried out preliminary technical investigations at nine potentially acceptable sites with different geologic materials and climatic conditions. In 1986, the DOE narrowed the candidates to three sites in the western United States (Washington, Texas, and Nevada), amid controversy regarding the basis of its decision (Carter, 1987). In 1987, Congress, bending to pressure to keep momentum in the slow-moving and expensive program, passed the Nuclear Waste Policy Amendments Act (NWPAA) that established only one site for site characterization—Yucca Mountain, Nevada (Carter, 1989).

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The selection of Yucca Mountain has been opposed in Nevada, both on the political basis of the selection as well as on technical, environmental, and other issues. In regard to the technical issues, the State argues that Yucca Mountain will prove unsuitable for a repository because of recognized hazards posed by potential earthquakes, volcanism, and groundwater intrusion that would compromise significantly the integrity of the repository during the 10,000 years for which the DOE must demonstrate that the waste will be isolated from the environment. Geotechnical problems with Yucca Mountain as a suitable repository site are a primary focus of Nevada's opposition to the HLW repository (Malone, 1990a and b). From an environmental perspective, the DOE Yucca Mountain Project will cause further unnecessary environmental damage. The State's review of the DOE's environmental program concluded that it is poorly conceived and weakly structured, thereby lacking the safeguards needed to minimize environmental damage. For further discussion of these issues see Cooper (1989), Loux (1989), and Power (1989). Some of the State's concerns were subsequently confirmed by the review of the Nuclear Waste Technical Review Board (NWTRB, 1990).

The DOE has been criticized in the past for not planning and carrying out a credible environmental program for site characterization at Yucca Mountain based on comprehensive, site-specific, baseline information and systematic, integrated impact analyses in accordance with the NEPA (Clary and Kraft, 1988 and 1989; Malone, 1990c). Unfortunately, the State has seen little improvement in environmental program planning at the DOE for the Yucca Mountain Project.

In a report to Congress on November 29, 1989, the DOE presented plans for restructuring the CRWMP, as it had concluded that the program cannot be effectively executed in its current form and must be restructured in order to develop a technically sound and integrated radioactive waste management system (U.S. DOE, 1989a). Environmental issues were not addressed specifically in that report; however, the significant deficiencies with regard to them warrant correction in a restructured program. For this reason, a review of significant aspects of the DOE's environmental program at Yucca Mountain is presented below. Malone (1989 and 1990c) has presented detailed discussions of the program elsewhere.

Overview of the DOE Environmental Program at Yucca Mountain

The DOE environmental program for site-characterization activities at Yucca Mountain (U.S. DOE, 1988a) consists of documents that include an overview of the environmental program (U.S. DOE, 1988b), and various reports that address plans for environmental monitoring and mitigation to be conducted during site characterization (U.S. DOE, 1988c), regulatory requirements that apply to site characterization (U.S. DOE, 1988d), reclamation (U.S. DOE, 1989b and 1990a), and field activities for acquiring environmental information to support monitoring, mitigation, compliance, and reclamation during the course of site characterization (*e.g.*, U.S. DOE, 1988e and 1990b). All documents and plans, except those addressing the field activities, are of a procedural nature, and the environmental program overview (U.S. DOE, 1988b) does not provide a comprehensive and integrated perspective on planned field investigations at Yucca Mountain. The DOE has pressed the State to issue environmental permits to initiate site characterization, even though it has failed to complete planning of all parts of its environmental program.

The DOE's failure to address environmental concerns in a systematic manner stems from its use of the 1986 statutory environmental assessment (EA), issued as the foundation of the program (U.S. DOE, 1986). The EA presented the DOE's conclusion that there would be no significant environmental impacts of site characterization. With few exceptions, the environmental data used for the EA were regional in nature, as opposed to being derived from site-specific studies; detailed comprehensive environmental investigations at Yucca Mountain remain to be carried out. Rather than incorporating a pre-site characterization environmental baseline program into the repository program, the DOE (1988b) used the results of the EA (U.S. DOE, 1986) to limit the scope of its subsequent environmental investigations to data collection that will serve the purpose of effecting "mitigation" of the impacts of the proposed site characterization activities and repository development.

If Yucca Mountain proves to be a suitable site, the DOE must prepare an environmental impact statement (EIS) prior to repository construction. The environmental studies for the repository EIS will be planned and implemented after site characterization has commenced and adverse impacts from those activities are incurred. As a result, the baseline for the EIS will not reflect cumulative impacts from past land disturbance at Yucca Mountain (*i.e.*, effects of the DOE's extensive activities from 1976-1986 related to nominating Yucca Mountain as a repository site), and as a consequence of extensive renewed siting activities during site characterization for eight or more years. There will be no comprehensive study of environmental conditions as they exist now, and no basis for restoring the site to its original condition, as required by the NWPA, as revised.

Beyond the issue of environmental impact documentation under the NEPA or the NWPA, concern remains over whether environmental objectives are being served adequately by the DOE's Yucca Mountain Project. This question addresses issues at the heart of the NEPA as the nation's comprehensive policy on the environment (Lemons *et al.*, 1989). The foundations of the problem are the DOE's focus on the procedural rather than the substantive requirements of the NEPA, and the failure of the DOE to establish meaningful environmental objectives in the program. In the Site Characterization Plan (U.S. DOE, 1988a), the response to environmental issues concerning repository construction and operation was put off until EIS scoping in October 1997 (U.S. DOE, 1989a). The

DOE has no comprehensive environmental management program based on defined goals and implementation plans for managing the environment and resources of Yucca Mountain, or for the repository program which extends disturbances into resource areas and jurisdictions far beyond the NTS. The ongoing studies to "mitigate" impacts lack direction and integration, because environmental goals have never been identified.

The DOE must realize that while it has a mandate of the NWPA to fulfill, it also must be a responsible manager of the lands under its jurisdiction, ensuring that environmental goals are observed and that they are not made subservient to repository development goals. The DOE has a poor record of environmental management on many of its sites, including the Nevada Test Site, and now must undertake extremely costly clean-up programs (U.S. DOE, 1989d).

In the absence of defined environmental objectives, a comprehensive environmental baseline, and an integrated environmental management program, the DOE will find it difficult to assess impacts in a meaningful manner and develop approaches to impact minimization and comprehensive mitigation. This shortcoming is revealed by the DOE's failure to identify meaningful significance criteria for avoiding environmental impacts, including those that assuredly could affect federally-listed rare and endangered species. The DOE, having predetermined a finding of no significant impact in the 1986 EA, refuses to officially recognize the possibility that significant impacts could result from its siting and site-characterization activities, and therefore has not identified avoidance criteria that can be objectively reviewed and applied.

Because the DOE has embarked on an environmental program that serves the objective of repository development, its approach has been to make promises about impact control without an integrated approach to either recognizing or averting impacts. The DOE's ongoing environmental field studies are intended to assist the DOE in conducting geotechnical studies at sites regardless of the sensitivities of the landscape and resources in which they occur. For example, during an April, 1990, field inspection by the NWTRB, the DOE was asked to identify the avoidance criteria by which geotechnical studies (including substantial surface disturbance) could be moved so as to prevent impacts on local populations of the threatened desert tortoise (*Gopherus agassizii*) and their habitat. The DOE staff could not provide such criteria. Moreover, DOE staff stated that they could not identify which geotechnical studies could be moved so as to avoid or minimize impacts. The DOE also intends to construct major facilities, such as for the proposed exploratory shaft, within the floodplains of large drainage courses. The hazards of drill pad wash-out and contamination of subsurface environments with surface runoff and the impacts to the ecology of the washes have been ignored in such siting decisions. From such site-characterization plans, it appears that the DOE program does not have a functional and effective means of integrating environmental impact avoidance conside ations into its activity planning process. Also, it appears th the DOE intends to site and conduct all studies proposed fc site characterization without regard to the impacts on sens tive environmental resources that would result.

In its 1990 report, the NWTRB cited significant deficiencie in the Yucca Mountain environmental program, but did n specify how the DOE might remedy those shortcoming (NWTRB, 1990). If the intended substance of the NEPA i to be realized in the CRWMP, a new approach is needed.

Basis for a Restructured Environmental Program

In late 1986, Nevada began planning its own environment program based on concepts of resource management, cumu lative impact assessment, and protection of ecological integ rity, *i.e.*, the principles that are embodied by the NEPA an concepts of sound environmental impact analysis. The State' environmental program is directed (1) to establish an inde pendent baseline investigation in order (2) to identify envi ronmental management objectives, (3) to specify impac significance criteria that can be used for monitoring th DOE's activities and the resultant effects on the environment and (4) to prepare approaches to restoration. In accordanc with the NWPA and the NWPAA, the state of Nevada i entitled to carry out oversight activities for the DOE reposi tory siting program at Yucca Mountain. Funding is provide through grants to the State authorized by Congress from th Nuclear Waste Fund, administered by the DOE.

The state of Nevada has prepared reports that: (1) point to th need for environmental oversight of the DOE project, (2 describe the concepts of reasonable and responsible environ mental planning, and (3) outline a study program for com pensating for the shortcomings of the DOE's program. Th documents include plans for environmental field studies tha finally were implemented in 1989, but later terminated whe funding to the State was severely curtailed. Much remains t be done to complete the environmental program conceive by the State, but the preliminary results are sufficient t formulate the framework of a more environmentally-sensi tive approach to site characterization than that pursued by th DOE.

ENVIRONMENTAL MANAGEMENT AND ITS APPLICATION AT YUCCA MOUNTAIN

Environmental Protection as a Fundamental Objective

Nevada believes that the DOE's site-characterization program, if properly conducted, will confirm the already existing evidence that Yucca Mountain is unsuitable for a HLW repository. Therefore, further study, and its attendant environmental disturbance, will result in unnecessary environmental impact. Nonetheless, as the DOE intends to pursu site-characterization, its environmental program should b designed not only to serve repository development goals, bu also to provide environmental review of the program independent of those goals. The alternative approach developec

by the state of Nevada embraces the concept of environmental management involving identification of environmental sensitivities, evaluation of potential site-characterization impacts and their significance in advance, avoidance of impacts to the extent practical, and mitigation of impacts *via* best management practices and site restoration.

The fundamental goal of environmental management at Yucca Mountain should be to protect the environment consistent with the resource value of the site. The primary principles of the alternative environmental management strategy are discussed below. This strategy is consistent with sound principles of environmental planning, assessment, and management (Jain *et al.*, 1982; Beanlands and Duinker, 1984; Murthy, 1988; Bartlett, 1986; Westman, 1985).

Identify Environmental Sensitivities and Constraints Prior to Further Disturbances

At present, the resource values at Yucca Mountain and vicinity remain unknown. The alternative approach implies an understanding of environmental conditions upon which an evaluation of resources can be made. A management plan then can be developed that minimizes impacts to sensitive and key components of the environment and maximizes the potential for reclamation or restoration of the environment. As the fundamental purpose of environmental management should be to maintain the integrity of the environment at Yucca Mountain while site-characterization activities are being carried out, it is necessary to evaluate Yucca Mountain's resources and environmental sensitivities, and from those identify and implement management objectives.

The first step must be to identify sensitive components of the environment and the constraints which they pose to site characterization and to reclamation. Such constraints must be observed in siting specific proposed activities. Based on known sensitive resources, it would be possible to identify potential impacts that should be avoided and conditions that may impede mitigation and reclamation. At Yucca Mountain, the environment is too little known at this time to designate key or sensitive components and to develop a sound management plan. The generic, regional information available and studies conducted for the state of Nevada suggest that the site is part of a unique ecosystem containing sensitive biota (ESA, 1990). Additionally, there are potentially significant physical environmental connections between Yucca Mountain and other unique environmental resources in the vicinity that remain undefined.

Evaluate Cumulative Impacts

Because the DOE repository siting and development program at Yucca Mountain has been, and will continue to be, accomplished in stages over several decades from the 1970s through about 2010 or later (U.S. DOE, 1986, 1988a, and 1989a), it is essential that an environmental management strategy include analysis of incremental and cumulative impacts. This is necessary for reclamation purposes, and also as a means for helping prevent changes in the environment of the site that could affect its fundamental integrity. No consideration has been given by the DOE to past impacts and it has fallen on the state of Nevada to characterize the disturbances (Winsor and Ulland, 1989; Winsor and Rousseau, 1990). The DOE's past and ongoing investigations also have focused on about a 78-square kilometer (30-square mile) area at the repository site where disturbances are concentrated. However, the DOE's proposed site-characterization studies and their impacts potentially extend over areas distant from Yucca Mountain.

For the alternative approach, cumulative impacts would be given sufficient study to ensure that a comprehensive assessment of all components and phases of the program are evaluated, and that all sites of disturbance are analyzed specifically and in combination with other sites. This means that, in contrast to the existing plan, each site-characterization activity would be planned carefully in advance and include a complete description of the activity, its precise location, its scheduling, elements that may lead to environmental alteration or hazards, and proposed means to reduce environmental impact.

Plan Site Characterization to Avoid Impacts

The DOE has not identified impact significance criteria, because the environmental sensitivities were not defined by the suspect findings of the statutory EA, and it has fragmented each environmental program element so that significant impact cannot be recognized. A reordering of priorities is needed such that site-characterization activities are planned to avoid impacts to all aspects of the environment to the extent practical, as required by the NWPA. In the alternative environmental management program, impact avoidance is given a priority position in environmental management. Avoidance is the preferred choice wherever and whenever environmental sensitivities are rated high. For example, in the case of the desert tortoise, the point of impact avoidance is to protect the individuals of a designated sensitive species and the integrity of their local habitat. An avoidance of impacts to the sensitive elements of the environment implies that impact significance criteria are identified in advance of any activity that could disturb the environment so that avoidance can be planned. Such criteria should incorporate means to identify both incremental and cumulative impacts in spatial and temporal contexts. In the case of the tortoise, criteria for determining whether a site-characterization activity should or should not be moved to avoid impacts to local populations of tortoise and their habitat should be identified.

The identification of site-specific criteria for impact avoidance is the only reasonable approach to protecting the environment from unnecessary damage. It is also the only way in which independent reviewers, such as the State, the U.S.Fish and Wildlife Service, or the National Park Service can determine whether the DOE is making an effective effort to protect the environment and significant species such as the desert tortoise and desert pupfish (*Cyprinodon diabolis*). Criteria

must be established for each element of the environment. The key environmental issue areas requiring such criteria are presented later in this paper.

Plan and Implement Mitigation and Reclamation To Preserve Ecological Integrity

In place of impact avoidance, the DOE has placed considerable emphasis on mitigation and an assumed ability to reclaim the site (U.S. DOE, 1988b). This emphasis is grounded in an optimism for reclamation success that is not shared by many experts familiar with the sensitivities of the desert environment, the extreme limitations which it imposes on mitigation efforts, and the state of the art in reclamation techniques (NAS, 1974; Box, 1976; Allen, 1988). There is scant evidence in the literature to support the DOE's claims to mitigate impacts to insignificance or to achieve its objective of establishing effective site reclamation.

The proposed management strategy must include a program for mitigation, reclamation, and site restoration in order to meet the requirements of the NWPA and NWPAA. While avoidance of impacts based on known sensitivities to disturbance is preferred, this goal cannot always be achieved. Thus, it is essential that either mitigation or reclamation and restoration measures be well-planned. Which course to pursue depends on the sensitivity and importance of the resource to be protected and the severity and extent of the impacts involved. The ultimate consequences of the impact to preservation of environmental integrity is the factor upon which decisions must rest relative to mitigation, reclamation, and restoration.

Mitigation and reclamation planning must begin with a recognition of the limited opportunity for success given the state of the art in these areas. Those limitations are based on the dearth of information about desert ecosystems in general, and at Yucca Mountain specifically, physical environment constraints (especially the limited availability of water), and the potentially high costs that may be associated with mitigation and reclamation. Those limitations provide the basis for a substantial research effort, one that is likely to require detailed onsite studies of natural conditions of vegetation, soil, hydrology, and other factors, and direct experimentation with reclamation techniques over a long period.

After some basic information is gathered about methods likely to achieve success, site-specific objectives for reclamation or restoration can be identified and plans formulated for achieving them. It is important to define realistic reclamation objectives in advance of surface disturbing activities, because these may guide the course, nature, and timing of the activities creating the disturbances.

Develop an Environmental Management Plan

The HLW program is necessarily complex, encompasses activities in a large geographic area with a variety of biophysical environments, and is extended over a long period. Additionally, the Yucca Mountain Project will continue to extend impacts into jurisdictional areas beyond the DOE's purview. A program with these qualities demands guidance under the auspices of a defined and integrated management plan. Currently, the DOE Environmental Program is an effort lacking specific environmental management objectives for the resources and land units. The Yucca Mountain Project should be guided not solely by the DOE's mission to develop a repository, but also by its stewardship mission to carry out responsible management of the NTS and to conform with land management objectives for the adjacent areas of U.S. Bureau of Land Management and U.S. Air Force land, as well as the more distant areas which potentially could be affected by the Yucca Mountain Project, *e.g.*, Death Valley National Monument.

For the alternative approach, the environmental program would be oriented to establishing specific objectives for the lands and resources that could be affected by the project, and credible means to attain them. The objectives and guidelines for implementation would be defined by the sensitivities of the resources in both their local contexts and in regard to the broader considerations of their status. The environmental management plan should serve as the aegis under which decisions about activities that may alter the environment can be made rationally and with purpose.

To prepare specific objectives and implement policies or land management guidelines, it will be necessary to synthesize a vast quantity of information about all aspects of the environment. The demand exists for information management systems capable of handling the volume and complexity of the information. The approach proposed here incorporates the concept of a centralized, controlled, environmental database readily accessible to many potential users (including all interested parties). The database includes both spatially-defined information, as well as the textual and tabular data collected over time regarding environmental variables, evaluations of environmental sensitivities, impact models, and plans for and records of disturbance activities, mitigation, reclamation, and regulatory-compliance monitoring. Remote sensing imagery interpretation for monitoring environmental change and the use of sophisticated computers of the type known as a Geographic Information System provide a primary means to accomplish the marshalling and use of large volumes of primary data from which to make cumulative impact assessments, develop environmental management plans, and assist decisionmaking about activities that potentially could cause significant environmental impacts (Winsor and Rousseau, 1990).

NEVADA'S ENVIRONMENTAL PROGRAM

The Nuclear Waste Project Office (NWPO) environmental program mission was defined after detailed evaluation of the Yucca Mountain Project found the structure, plans, and goals of the DOE's CRWMP falling short of sound environmental practice (NWPO, 1987; ESA and RCI, 1989).

The environmental program was formally set in motion in 1988. The program established eight primary goals (NWPO, 1987; ESA and RCI, 1989):

1. identify environmental management objectives and lay out a program to achieve them;

2. undertake studies to establish a baseline of environmental information at Yucca Mountain before further environmental disruption occurs;

3. use the environmental baseline to assess the impacts of the DOE's past disturbances and proposed site characterization;

4. use the preceding impact analysis to evaluate the efficacy of the preliminary impact analyses reported by the DOE in the statutory EA (U.S. DOE, 1986);

5. identify and assess federal, state, and local regulatory environmental requirements;

6. determine the scope of reclamation measures needed;

7. develop environmental monitoring and impact mitigation plans; and

8. incorporate environmental studies during site characterization or adjust the monitoring program to accommodate information needs for the EIS and the siting guidelines, once more is known about the repository design.

Management Objectives and Study Plans

The state of Nevada's primary goal is to protect the ecological integrity and biological diversity of the Yucca Mountain area to the extent practicable and commensurate with its ecological and environmental values. The immediate objective is to avoid significantly altering the natural ecosystem, and thereby compromising its environmental integrity, so that any unique characteristics and resources endemic to the area can be studied before they are altered by further impacts from site characterization. The overall principles of environmental resource management discussed previously are the framework of the program. The primary precepts of this strategy are as follows:

1) Avoidance of impact should be the primary goal; impacts that are unnecessary or which would seriously compromise attainment of environmental objectives should be prevented.

2) Mitigation implemented prior to and during disturbance to eliminate and reduce impact should be the second goal. If impacts cannot be avoided, mitigation should be identified clearly in advance of the impact. Mitigation should be viewed broadly in concept, but measures should be identified with a high degree of specificity, so as to include application of specific techniques to a given site, preparation for reclamation techniques, off-site considerations and compensation.

3) Reclamation should be regarded as a follow-up to unavoidable disturbance and impact. Reclamation should be regarded as an integrated program directed to attainment of resource management objectives. It also must be regarded as an ongoing program: initiated prior to disturbance—at which time specific reclamation needs and plans are defined, implemented immediately after impact occurs, applied continuously and monitored for success, and adapted to changes in information on potentially successful techniques.

The objectives and strategy require refinement. Too little information has been collected about the Yucca Mountain area to achieve definition of specific environmental objectives. General objectives have been identified using the regional-based information about the vegetation, wildlife, soils, hydrology and water quality, climate and air quality, noise and aesthetic environment, and cultural resources of the area (ESA and RCI, 1989). Additionally, means to identify impacts have been described using indicators of direct and indirect impacts. The refinement of the environmental management plan requires information collection in an integrated study design. A study plan has been prepared that guides the overall effort required to achieve the objectives, as well as the eight goals of the environmental program previously identified (ESA, 1989a). Investigations conducted in 1988-1989 for the State have provided the basis for some refinement of objectives keyed to observed conditions at Yucca Mountain.

Environmental Baseline of Yucca Mountain

A primary objective of the environmental program is to assess the full complement of impacts of the DOE's past siting and proposed site-characterization activities with a view toward cumulative impact assessment. To achieve this goal, it is necessary to obtain baseline information relative to: (1) the fundamental character of the resources, (2) the amount of disturbance that has occurred to date, and (3) the sensitivities of the resources to impacts. Because information of these types is critical to the completion of the other tasks, its collection has occupied the greatest portion of the work program to date. Enough information has been obtained through literature review, interpretation of remote sensing imagery, and some field investigations in the Yucca Mountain area to obtain a preliminary understanding of the environment and the sensitivities involved. Summarized here are results of studies on biota, soils, extent of existing disturbed areas, and reclamation. The plans were laid for other environmental investigations in the field. These included studies of erosion, climatology, air quality, hydrology, water quality, noise, cultural resources, and aesthetics. Because of funding limitations, these baseline studies were curtailed, but will be resumed at a later time, if possible.

Vegetation. The distribution of regional vegetation was described and mapped at the climax series level for most of a 155-square kilometer (60-square mile) area centered on Yucca Mountain. The mapping and analysis were accomplished in phases, using interpretation of remote sensing imagery, including low-altitude, large scale color stereo-paired aerial photography from 1988, high-altitude satellite spectral imagery from the American Landsat 5 Thematic Mapper satellite, and panchromatic imagery from the French SPOT satellite (Winsor and Rousseau, 1990). Onsite verification studies were conducted in two areas to which the State's environmental team was permitted access. Fifty-one permanent field sampling sites were established that represented the diversity of vegetation types in the Yucca Mountain area. Quantitative data on perennial vegetation were collected in the field (because of a persistent drought over the last few years, the growth of annuals was insufficient to warrant detailed data collection for them), and used to characterize and distinguish at least eight climax series types and 24 series-association sub-types (ESA, 1990). These findings, which are a significant refinement of previous work performed by the DOE, (O'Farrell and Collins, 1984), suggest that substantial biological diversity exists in the immediate vicinity of Yucca Mountain. The State's team also collected important information linking the vegetation types to important biophysical relationships. Such information will prove useful in carrying out sensitivity analysis, impact assessment, and reclamation planning. Two protected species considered to be of special status, the black wooly-pod (*Astragalus funereus*) and the Mojave fish-hook cactus (*Sclerocactus polyancistrus*), are known to occur in the area of Yucca Mountain.

The DOE did not conduct detailed vegetation studies at Yucca Mountain for the statutory EA (U.S. DOE, 1986); rather, it provided only small-scale mapping and characterization of five plant associations based on nine transects. The DOE relied heavily on the regional data on vegetation of the NTS for purposes of impact assessment. The State's team found that use of regional vegetation data is not well-suited for impact assessments. Similarities of the vegetation of Yucca Mountain and other parts of the NTS do not extend beyond the biome level of a vegetation classification system. The biome is too coarse a classification for identifying meaningful ecological units for impact assessment, reclamation planning, and resource management purposes. The State's large-scale mapping and more extensive primary data collection for identifying the plant associations (24, as compared to the DOE's five associations in the EA) offer far greater utility for identification of ecological relationships (such as connections to biophysical controls, identification of keystone and critical-link species, indices of biodiversity, and relationships to foodwebs and habitat requirements of wildlife), as well as for assessment of sensitivities to disturbance.

The generic, regional information available and studies conducted for the state of Nevada suggest that the site is part of a unique ecosystem limited in extent by virtue of its locatio within a transitional desert ecotone; its soils are of volcani origin, as opposed to sedimentary, like most of the surround ing area, *i.e.*, the Mojave Desert to the south, or the Gre Basin to the north (Beatley, 1980; Collins *et al.*, 1981; Mitchel 1984; ESA, 1990). Additionally, the field investigation confirm the fact that much of the area remains in near-pristin condition, a situation unusual in most of southern Nevada.

Wildlife. The State's wildlife investigations have focuse on: (1) identification of the terrestrial wildlife of the Yucc Mountain area, (2) assessments of the status of the dese tortoise and its habitat at Yucca Mountain, and (3) identific tion of the sensitivities and issues potentially affecting th unique ecological areas at nearby Ash Meadows and Devil' Hole.

The Yucca Mountain wildlife investigations to date includ field studies of mammals, reptiles, and amphibians. The fiel studies indicate the presence of small rodents typical of th Mojave and Great Basin biomes. A richer fauna is considere to be present potentially, but the severe drought appears t have affected wildlife use of the area and reduced the endemi population at the time the studies were conducted.

The desert tortoise is a species of special concern that occur at Yucca Mountain. It has been a candidate species for som time, and in 1989 was listed as threatened in Nevada an California. It is also a state-protected species in this area.

Field investigations of the tortoise were conducted on th portion of the NTS at the base of Yucca Mountain in lat summer 1989 (Karl, 1989). The investigations included firs reconnaissance surveys followed by studies on 23 stri transects to assess the distribution, habitat associations, an relative abundance of tortoises. Observations of tortoise an sign were used to yield a rough estimate of tortoise abundanc at about 3 to 19 individuals per square kilometer (10 to 50 pe square mile). The highest densities appear to occur o alluvial fans, many of which are areas in which the mos intensive disturbance from DOE site characterization is an ticipated to occur (U.S. DOE, 1988a). The data are prelimi nary, but are indicative of tortoise populations greater tha those reported by the DOE at less than seven tortoises pe square kilometer (20 per square mile) (U.S. DOE, 1986 an 1989c) and of higher density on the alluvial fans. Both th difference in tortoise abundance and distribution of estimate among the DOE's reports and the State's survey are poten tially significant for impact analysis of disturbances associ ated with site characterization. Preliminary assessment were made of habitat quality, most of which is considered t be fair.

Little actually is known about the tortoise in the Yucc Mountain area (Berry, 1984; Karl 1981, 1983, and 1989 Although the DOE has, to date, considered impacts to th tortoise to be insignificant, there are numerous unanswere

questions regarding the local populations. Key issues to be resolved include potential fragmentation of the endemic populations and their habitat. Cumulative impacts must be considered in the context of the widespread decline of the tortoise throughout much of the Mojave Desert (because of disease and other factors) and in southern Nevada in particular. There is a potential for the loss of possibly significant habitat: habitat relationships and quality remain as yet undefined and unstudied at Yucca Mountain. The sensitivity of the population and the habitat to alteration is an important consideration because the Yucca Mountain population is at the edge of the natural range of the species and presumably at the margin of its environmental tolerance. The concern is that even small changes in the environment may result in large impacts on the population. Tolerances to, and recovery rates from, natural and human-induced environmental perturbations remain unknown. Little is known about the vitality of the population—if it is growing, stable, or declining, and whether the respiratory disease that has destroyed a large portion of the tortoise population west of the Colorado River is present in the Yucca Mountain population.

There is little evidence to support the assumptions inherent in the DOE's mitigation plan (U.S. DOE, 1988c and 1989c) that tortoises can be relocated easily without inducing significant adverse effects on both the relocatees and the individuals in the relocation site. The State's desert tortoise studies, like those of the other environmental factors, indicate that there are many more questions than answers about the environment and resources of Yucca Mountain, and that assumptions of no significant impact must be regarded as premature.

The State has also investigated potential concerns regarding the relationship of the DOE's site-characterization program to the extremely sensitive resources and environment at Ash Meadows and Devil's Hole. Ash Meadows, located 40 kilometers (25 miles) south of Yucca Mountain, is a 57,500 hectare (23,000 acre) oasis of enormous biological importance. It supports more species of endemic animals and plants than any area of similar size in the United States, including at least 12 federally-listed endangered and threatened species (Hendrickson and Kubly, 1984). More than 30 springs and seeps create habitat for at least 30 animals and plants found nowhere else on earth. Devil's Hole, located near Ash Meadows, is the site of the most restricted habitat of perhaps any vertebrate in the world, the Devil's Hole pupfish. Both areas are protected, currently managed primarily by the U.S. National Park Service.

Ash Meadows and Devil's Hole are supported almost entirely by groundwater. The springs are the discharge from a groundwater basin to the north and northeast that likely includes Yucca Mountain. A potential exists for DOE activities at Yucca Mountain to affect the hydrological conditions at Ash Meadows and Devil's Hole, either through the release of contaminants or by alteration of groundwater flows. Even minor alterations of water level in Devil's Hole could destroy the entire fragile ecosystem. The DOE has yet to demonstrate that its site-characterization activities will not result in significant, irreversible, adverse impacts on Ash Meadows and Devil's Hole. A challenge to this effect has been made by the National Park Service (Williams, 1988) and must be resolved by the DOE. There is a clear need for the establishment of specific impact criteria that can form the basis of monitoring groundwater quantity and quality and defining feasible approaches to prevention of impact.

Soils. An evaluation of soils was omitted from the DOE's statutory EA (U.S. DOE, 1986), a fundamental oversight given the important relationship that soils bear to vegetation, wildlife, and hydrology in the desert. A draft study plan for soils has just been prepared by the DOE (U.S. DOE, 1990b); these studies would be undertaken after the initiation of site characterization. The State has initiated a soils investigation so that information can be provided to understand better biophysical relationships, estimate impacts, and plan for reclamation before the DOE's siting activities irreparably alter the site (RCI, 1989a). The soil survey included mapping of soil units and characterization of soil associations in a 1,820 hectare (4,500 acre) area of the NTS near Yucca Mountain. At least seven soil associations and 17 soil series were mapped at large scale in the area. Additionally, landforms were identified by genetic class and mapped. Both landforms and soils appear to bear significant relationships to vegetation in the area, and will form important controls in reclamation planning. Primary characteristics of the soils useful for impact assessment and reclamation planning were analyzed as part of the studies.

The DOE's Past Disturbances and Proposed Activities

Since 1976, DOE preliminary investigations for the repository have caused widespread disturbances of the landscape. Those disturbances have not been identified accurately by the DOE to date (U.S. DOE, 1988a). In order to obtain a better understanding of the status of the environment at Yucca Mountain, to predict future impacts, and to plan for reclamation, as required by the NWPA, the State undertook an investigation of the extent of past disturbance on and near Yucca Mountain. The investigation was accomplished largely through mapping, using interpretation of large scale stereo-paired recent photography, historic photography, and remote sensing Landsat and SPOT imagery. The results of this investigation have been published elsewhere (ESA, 1989b; Winsor and Ulland, 1989; Winsor and Rousseau, 1990).

Disturbances were categorized by 24 activity types with associated disturbance characteristics. The disturbances were mapped and tagged with an identification number and type. A total of 258 hectares (638 acres) of disturbance was measured. Assuming similar disturbance characteristics of planned site-characterization activities, an additional total 211 hectares (522 acres) would be disturbed. The disturbances vary greatly in character, from total vegetation and soil removal down to bedrock, to lesser disturbances that

probably will undergo natural revegetation over time. The disturbance assessment provided further indication of the extremely slow process of natural recovery of disturbance in the desert.

Reclamation Needs, Strategies, and Practices

The DOE must reclaim the site if it decides not to construct the repository or, in the event of repository development, to reclaim the site at the time of facility closure. Restoration of disturbed land in arid environments is highly constrained by the special limitations of the harsh climate, particularly low and variable precipitation, wind erosion of topsoil, and the need for establishment of critical soil microorganisms (Allen, 1989). Although proposed activities for site characterization and repository development are the types of disturbances typically associated with mining, successful reclamation of the site will not be achieved easily. The DOE has given scant attention to the critical limitations of the Yucca Mountain environment in site restoration and has provided minimal information about the scope or goals of its reclamation program, the types of reclamation practices it intends to employ, schedules, or other pertinent information (U.S. DOE, 1989b, 1990a). Accordingly, the State has undertaken an investigation of the overall potential and strategy for reclamation that incorporates the concept of application of best management practices (ESA, 1989a; ESA and RCI, 1989). The strategy is intended to identify objectives of reclamation, appropriate levels of effort, and guidance for establishing specific reclamation plans. That strategy is based on the recognition that local site variability has produced numerous plant communities and soil conditions, each with different potential for revegetation (ESA, 1990). Each disturbance of the vegetation and soil will have to be considered independently when formulating reclamation prescriptions. No single approach can be applied to the entire Yucca Mountain site and area. Additionally, reclamation performance standards necessarily may vary over the site in accordance with site-specific reclamation potential (RCI, 1989b).

RCI (1989b) found that previous reclamation work has been done only outside the Yucca Mountain area. Studies of native shrub species' adaptability have occurred primarily in southern California and Arizona. Species adaptability recommendations, other than for native shrubs, are derived from seeding guides and are based more on species characteristics than on actual field trials. Little or no soils information on previous study sites has been documented, and the studies of soil stabilization, site preparation, mulching, and fertilization conducted mostly at mining sites in southern California are site-specific case studies. Therefore, it is difficult to extrapolate results of the past out-of-area studies of reclamation to specific sites at Yucca Mountain. Additionally, many reclamation studies reported in the literature were of short term and conducted at an applied level of research with little understanding of why a response occurred. As a result, the reported reclamation recommendations were based on trial-and-error approaches with little understanding of the underlying mechanisms that would allow extrapolation to othe sites like Yucca Mountain. Scientific research of desert so and vegetation interrelationships is in its infancy. It appear that much of the desert vegetation is distributed in "fertil islands" related to sensitive vegetation/soil interdepender cies. An understanding of these interrelationships and sen sitivities is critical to establishing elements in reclamatio requirements, such as the important work on reestablishmer of mycorrhizal fungi in the soil to improve reestablishment o some desert shrubs (*e.g.*, Allen, 1989).

The disturbance assessments reported earlier were used t estimate the potential costs of reclamation of the past dis turbances. Field inspections were made to assess the scop and anticipated problems for planning reclamation efforts The cost estimates range from five million to 23 millior dollars, depending on the level of effort and goals for recla mation of the site (ESA and RCI, 1989). Reclamation cost for proposed site-characterization activities are not known because many of the DOE's plans are not fully conceived o sited. Much potential damage from site characterization could be avoided by a better-planned program in which impact avoidance is given higher priority. Where environmental disturbance is necessary, many established best management practices can be used to minimize soil and vegetation damage, promote reclamation, and thereby reduce reclamation needs. For example, many fertile islands can be left intact without compromising the intended grading design, and track equipment could be used on many roads instead of blading, so as to reduce damage to the vegetation and to maintain an indigenous onsite seed source for revegetation. By such practices, revegetation can be promoted by both natural processes, in conjunction with supplemental planting.

The State's objective for reclamation is to encourage reestablishment of the ecological integrity of the site at conditions approximating those before the DOE initiated its studies for nominating Yucca Mountain as a repository site. The strategy is based on the integration of reclamation considerations into all activity phases including the periods prior to disturbance, during the disturbance activity, and following abandonment of a specific site. Reclamation should be oriented to development of sound and integrated planning and implementation. Overall and site-specific reclamation objectives should be defined in advance of disturbance activities and specific practices; responsibilities and schedules should be identified for each phase of reclamation activity. A monitoring program also is a critical element of the State's reclamation strategy.

FUTURE PROGRAM DIRECTIONS

The concept of the environmental management program envisioned by the State and summarized in this paper can be realized if efforts are continued in a number of key areas discussed below. Continued primary data collection in a field-based program is essential to other aspects of environmental management planning. The State's environmental

team was able to conduct only limited baseline studies in the field. The baseline studies of vegetation, wildlife, special status species, and soils should be continued and expanded onto Yucca Mountain and into the surrounding region (RCI, 1989a; ESA, 1990). Seasonal investigations of terrestrial ecology are needed to understand better biophysical relationships and sensitivities of the environment to disturbances. The baseline studies should be expanded over several years to capture a broader range in environmental conditions: the 1989 field studies were conducted in the third year of a drought.

Studies of the desert tortoise require considerable expansion in scope and geography, and should be conducted over extended periods (Karl, 1989). As noted, there are many questions that need to be resolved before the DOE undertakes a program of tortoise relocation and habitat destruction in conjunction with site characterization. Studies of vegetation must be integrated into the habitat quality evaluations for tortoise impact assessments.

The baseline studies must also be expanded to encompass the full range of environmental factors presented in the State's Environmental Studies Plan (ESA, 1989a). Studies postponed due to funding limitations should be initiated, including climatology, air quality, hydrology, erosion, water quality, noise, cultural resources, and visual/aesthetics. These studies are needed because: (1) impacts of site characterization are anticipated to affect the resources in question, (2) they are critical to understanding biophysical relationships of the Yucca Mountain ecosystem, and (3) they are not being addressed adequately by the DOE (NWPO, 1987 and 1988; Winsor and Ulland, 1989; Malone, 1990c). Integration of the findings of sophisticated hydrological models are needed to assess the potential for significant effects of site characterization at Ash Meadows and Devil's Hole. Also of great importance are the proposed studies for establishing reclamation procedures (RCI, 1989b).

In conjunction with the baseline studies, a complete evaluation of environmental sensitivities is required. Preliminary assessments of sensitivities have been established, at least at the level of identifying key environmental concerns and generic sources of impacts from human disturbances. More comprehensive assessments are needed of biophysical relationships, environmental responses to disturbance stimuli, and constraints posed by the natural environment of Yucca Mountain. These are needed both in a site-specific context as well as for general and cumulative matrices. Analyses of these types set the stage for definition of useful impact significance criteria.

The State's objective in impact assessment is to establish meaningful impact analyses using predetermined impact significance criteria. To achieve this, further investigation in two areas is required. First, impact models must be constructed to predict the effects of each disturbance type associated with a site-characterization activity. These should be based on observed, and preferably measured, effects of past disturbances at Yucca Mountain and generic effects of new planned activities by the DOE. The models should incorporate both direct and indirect effects that can be used to define thresholds of significance. Second, impact indicators must be identified in advance of disturbance activities so that impacts can be recognized through monitoring efforts. Preliminary identification of impact indicators has been made using generic criteria (ESA and RCI, 1989); these require refinement and integration into the impact models.

Continued investigations of best management practices as applied to the specific environment of Yucca Mountain are needed. The preliminary work previously described indicates that much information is lacking about reclamation practices and their potential for success. Most literature on reclamation in desert environments indicates that soil reestablishment and revegetation are extremely slow processes under natural conditions, and that proactive reclamation is a labor intensive and expensive process that often has met with limited success (RCI, 1989b). For these reasons, further research is needed regarding which reclamation practices are likely to succeed at Yucca Mountain. Active tests of reclamation techniques are needed in the Yucca Mountain environment. Similarly, further information is required regarding other mitigation measures and their potential for success at Yucca Mountain, *e.g.*, dust control, noise and vibration control, and cultural resource recovery requirements.

In its independent role, the State intends to monitor fully all DOE activities during site characterization. A full monitoring program consistent with the objectives, approaches, and constraints recognized by Duinker (1989) should include use of remote sensing methods and field studies to detect environmental change, pre-disturbance site assessments, ongoing measurements of environmental effects of disturbance-generating activities, ongoing monitoring of mitigation and reclamation efforts, and compliance monitoring. The development of an integrated, centralized database is essential for this purpose, particularly use of a Geographic Information System (Winsor and Rousseau, 1990).

CONCLUSIONS

Nevada questions the necessity of further environmental disturbance at Yucca Mountain and has significant concerns about the environment that are not being addressed effectively by the DOE. The deficiencies in the DOE environmental program will undermine the credibility and success of the EIS that must be prepared for repository construction. Additionally, those deficiencies will pose potentially critical limitations to the reclamation program that ultimately must be pursued at Yucca Mountain. Even more important to national nuclear waste policy, shortcomings in the DOE environmental program jeopardize the efficacy of the repository program by calling into question the soundness of fundamental analyses of the ability of a geologic repository at Yucca Mountain to

perform as intended and protect the environment for at least 10,000 years. The DOE must recognize the Yucca Mountain Project for the unique, first-ever effort that it is, and not approach repository siting as a routine construction project.

Another important issue raised by the NWPA, NWPAA, and the choice of Yucca Mountain as the sole site for consideration for a geologic repository involves reclamation potential. National policy rightly calls for reclamation of a site following environmental disturbance as a result of characterization and repository development. Yet in the case of the Yucca Mountain site, where harsh desert conditions prevail, it is questionable that the environment is sufficiently permissive for reclamation goals to be met. This is due to the lack of effective site reclamation methodologies for arid regions like those of the Transition Desert (Wallace *et al.*, 1980; RCI, 1989b). Because of this, the wisdom of pursuing repository siting in an area where reclamation goals are unlikely to be achieved must be called into question. For this reason, the proposed restructuring of the national nuclear waste repository program (U.S. DOE, 1989a) must include consideration of the reclamation issue and the need for considering alternative siting measures more in line with meeting reclamation goals than likely can be attained at the Yucca Mountain site. This is another instance where environmental limitations and the lack of adequate scientific knowledge and technical methodologies to overcome them must be considered in establishing national policies such as those embodied in the NWPA and the NWPAA (Malone, 1990a and 1990b). At the very least, a reordering of priorities is needed for the Yucca Mountain Project, such that impact avoidance is given a higher degree of importance in planning and conducting site characterization.

The DOE's proposed restructuring of the CRWMP presents an opportunity for effecting a significant alteration in its approach to environmental analysis and resource management at Yucca Mountain (U.S. DOE, 1989a). It is time that the DOE develop an environmental management program that is in line with current concepts of environmental planning and management for federal lands. In recent years, some federal agencies with stewardship responsibility for publicly-owned lands have made significant strides in developing environmental management plans with clearly drawn objectives for resource management, by implementing plans and policies, and by establishing protocols for minimizing adverse impacts to the environment. It is hoped that the DOE will rethink carefully its strategy about environmental management for the CRWMP and incorporate an environmental ethic that responds to the substance of the NEPA as the nation's comprehensive policy on environmental quality. The alternative environmental management program proposed here offers the framework for this long-needed fresh approach to the environment for the nuclear waste repository project at Yucca Mountain.

REFERENCES

Allen, E.B. 1988. The Reconstruction of Disturbed Arid Lands: Ecological Approach. Westview Press, Inc., Boulder, CO.

Allen, E.B. 1989. The Restoration of Disturbed Arid Landsca with Special Reference to Mycorrhizal Fungi. *Journal of A Environments* 17: 279-286.

Bartlett, R.V. 1986. Rationality and the Logic of the Natic Environmental Policy Act. *The Environmental Professiona* 105-111.

Beanlands, G.E., and P.N. Duinker. 1984. An Ecological Fra work for Environmental Impact Assessment. *Journal of E ronmental Management* 18: 267-277.

Beatley, J.C. 1980. Fluctuations and Stability in Climax Shrub Woodland Vegetation of the Mojave, Great Basin, and Transit Deserts of Southern Nevada. *Israel Journal of Botany* 28: 1 168.

Berry, K. 1984. The Status of the Desert Tortoise (*Gopherus agass* in the United States. Order No. 11310-0083-81. Report to U.S. Fish and Wildlife Service from the Desert Tortoise Coun Portland, OR.

Box, T.W. 1976. The Significance and Responsibility of Rehab tating Drastically Disturbed Lands. In *Reclamation of Dra cally Disturbed Lands*, F.W. Schaller and P. Sutton, eds. Am can Society of Agronomy, Crop Science Society of America, S Science Society of America, Madison, WI, pp. 1-10.

Carter, L.J. 1987. *Nuclear Imperatives and Public Trust: Deal with Radioactive Waste*. Resources for the Future, Washingt DC.

Carter, L.J. 1989. Nuclear Waste Policy and Politics. *Forum Applied Research and Public Policy* 4 (3): 5-18.

Clary, B.B., and M.E. Kraft. 1988. Impact Assessment and Poli Failure: The Nuclear Waste Policy Act of 1982. *Policy Stud Review* 8: 105-115.

Clary, B.B., and M.E. Kraft. 1989. Environmental Assessme Science, and Policy Failure: The Politics of Nuclear Wa Disposal. In *Policy Through Impact Assessment: Institution ized Analysis as a Policy Strategy*, R.V. Bartlett, ed. Greenwo Press, New York, pp. 51-62.

Collins, E., T.P. O'Farrell, and W.A. Rhoads. 1981. Annotat Bibliography for Biological Overview for the Nevada Nucle Waste Storage Investigations, Nevada Test Site, Nye Coun Nevada. EGG 1183-2419. EG&G Energy Measurements, Sar Barbara Operations, Goleta, CA.

Cooper, B.S. 1989. Focus Shifts from Capitol to Nevada. *Forum Applied Research and Public Policy* 4 (3): 26-28.

Duinker, P.N. 1989. Ecological Effects Monitoring in Environme tal Impact Assessment: What Can It Accomplish? *Environmen Management* 13: 797-805.

(ESA) Environmental Science Associates, Inc. 1989a. Neva Environmental Studies Program. San Francisco, CA.

(ESA) Environmental Science Associates, Inc. 1989b. Impact A sistance Report: Inventory of Past DOE Land Disturbance, Yuc Mountain, Nevada, and Estimated General Reclamation Cos San Francisco.

(ESA) Environmental Science Associates, Inc. 1990. Vegetati Studies at Yucca Mountain, Nye County, Nevada. San Francisc

(ESA and RCI) Environmental Science Associates, Inc., and R source Concepts, Inc. 1989. Environmental Management O jectives, Impact Potential and Reclamation Planning for DC Site Characterization at Yucca Mountain, Nevada. San Francisc

Hendrickson, D.A., and D.M. Kubly. 1984. Desert Waters: Pa Present, and Future. *The Nature Conservancy News* 34 (5): 6-2

Iain, R.K., L.V. Urban, and G.S. Stacey. 1981. *Environmental Impact Analysis: A New Dimension in Decision Making*. Van Nostrand Reinhold Co., New York.

Karl, A. 1981. The Distribution and Relative Densities of the Desert Tortoise, *Gopherus agassizii*, in Lincoln and Nye Counties, Nevada. U.S. Department of the Interior, Bureau of Land Management, Contract No. YA-512-CT9-90.

Karl, A. 1983. The Distribution, Relative Densities and Habitat Associations of the Desert Tortoise, *Gopherus agassizii*, in Nevada. M.S. Thesis. California State University, Northridge. 111pp.

Karl, A. 1989. Yucca Mountain Project: Investigations of Desert Tortoise Abundance and Distribution on the Focused Baseline Study Area, Fall 1989 Field Studies. Prepared for Environmental Science Associates, Inc. San Francisco.

Lemons, J., C. Malone, and B. Piasecki. 1989. America's High Level Nuclear Waste Repository: A Case Study of Environmental Science and Public Policy. *International Journal of Environmental Studies* 34: 25-42.

Loux, R.R. 1989. A View on Siting Issue from Nevada. *Forum for Applied Research and Public Policy* 4 (3): 29-31.

Malone, C.R. 1989. Environmental Review and Regulation for Siting a Nuclear Waste Repository at Yucca Mountain, Nevada. *Environmental Impact Assessment Review* 9: 77-95.

Malone, C.R. 1990a. The Yucca Mountain Project: Storage Problems of High-Level Radioactive Wastes. *Environmental Science and Technology* 23: 1452-1453.

Malone, C.R. 1990b. Geologic and Hydrologic Issues Related to Siting a Repository for High-Level Nuclear Waste at Yucca Mountain, Nevada, U.S.A. *Journal of Environmental Management* 30: 381-396.

Malone, C.R. 1990c. Environmental Planning for Siting a High-Level Nuclear Waste Repository at Yucca Mountain, Nevada. *Environmental Management* 14: 25-32.

Mitchell, D.L. 1984. Evaluation of Habitat Restoration Needs at Yucca Mountain, Nevada Test Site, Nye County, Nevada. EGG 10282-2030. EG&G Energy Measurements, Santa Barbara Operations, Goleta, CA.

Murthy, D.S. 1988. *National Environmental Policy Act (NEPA) Policy*. CRC Press, Boca Raton, FL.

(NAS) National Academy of Sciences. 1974. *Rehabilitation of Western Coal Lands*. J.B. Lippincott, Cambridge, MA.

(NWPO) Nuclear Waste Project Office. 1987. Environmental Program Planning for the Proposed High-Level Nuclear Waste Repository at Yucca Mountain, Nevada. NWPO-TR-001-87. State of Nevada, Agency for Nuclear Projects. Carson City.

(NWPO) Nuclear Waste Project Office. 1988. A Role in Environmental Compliance for the State of Nevada During Site Characterization of the Proposed High-Level Nuclear Waste Repository at Yucca Mountain, Nevada. NWPO-TR-008-88. State of Nevada, Agency for Nuclear Projects. Carson City.

(NWTRB) Nuclear Waste Technical Review Board. 1990. First Report to the U.S. Congress and the U.S. Secretary of Energy. Washington, DC.

O'Farrell, T.P., and E. Collins. 1984. 1983 Biotic Studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. EGG 10282-2031s764-R. EG&G Energy Measurements, Santa Barbara, CA.

Parker, G.J., J.R. Krummel, K.E. LaGory, G.J. Marmer, and S.P. Goel. 1990. The Environmental Protection Program for Site Characterization at Yucca Mountain, Nevada. *The Environmental Professional* 12: 186-196.

Power, M.S. 1989. Politics and Science in Siting Battle. *Forum for Applied Research and Public Policy* 4 (3): 19-25.

(RCI) Resource Concepts, Inc. 1989a. Soil Survey of Yucca Mountain Study Area, Nye County Nevada. Prepared by Bruce Kenny, registered soil scientist. Carson City, NV.

(RCI) Resource Concepts, Inc. 1989b. Review of Revegetation Practices Appropriate for Reclamation of the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada. Carson City, NV.

(U.S. DOE) U.S. Department of Energy. 1986. Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada. DOE/RW-0073. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988a. Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada. DOE/RW-0199. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988b. Environmental Program Overview. DOE/RW-0207. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988c. Environmental Monitoring and Mitigation Plan for Site Characterization. DOE/RW-0208. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988d. Environmental Regulatory Compliance Plan for Site Characterization. DOE/RW-0209. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988e. Environmental Field Activity Plan for Terrestrial Ecosystems. DOE/NV-10576-14. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1989a. Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program. DOE/RW-0247, November 29. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1989b. Draft Reclamation Program Plan for Site Characterization. DOE/RW-0244. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1989c. Biological Assessment of the Effects of Site Characterization Activities on the Endangered Desert Tortoise. Las Vegas. October.

(U.S. DOE) U.S. Department of Energy. 1989d. Environmental Restoration and Waste Management: Five-Year Plan. DOE/S-0070. Washington DC.

(U.S. DOE) U.S. Department of Energy. 1990a. Draft Reclamation Feasibility Plan. DOE/YMP-90-10. Nevada Operations Office/Yucca Mountain Project Office. Las Vegas.

(U.S. DOE) U.S. Department of Energy. 1990b. Draft Environmental Field Activity Plan for Soils. DOE/YMP-90-11. Nevada Operations Office/Yucca Mountain Project Office. Las Vegas.

Wallace, A., E. Romney, and R. Hunter. 1980. The Challenge of a Desert: Revegetation on Disturbed Desert Lands. In *Soil-Plant-Animal Relationships Bearing on Revegetation and Land Reclamation in Nevada Deserts. Great Basin Naturalist Memoirs No. 4*. Brigham Young University, Provo, UT, pp. 216-55.

Westman, W.E. 1985. *Ecology, Impact Assessment, and Environmental Planning*. John Wiley and Sons, New York.

Williams, O.R. 1988. Protest to U.S. DOE Water Rights Application No. 52338 with the Nevada State Engineer. U.S. National Park Service, Fort Collins, CO. December 30.

Winsor, M.F., and D. Rousseau. 1990. Applications of a Geographic Information System and Remote Sensing in Assessing Superficial Environmental Impacts of Siting and Site Characterization for a Proposed High Level Nuclear Waste Repository at Yucca Mountain, Nevada. In *Proceedings, The Scientific Challenges of NEPA: Future Directions Based on 20 Years of Experience. Ninth Oak Ridge National Laboratory Life Sciences Symposium, Knoxville, Tennessee, October 24-27, 1989* (in press).

Winsor, M.F., and L. Ulland. 1989. An Evaluation of Environmental Effects of the DOE HLW Repository Siting and Characterization Program at Yucca Mountain, Nevada. In *Proceedings, Waste Management '89* 1: 559-564.

ATTACHMENT E

EIS001887

Implications of Environmental Program Planning for Siting a Nuclear Waste Repository at Yucca Mountain, Nevada, USA

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ABSTRACT / The US Department of Energy (DOE) plans to conduct site characterization studies at Yucca Mountain, Nevada, to determine if the location is a suitable site for a nuclear waste repository. In lieu of traditional environmental review in accordance with the National Environmental Policy Act of 1969, the DOE is relying on an environmental assessment (EA) mandated by the Nuclear Waste Policy Act of 1982 as the cornerstone of its environmental program for the Yucca Mountain Project. Because of statutory restrictions, the EA is not based on comprehensive baseline information. Neither does it address fundamentals of environmental analysis such as ecological integrity and assessment of cumulative impacts. Consequently, the present environmental program for Yucca Mountain reflects decisions made without complete information and integrated environmental review. The shortcomings of the program risk compromising the natural integrity of Yucca Mountain and invalidating future assessment of the ability of a nuclear waste repository located at the site to protect the environment. Significant improvements are needed in the repository siting program before it can serve as a model of how society can evaluate the long-term environmental consequences of advanced technologies, as has been suggested.

Disposal of highly radioactive waste from nuclear power plants and production of nuclear weapons in deep geologic repositories in the United States is mandated by the Nuclear Waste Policy Act of 1982 (NWPA). The NWPA directed the US Department of Energy (DOE) to conduct geologic and hydrologic site characterization studies at three candidate sites to establish the suitability of the sites for location of a repository. Difficulties encountered by the DOE in implementing environmental provisions of the NWPA resulted in a failure of the national nuclear waste policy (Clary and Kraft 1988, Lemons and others 1989) and led to passage of the Nuclear Waste Policy Amendments Act of 1987 (NWPAA). The NWPAA reformulated national policy and mandated that the DOE consider only the Yucca Mountain site in southwestern Nevada as a potential location for a repository. [Favorable qualities of the Yucca Mountain site have been discussed by the DOE (US DOE 1986).] The amendment of NWPA thus presents an opportunity for the DOE to modify its approach to repository siting to bring about a more successful nuclear waste disposal program than was the case prior to 1987. Clary and Kraft (1988) point out that whether or not this occurs depends on DOE's capacity to learn from experience and to devise appropriate strategies. Procedural aspects of the post-1987 environmental policy for the repository siting project at Yucca Mountain have been described (Lemons and Malone 1989, Malone 1989), thereby setting the stage for a review and analysis of the substance of the post-1987 DOE environmental program.

KEY WORDS: Environmental analysis; Repository siting; Yucca Mountain

An important issue related to the success of the Yucca Mountain environmental program is the suggestion that the high-level nuclear waste issue may serve as a model for how society deals with the consequences of new technologies that have the potential for threatening the environment for thousands of years (National Board for Spent Nuclear Fuel 1988). This issue compliments recent discussion regarding how society can avert environmental problems that have the potential for threatening the future (DeYoung and Kaplan 1988). The Yucca Mountain Project is relevant in this context because a nuclear waste repository must be demonstrated capable of isolating radionuclides from the environment for at least 10,000 years (US Environmental Protection Agency 1985, Egan and Clark 1989). Assessing whether or not a sealed and abandoned geologic repository will protect the environment for thousands of years is a complex problem beyond the scope of this article. The issue is steeped in uncertainty and subjectivity that must be addressed by performance assessment methodologies that have yet to be developed and that will be based more on probabilistic approaches than on deterministic ones (Lieberman and Lee 1986, Buxton 1989). However, the impacts of geologic and hydrologic site characterization activities cannot be separated easily from the long-term environmental behavior of a

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repository system because information on the natural setting gathered during the siting phase ultimately will be used to assess the long-term environmental fate of radionuclides. The efficacy of repository performance assessment could depend on the cumulative impacts resulting from activities carried out in the course of detailed site characterization, i.e., determining the suitability of the site for a repository. Thus, in the context of a nuclear waste repository, the concept of performance assessment largely is analogous to the environmental concept of cumulative impact assessment that is a fundamental cornerstone of US environmental policy (Westman 1985, Bartlett 1986, Caldwell 1988). These issues are addressed below by reviewing the substance of the DOE environmental program plans for site characterization of Yucca Mountain in the context of some current views on environmental impact analysis.

DOE Environmental Program from 1982 to 1987

In order to analyze and evaluate the current DOE environmental program for siting a nuclear waste repository at Yucca Mountain, it is necessary to understand the program since the enactment of the NWPA in early 1983. This departure point is significant because NWPA contains provisions that exempt repository siting activities from preparing an environmental impact statement pursuant to compliance with the National Environmental Policy Act (NEPA) of 1969. This issue is seen as the root of the procedural difficulties with the Yucca Mountain environmental program (Lemons and Malone 1989, Malone 1989). As documented by Clary and Kraft (1988), the DOE prepared environmental assessments (EAs) for potential repository sites as directed by NWPA. However, the resulting poor technical quality of the documents was the underlying cause for the policy failure of NWPA and the passage of NWPAA in 1987. To determine whether the current approach being taken by the DOE for the Yucca Mountain Project stands to achieve the outcome desired by NWPAA (Clary and Kraft 1988), it is helpful to review the statutory EA for the Yucca Mountain site (US DOE 1986).

In accordance with the NWPA, the Yucca Mountain statutory EA (US DOE 1986) was prepared based on available regional information. No new studies were undertaken to provide comprehensive, site-specific environmental insights. Another limitation was that only preliminary descriptions of the proposed site characterization activities at Yucca Mountain were available for preparation of the NWPA statutory EA. When the document was issued, the DOE (US DOE 1986) stated that as a result of the lack of complete information on baseline environmental conditions at the site and on the proposed action, the results should be considered preliminary. An indication of the extent of uncertainty that characterized the NWPA statutory EA for the Yucca Mountain site can be gained from Table 1 by comparing the description of the proposed action used for impact analysis with the site characterization activities currently planned. For example, the statutory EA stated that there are to be 20 drill holes, whereas the current plans (US DOE 1988d) reveal that up to 400 holes may be drilled or cored. Additional shortcomings of the NWPA statutory EA from the perspective of environmental analysis include the following:

1. No mention was made of environmental impacts associated with disturbance to soils, and no ecological information existed with respect to soils at Yucca Mountain.
2. There were no data on air quality and meteorological conditions at the site.
3. No groundwater quality information was presented.
4. No consideration was given to impacts from noise.
5. No information existed on visual resources and potential impacts from the repository program.
6. Without any basis in empiricism or deterministic analysis, the EA concluded there would be no significant environmental impacts from site characterization.
7. Without any regulatory analysis, the EA concluded that all applicable environmental requirements can be met during site characterization.

Clearly the NWPA statutory EA for the Yucca Mountain site was not suited for purposes of rigorous environmental review, evaluation, and planning in the traditional sense of NEPA (Lemons and Malone 1989, Malone 1989). Clary and Kraft (1988) concluded that the failure of the DOE to carry out systematic and objective surveys and impact analyses, to adopt credible methodologies and analytical procedures, and to defend the findings of minimal environmental consequences resulted in the DOE not achieving its goals under the NWPA. The roots of this failure have been attributed to the NEPA exemptions granted by the NWPA to repository siting activities and the prohibition on acquisition of complete information on environmental conditions at sites like Yucca Mountain (Lemons and Malone 1989, Malone 1989). As a consequence, the DOE did not carry out environmental impact analysis in accordance with traditional NEPA standards and guidelines. In light of the complex, controversial nature of the nuclear waste issue, this

Table 1. Surface-disturbing siting activities for the Yucca Mountain Project

Activity	Described in EA (DOE 1986)	Carried out before 1987 (DOE 1988d)	Planned for after 1987 (DOE 1988d)
Drill holes (N)	20	216	350–400
Trenches (N)	Unspecified	64	25–30
Hydraulic pavements (N)	Not included	6	2
Seismic surveys (km)	80	Unknown	150–240
Infiltration plots and ponds (N)	Not included	Unknown	87
Exploratory shaft facilities (ha)	8	8	13
Access roads (km)	160	190	40–50
Area disturbed (ha)	280–320	370	200–320

shortcoming must be viewed as a major error in decision making and policy that NEPA was meant to avoid.

In addition to understanding the background to the statutory EA, it is useful to consider the environmental regulatory requirements that apply to repository site characterization activities at Yucca Mountain. The planned activities are to be carried out over a period of five to seven years and will be in addition to similar activities that were conducted prior to 1986 when siting was halted pending preparation of site characterization plans (Table 1). In large part the regulatory requirements that apply to the Yucca Mountain Project (Malone 1989) set the framework for the DOE environmental program. The most notable of the environmental requirements are those contained in NWPA (Table 2) that have been at the root of decisions made by DOE with respect to environmental review for site characterization. As a consequence of the partial NEPA exemptions, it is DOE policy that the NWPA statutory EAs were program-specific decision documents that bear no relation to the requirements of the NEPA. Because an environmental impact statement is not required for site characterization, the DOE has no plans for evaluating impacts that could occur as a result of site characterization and errors reflected in the NWPA statutory EA for Yucca Mountain risk being perpetuated during site characterization. Federal and state environmental regulations that apply to the project also influence the environmental program, but none of these require comprehensive environmental analysis (Malone 1989). For the most part the federal and state compliance requirements are similar to those that apply to all major construction activities on federally owned land.

Table 2. Environmental provisions of the Nuclear Waste Policy Act for repository site characterization

Section	Requirement
112 (a) and (b)	Recommendation of candidate site for consideration as a repository site requires preparation of a statutory environmental assessment (EA) based on information available at the time.
112 (e) and 113 (d)	Siting activities are exempt from preparation of an EIS pursuant to NEPA.
113 (a), (b), and (c)	Subsequent to site recommendation, geologic and hydrologic siting studies are to be carried out at Yucca Mountain in a manner that minimizes the significant adverse environmental impacts that are to be identified in a second EA (separate from the Section 112 EA) submitted as part of the plans for siting studies. The plans also are to include reclamation of the Yucca Mountain site and mitigation of significant adverse impacts.

DOE Environmental Program for Yucca Mountain since 1987

Following passage of the NWPAA in 1987, the DOE issued an Environmental Program Overview (US DOE 1988a) that describes environmental planning for site characterization activities at Yucca Mountain. The program overview describes the purpose of other documents that, when completed, will comprise composite plans for protecting the environment at Yucca Mountain during site characterization (Table 3). All the plans are based on the findings and conclusions of the NWPA statutory EA (US DOE 1986) and are predicated on the assumption that the EA provides a sound basis for continued environmental program planning. As discussed in the preceding section, the adequacy of the statutory EA is fundamental to the post-1987 DOE environmental program. The components of the DOE environmental program plan for site characterization activities are discussed below, followed by a critique of the success with which the Environmental Program Overview (US DOE 1988a) illustrates that the documents reflect comprehensive, integrated environmental program planning for the Yucca Mountain Project.

EIS001887

Table 3. Documents described in the environmental program overview (DOE 1988c) as comprising the environmental program plans for site characterization at Yucca Mountain

Title	Reference
Environmental Monitoring and Mitigation Plan	US DOE 1988a
Environmental Regulatory Compliance Plan	US DOE 1988b
Reclamation Program Plan	In preparation
Reclamation Feasibility Plan	In preparation
Reclamation Implementation Plan	In preparation
Environmental Field Activity Plans for:	
Aesthetics	Unscheduled
Air quality	US DOE 1988f
Archeology	US DOE 1988g
Noise	Unscheduled
Soils	Unscheduled
Ecosystems	US DOE 1988e
Water resources	In preparation

Monitoring, Mitigation, Reclamation, and Regulatory Compliance

An Environmental Monitoring and Mitigation Plan (US DOE 1988a) addresses monitoring and mitigating significant adverse impacts from future site characterization activities and was prepared to assure that site characterization would be conducted in a manner that minimizes environmental impacts. The plan is not comprehensive and fails to address all components of the environment because the NWPA statutory EA was used to identify potential impacts to be minimized and mitigated during site characterization (US DOE 1988a,b). Thus, if a potential impact is not identified in the statutory EA, it is not addressed in the monitoring and mitigation plan. For example, terrestrial ecosystems are to be surveyed principally where site characterization activities will result directly in site disturbance and not across the entire study site. There will be no comprehensive studies associated with impact monitoring and mitigation prior to site characterization. No monitoring will be conducted for soils, noise, and aesthetics because the statutory EA concluded that no impacts will occur in those components of the environment. Monitoring for air pollutants from site characterization will cover only particulate matter, and no other emissions resulting from site characterization will be measured. There will be no attempt to address cumulative impacts of any kind, and the only form of mitigation to be considered is subsequent alteration of an ongoing activity if impacts are detected. In the DOE's view, the concept of cumulative impacts from past and planned activities and the need to consider direct mitigation measures are ideas restricted to NEPA and do not apply to the Yucca Mountain Project (US DOE 1988b). Thus, the scope of the plan for monitoring and mitigation is narrowly restricted to the context of the NWPA and the statutory EA with no consideration of a broad perspective on environmental review.

Following the monitoring and mitigation plan, the DOE issued a plan for complying with environmental requirements other than those derived directly from the NWPA. The Environmental Regulatory Compliance Plan (US DOE 1988c) is a procedural document that implements the DOE internal orders requiring that operations be carried out in an environmentally sound manner as defined by statutes and regulations. This reflects how DOE equates environmental protection with regulatory compliance. Such a policy would be more credible if NEPA were complied with in its entirity during repository siting, but this is not to be the case. Aside from the specific exemptions granted by the NWPA that remain applicable to site characterization at Yucca Mountain, there is no indication in the regulatory compliance plan (US DOE 1988c) of how the requirements that address planning, decision making, and other aspects of NEPA may be met. Other than the limitations imposed on NEPA, the compliance plan adequately identifies the range of non-NWPA and environmental requirements likely to apply to the Yucca Mountain Project. How compliance will be achieved is not addressed, and although the plan mentions that a compliance auditing program will be developed, there is no discussion of its substance.

The DOE is preparing three separate plans for reclamation activities at Yucca Mountain (Table 3) pursuant to the requirements of NWPA. The first of the documents is to be a Reclamation Program Plan meant to discuss the requirements that mandate reclamation. The second document will be a Reclamation Feasibility Plan describing field studies for developing reclamation practices for the Yucca Mountain site. The third document will be a Reclamation Implementation Plan that discusses how the results of the feasibility plan will be implemented. A notable feature of these plans is that they will include plans for floristic studies of the Yucca Mountain ecosystem (US DOE 1988a) that will be apart from the ecological investigations to be carried out on soils and on fauna. As a consequence, no single plan exists for comprehensive ecological studies.

Environmental Field Activities

Field studies and analyses needed to provide data and information for the Environmental Monitoring and Mitigation Plan, the Environmental Regulatory Compliance Plan, and the uncompleted reclamation

plans are to be described by DOE in a set of Environmental Field Activity Plans (Table 3). Each individual disciplinary field activity plan is to be developed to reflect only the studies needed to meet environmental requirements as they arise in a stepwise manner during the course of the Yucca Mountain Project. Thus, as a need for field information arises, a new activity plan will be prepared or an existing one amended to reflect the studies required. This approach precludes DOE ever achieving the comprehensive planning and integration that typically characterize sound and effective environmental analysis. As a result of the piecemeal manner in which the field plans are being prepared, it is not possible to obtain a perspective on the overall studies that are to comprise the DOE environmental program for the Yucca Mountain Project. The difficulties inherent in the approach are apparent from the following observations.

1. The Environmental Field Activity Plan for Terresterial Ecosystems (US DOE 1988e) describes preconstruction surveys needed at Yucca Mountain to assure that no protected species or habitat is present. These surveys will focus on the desert tortoise (*Gopherus agassizii*) because that species is a candidate for protection under the Endangered Species Act. Following completion of site characterization, DOE will conduct postconstruction surveys to determine the need for impact mitigation and reclamation. As noted above, the ecosystems field plan contains no floristic studies as these are to be included among the reclamation plans. Neither does the plan contain studies or analyses of ecosystem-level parameters such as productivity, nutrient cycling, and ecological integrity.

2. The Environmental Field Activity Plan for Air Quality (US DOE 1988f) addresses monitoring of particulate matter to determine if regulatory exceedences will occur during site characterization. No other criteria pollutants are to be monitored with respect to site characterization activities, and no dispersion modeling is planned. Meteorological monitoring (US DOE 1985) is a program separate from the environmental program and is not addressed in the air quality plan.

3. A comprehensive survey of Yucca Mountain for archeological sites was conducted in 1982 prior to passage of NWPA and was reported in the NWPA statutory EA (US DOE 1986). The archeological resources data base constitutes the only source of comprehensive site-specific environmental information available for Yucca Mountain. Locations of archeological sites are known and an archeological field activity plan (US DOE 1988g) contains plans for recovery of artifacts where site characterization will directly disturb them. All the measures required by federal archeological resources protection laws and regulations are addressed by the field plan.

4. A field plan for water resources is being prepared for purposes of environmental regulatory compliance and monitoring. The initial omission by the DOE of such a plan was on the basis that the NWPA statutory EA found no potential impacts to water resources as a result of site characterization activities at Yucca Mountain. However, DOE (US DOE 1988c) subsequently learned that field studies were needed for purposes of regulatory compliance.

5. No field plans are available for soils, noise, and aesthetics. As the DOE contends that no regulatory requirements exist for soils, noise, and aesthetics during repository siting, field plans will not be prepared for analysis of impacts from site characterization. Monitoring for these aspects of the environment as part of the Environmental Monitoring and Mitigation Plan (US DOE 1988b) was omitted because the NWPA statutory EA concluded that adverse impacts would no result from site characterization activities.

Environmental Program Overview

The Environmental Program Overview for site characterization activities at Yucca Mountain (US DOE 1988a) describes the procedural purpose of the individual plans that comprise the DOE environmental program (Table 3). The document does not discuss the substance of each plan and thus does not provide an integrated view of the scientific nature of the DOE environmental program. There is no component of the plan that accomplishes a substantive, as opposed to a procedural, overview and illustrates that the program reflects a comprehensive approach to planning for environmental protection. The absence of complete environmental baseline information precludes accomplishing a sound analysis of impacts that could result from site characterization and renders all planning based on the NWPA statutory EA subject to uncertainty. The lack of complete information on conditions at the site will not be remedied because the true baseline will never be known. The decision to monitor impacts primarily where the NWPA statutory EA predicted them means that unmonitored components of the environment could be impacted and never detected.

Discussion and Conclusions

Environmental protection programs are based increasingly on concepts of cumulative impacts, biological diversity, environmental integrity, and resources conservation (Stakhiv 1988, Westman 1985, Jordan

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and others 1988, Office of Technological Assessment 1987). This is not the case with the Yucca Mountain repository siting project. Given the inadequacies of the environmental planning effort, it is unlikely that the DOE can carry out a credible and effective program of impact analysis and environmental protection during site characterization at Yucca Mountain. There is some reason to believe that prior to repository construction at Yucca Mountain, a more comprehensive and integrated approach to DOE's environmental program could be developed. This possibility exists because of the requirements that performance assessment studies be carried out before authorization of repository construction in order to demonstrate the ability of the environment's natural setting to safely contain nuclear wastes for at least 10,000 years (US Environmental Protection Agency 1984, Egan and Clark 1989). Performance assessment must address the sustained integrity of the site's natural setting and confirm that cumulative impacts of radionuclides from a repository will not threaten the quality of the environment (Lieberman and Lee 1986, Buxton 1989). However, the assessment ultimately could be flawed because of DOE's current policy of not performing comprehensive, integrated siting studies and not analyzing cumulative impacts as a result of site characterization.

A sound environmental program plan for Yucca Mountain must provide for acquisition of comprehensive information on the site. This means that baseline conditions should be described before site characterization proceeds. It will not be sufficient for studies to be carried out after site characterization has been initiated, as the US DOE (1988a,b) plans to do. The lack of complete environmental baseline information for the Yucca Mountain site coupled with the DOE decision to monitor impacts primarily where the NWPA statutory EA predicted them means that unmonitored components of the environment could be impacted and never detected. This is important with respect to the need for impact mitigation and site reclamation. The consequences that environmental impacts that are not remediated could have to the preservation of the site's natural integrity are a critical factor in light of the performance assessment requirements (US Environmental Protection Agency 1985, Egan and Clark, 1989). It is essential that geologic and hydrologic characterization not compromise the fundamental nature of the environment. To do so would impose uncertainty on the ability of the site to perform as intended and protect future environmental systems from serious radiological impact. To this end it seems that auditing of predicted impacts as discussed by Canter (1985) is needed at Yucca Mountain.

A major weakness in the post-1987 DOE environmental program for Yucca Mountain was inevitable when the decision was made to accept the statutory EA (US DOE 1986) mandated by the NWPA as the basis for subsequent planning. The alternative would have been to follow the intent of the NWPA, set the statutory EA aside once it had served the decision-making purpose intended by NWPA, and prepare another assessment based on comprehensive, empirically derived information as an intrinsic component of site characterization. In choosing not to follow such a course, the DOE has not benefited from the experience of the failed 1982 policy (Cleary and Craft 1988) and, as a result, the absence of appropriate environmental analysis continues to trouble the repository siting project. Continuing to pursue the environmental policy eminating from NWPA in 1982, already proven to be faulty, will only result in another failure of the high-level nuclear waste repository program. The reason for the DOE reliance on the NWPA statutory EA is unclear but may be based on legal considerations and an unwillingness to suggest that the document was inadequate by undertaking another analysis based on comprehensive environmental information and complete plans for site characterization (Malone 1989).

If an alternative to the present course of environmental program planning for the Yucca Mountain Project were to be developed, it could adopt an approach that holds promise for accommodating the complexities inherent in repository performance studies where uncertainty is a significant consideration (Buxton 1989). In this respect recent developments in expert systems technology (Lein 1989) offer a unique approach to complex environmental assessment and merit consideration. The computer-based expert systems approach is well suited to accommodating the multifaceted considerations inherent to environmental performance assessment. Interdisciplinary knowledge can be encoded to provide solutions to specialized problems that transcend traditional, formalized environmental analysis. An especially appealing aspect of the systems approach is that it provides for the screening and evaluation of alternative considerations, such as siting activities and engineering designs, before adverse consequences occur (Lein 1989). If adopted by the DOE, expert systems methodology could provide the framework for an enlightened approach to environmental planning and performance assessment for the Yucca Mountain site that is consistent with the complexity and significance of the nuclear waste disposal issue and program in the United States.

A fundamental lesson to be learned from the experiences that led to and that are following from the

NWPA policy failure is that in matters of critical environmental concern over high-risk technologies like nuclear energy and disposal of nuclear waste the environmental rationality embodied within NEPA (Bartlett 1986) should not be set aside for an expedient politically based rationality. The environmental rationale that is the cornerstone of NEPA and upon which the precepts of sound environmental impact analysis are based (Bartlett 1986, Caldwell 1988) will serve society well when faced with making decisions in the face of uncertainties that carry unknown risks to the environmental systems of future generations. The concepts of environmental integrity (Westman 1985) and cumulative impact analysis (Stakhiv 1988) are essential to the task of assessing the performance of an environmental system in which a repository is to be developed for isolating nuclear wastes for thousands of years. In this sense the emerging methodology of performance assessment for a repository system stands to benefit from adopting the precepts of sound environmental planning and management founded on preserving the integrity of environmental systems and analysis of cumulative impacts disturbuted over time. Only if performance assessment is conceptually sound and does not compromise basic precepts of environmental protection and analysis like those embodied in NEPA can it ever offer society a potential means of addressing the long-term consequences of scientific and technological development on future environmental systems and generations. In this respect, how society deals with the issue of nuclear waste could be a turning point in addressing the consequences of far-reaching actions on future environmental systems and generations (National Board on Spent Nuclear Fuel 1988; DeYoung and Kaplan 1988). The US nuclear repository program as now reflected by the DOE Yucca Mountain Project shows little promise of contributing to the resolution of this problem.

Literature Cited

Bartlett, R. V. 1986. Rationality and the logic of the National Environmental Policy Act. *The Environmental Professional* 8:105–111.

Buxton, B. E. 1989. Geostatistical, sensitivity, and uncertainty methods for ground-water flow and radionuclide transport modeling. Battelle Press, Columbus, Ohio. 670 pp.

Caldwell, L. K. 1988. Environmental impact analysis (EIA): Origins, evolution, and future directions. *Policy Studies Review* 8:75–83.

Canter, L. W. 1985. Impact prediction auditing. *The Environmental Professional* 7:255–264.

Clary, B. B., and M. E. Kraft. 1988. Impact assessment and policy failure: The Nuclear Waste Policy Act of 1982. *Policy Studies Review* 8:105–115.

DeYoung, R., and S. Kaplan. 1988. On averting the tragedy of the commons. *Environmental Management* 12:273–283.

Egan, D., and R. Clark. 1989. Amended environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level, and transuranic radioactive wastes. 40 CFR Part 191: Working draft I, June 2. US Environmental Protection Agency, Washington, DC. 32 pp.

Jordan, W. R., III, R. L. Peters II, and E. B. Allen. 1988. Ecological restoration as a strategy for conserving biological diversity. *Environmental Management* 12:55–72.

Lein, J. K. 1989. An expert system approach to environmental impact assessment. *International Journal of Environmental Studies* 33:13–27.

Lemons, J., and C. Malone. 1989. Siting America's geologic repository for high-level nuclear waste: Implications for environmental policy. *Environmental Management* 13:435–441.

Lemons, J., C. Malone, and B. Piasecki. 1989. America's high-level nuclear waste repository: A case study of environmental science and public policy. *International Journal of Environmental Studies* 34:25–42.

Lieberman, J. A., and W. W. L. Lee. 1986. Mathematical modeling of waste respository performance: A peer review. Pages 749–758 *in* H. C. Burkholder (ed.), High-level nuclear waste disposal. Battelle Press, Columbus, Ohio.

Malone, C. R. 1989. Environmental review and regulation for siting a nuclear waste repository at Yucca Mountain, Nevada. *Environmental Impact Assessment Review* 9:77–95.

National Board on Spent Nuclear Fuel. 1988. Ethical aspects of nuclear waste. Report 29. SKN, Stockholm, Sweden. 23 pp.

Office of Technology Assessment. 1987. Technologies to maintain biological diversity. US Government Printing Office, Washington, DC. 334 pp.

Stakhiv, E. Z. 1988. An evaluation paradigm for cumulative impact analysis. *Environmental Management* 12:725–748.

US DOE (Department of Energy). 1984. Nuclear Waste Policy Act of 1982: General guidelines for the recommendation of sites for the nuclear waste repositories (final siting guidelines), 10 CFR Part 960. *Federal Register* 49:47714–47770.

US DOE (Department of Energy). 1985. Meteorological monitoring plan. DOE/NVO 10270-5. US Department of Energy, Las Vegas, Nevada. 54 pp.

US DOE (Department of Energy). 1986. Environmental assessment: Yucca Mountain Site, Nevada research and development area, Nevada. DOE/RW-0073. US Department of Energy, Washington, DC. 902 pp.

US DOE (Department of Energy). 1988a. Environmental monitoring and mitigation plan for site characterization. DOE/RW-0208. US Department of Energy, Washington, DC. 104 pp.

US DOE (Department of Energy). 1988b. Environmental regulatory compliance plan for site characterization. DOE/RW-0209. US Department of Energy, Washington, DC. 139 pp.

US DOE (Department of Energy). 1988c. Environmental program overview. DOE/RW-0207. US Department of Energy, Washington, DC. 50 pp.

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US DOE (Department of Energy). 1988d. Site characterization plan. DOE/RW-0199. US Department of Energy, Washington, DC. 6331 pp.

US DOE (Department of Energy). 1988e. Environmental field activity plan for terrestrial ecosystems. DOE/NV-10576-14. US Department of Energy, Las Vegas, Nevada. 109 pp.

US DOE (Department of Energy). 1988f. Environmental field activity plan for air quality. DOE/NV-10576-13. US Department of Energy, Las Vegas, Nevada. 46 pp.

US DOE (Department of Energy). 1988g. Environmental field activity plan for cultural resources: Archaeological component. DOE/NV-10576-16. US Department of Energy, Las Vegas, Nevada. 81 pp.

US DOE (Environmental Protection Agency). 1985. Environmental standards for the management and disposal of spent nuclear fuel, high-level, and transuranic radioactive wastes, 40 CFR Part 191. *Federal Register* 50:38066–38089 (Remanded July 17, 1987, US Court of Appeals, First Circuit).

Westman, W. E. 1985. Ecology, impact assessment, and environmental planning. John Wiley & Sons, New York. 532 pp.

ATTACHMENT F

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ECOLOGY, ETHICS, AND PROFESSIONAL ENVIRONMENTAL PRACTICE: THE YUCCA MOUNTAIN, NEVADA, PROJECT AS A CASE STUDY

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Abstract. The U.S. Department of Energy (DOE) is proposing to develop a geologic repository for disposing of high-level nuclear waste at Yucca Mountain, Nevada. In this commentary, the ecology program for the DOE's Yucca Mountain Project is discussed from the perspective of state-of-the-art ecosystem analysis, environmental ethics, and standards of professional practice. Specifically at issue is the need by the Yucca Mountain ecology program to adopt an ecosystem approach that encompasses the current strategy based on population biology and community ecology alone. The premise here is that an ecosystem approach is essential for assessing the long-term potential environmental impacts at Yucca Mountain in light of the thermal effects expected to be associated with heat from radioactive decay.

INTRODUCTION

The resolution of environmental issues, both short-term and long-term, involves a proper synthesis of environmental information with principles of ethics and values (Lemons, 1987; Shrader-Frechette, 1993; Golley, 1994). In some cases this does not happen, a frequent reason being that environmental science and management often are not practiced holistically in an integrated and interdisciplinary sense as advocated by environmental professionals such as Cairns and Crawford (1991) and Dorney and Dorney (1989). Some environmental professionals do not comprehend holistic approaches to environmental protection or for other reasons do not practice their profession in a manner that integrates principles of interdisciplinary environmental science and ethics adequately.

My commentary discusses such a case from the perspective of the ecosystem approach (e.g., Allen and Hoekstra, 1992; Golley, 1993; Slocombe, 1993b; Grumbine, 1994a) and comments on issues of methodological value judgment, environmental ethics, and standards of professional environmental practice. From this perspective, I suggest how concepts of ecosystem analysis combined with sound principles of ethics and professional practice can contribute to the resolution of some controversial environmental issues.

The case study at hand is the U.S. Department of Energy (DOE) project to dispose of high-level nuclear waste in a deep geologic repository at Yucca Mountain, Nevada. The Yucca Mountain Project previously has been used by Lemons (1995) and Shrader-Frechette (1993, 1994) to illustrate clashes between ethics and methodological value judgment. In the present commentary, I use the Yucca Mountain ecology program as an example of how environmental decisions need to be based on an understanding of the capabilities for human actions to pose a threat to long-term environmental quality (e.g., Peters and Lovejoy, 1992). In cases involving potential consequences to long-term ecosystem integrity (Woodley et al., 1993), it is prudent for decisions to be made in a manner that poses the least threat to the environment for future generations. Extremely long-lived radioactive and associated hazardous waste threatens environmental quality for as long as 10 million years (Kirchner, 1990). Therefore, decisions made now about such wastes could deprive future generations of options and choices that are rightfully theirs to make (Baldwin, 1985). From this standpoint logically fall questions about ecology and environmental ethics with respect to the Yucca Mountain Project.

It should be noted at the outset that the concern I express here is not over the loss of a small amount of desert ecosystem. Instead, my concern involves the greater potential environmental consequences that could follow from the sacrifice of the ecosystem atop a high-level nuclear waste repository at Yucca Mountain (Figure 1). Thus, it is not explicitly the principle of maintaining ecosystem integrity and biodiversity that is at issue but rather what might result from failing to use ecosystem analysis to assess the potential consequences. This in turn leads to issues of ethics and professional practice and some of the challenges faced by the environmental profession in terms of applying the best scientific concepts and practices available for preserving the environment for future generations.

THE YUCCA MOUNTAIN CASE

The purpose of the Yucca Mountain Project along with other information relevant to my commentary is shown in Table 1.

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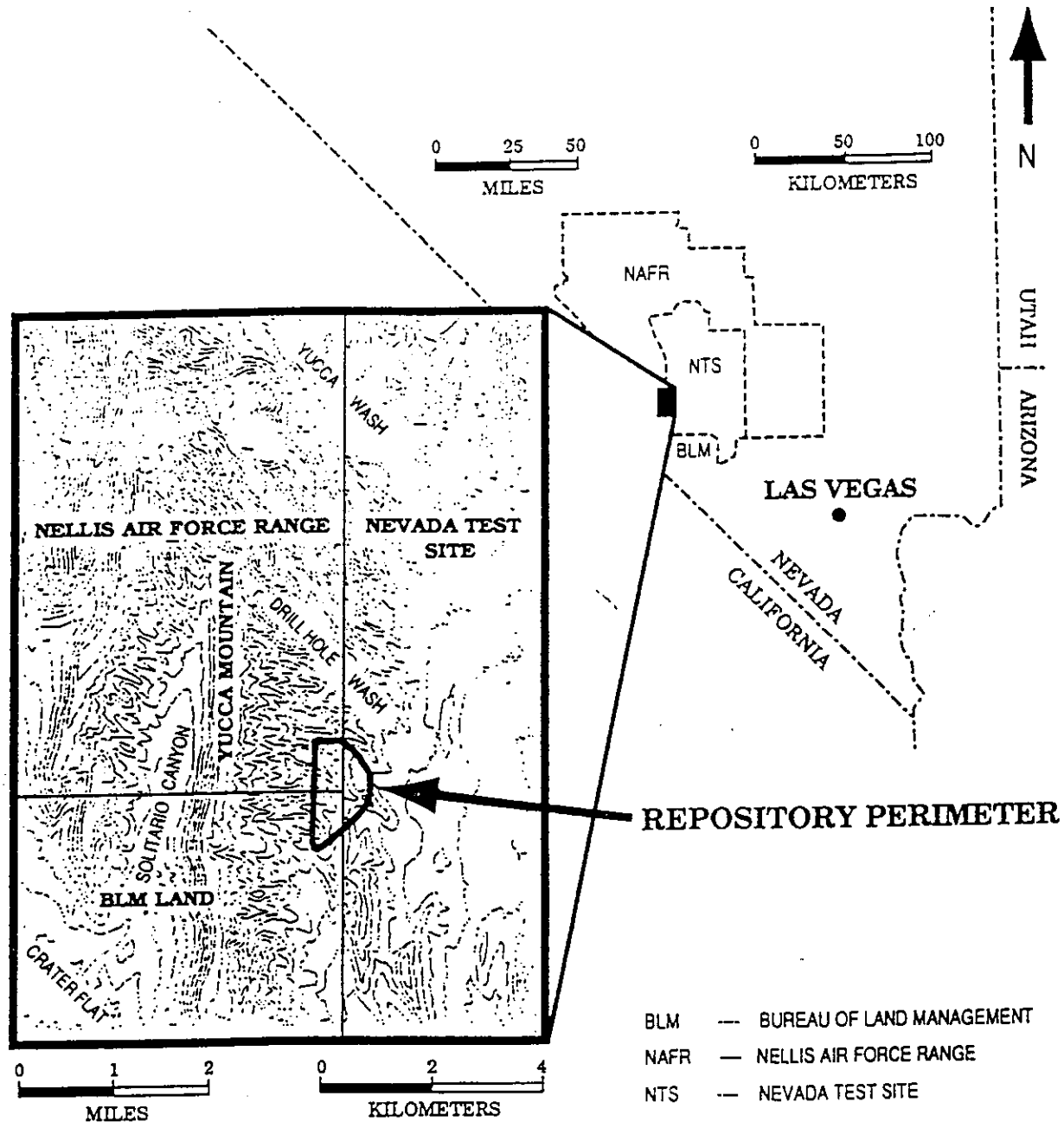
Figure 1. Map of the U.S. DOE Yucca Mountain Project Site Showing the Perimeter of the Proposed Geologic Repository for Disposing of Nuclear Waste



Regulations require that the repository must isolate nuclear waste from the environment for a minimum of 10,000 years (Lemons et al., 1989; Malone, 1989; Shrader-Frechette, 1993). This is because there will be large amounts of long-lasting radioactive contaminants such as plutonium-239 (Kirchner, 1990), which has a half-life of 24,390 years. As noted, Kirchner demonstrated that nuclear waste inside a deep geologic repository would be hazardous for as long as 10 million years. He suggested that a waste containment period of 10,000 years is far too short, a matter that remains open for

Table 1. Important Features of the Yucca Mountain Repository Project

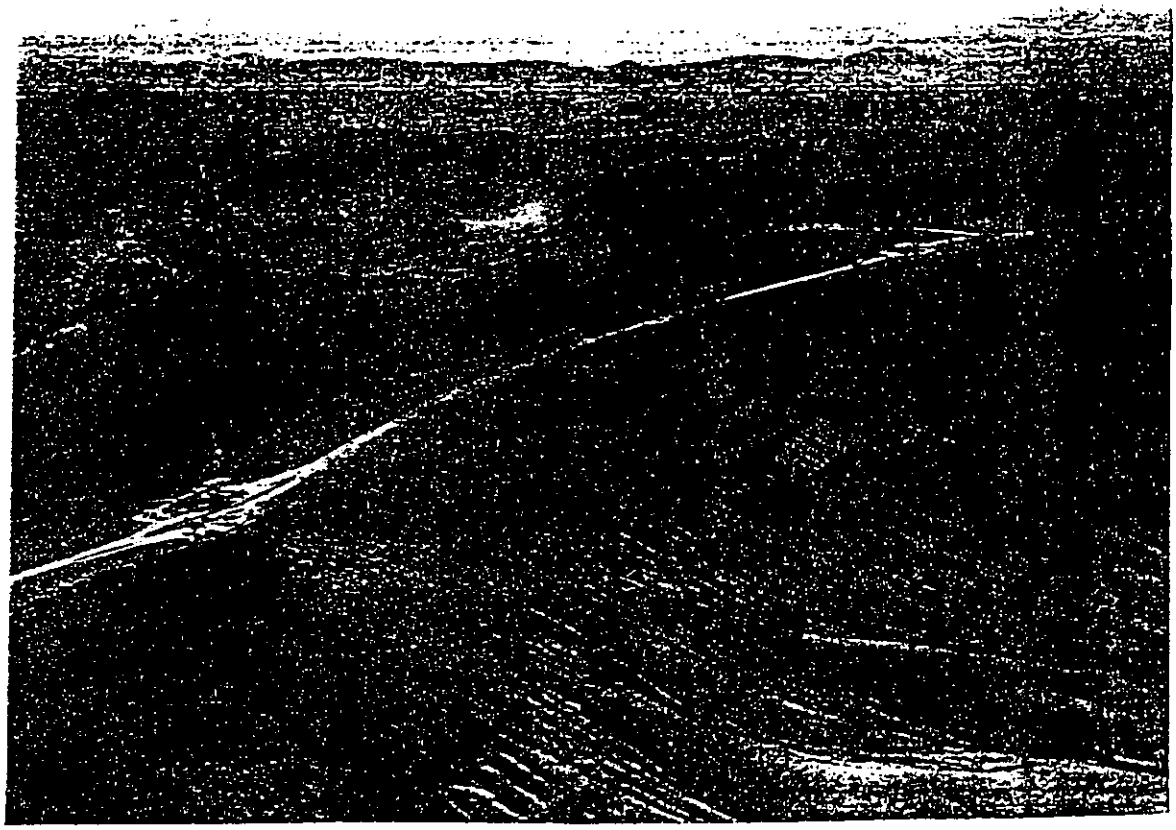
Purpose:	Confinement of 70 kmt of commercial and military high-level nuclear waste for >10,000 years
Total Cost:	$35-55C Billion
Schedule:	Opens 2010 Is Sealed 2150
Depth:	350 m below the surface 225 m above the groundwater table
Repository Temperature:	300°C to >100°C for >10,000 years

reconsideration regarding the Yucca Mountain Project. For long-term isolation of nuclear waste to be achieved requires that a site must not experience significant climatic, geologic, hydrologic, or other environmental perturbation that would compromise a repository's integrity.

As would be expected in any attempt to forecast long-term environmental conditions at Yucca Mountain, many uncertainties exist regarding assurances of containment of radioactive waste (Malone, 1990a; Shrader-Frechette, 1993). The need for the very best scientific insight on this issue recently was emphasized by the work of Bowman and Venneri (1995). The investigators predict that under plausible long-term conditions likely to occur at Yucca Mountain, highly radioactive waste emplaced in a geologic repository at the site could result in nuclear criticality and explosion that would release radioactive material into the surrounding environment and the global atmosphere. A peer review process

Figure 2. A Portion of the Potential Thermal Impact Zone at the Yucca Mountain Site

Shows part of the 7 km² potential thermal impact zone atop and on either side of the north/south-running ridgetop in the foreground (north is to the left of the photograph).



within the DOE complex attempted to disprove the findings but failed (Benjamin, 1994; Bowman, 1995).

A principal matter of concern at Yucca Mountain is the heat that will occur within a repository as a result of radioactive decay. This is estimated to cause peak temperatures around 300°C at the repository walls that would remain above 100°C for over 10,000 years (Buscheck and Nitao, 1993; Buscheck et al., 1993). The hydrothermal scenario for such a "hot" repository is poorly understood with respect to the associated environmental consequences. Hydrothermal process modeling by Buscheck and others suggests that temperatures within the top 7 m at Yucca Mountain can be expected to rise by an average of 2°-13°C. This is consistent with the 6°C rise allowed by the DOE (1988b) for temperature increases at the ground surface.

The repository-driven hydrothermal regime being studied is anticipated (Buscheck, 1994b) to influence the surface environment beginning about 200 years after the repository is filled in 2050. Peak effects would occur at the surface of Yucca Mountain after another 400 to 800 years and would remain in effect for at least 10,000 years or longer. These effects would occur over an area 3 km in diameter (7 km^2) (Buscheck and Nitao, 1993), designated here as "the surface thermal impact zone." This is comparable to the 10 km^2 disturbed area allowed by the DOE (1988b). The potential impact zone is partially shown in Figure 2. The investigators have yet to conduct field studies relative to thermally induced changes near the surface at Yucca Mountain (Buscheck, 1994a).

The issue of repository-induced thermal impacts at Yucca Mountain is more than a scientific curiosity. An environment altered by subterranean heat at Yucca Mountain could influence the ecosystem and in turn the hydrologic balance and groundwater regime above a repository. Because groundwater is considered to be the most important factor affecting a repository's performance (by corroding waste canisters and transporting radionuclides), long-term interactions between the nuclear waste and the underground setting should not be ignored (Malone, 1989-90, 1990c; Fehringer, 1994; Lemons and Malone, 1994; NWTRB, 1994).

The problem would arise from increases in environmental temperature and therefore is similar to questions posed by elevated soil temperatures associated with global warming (e.g., Peters and Lovejoy, 1992). Accordingly, it is logical to consider whether or not understanding the issue of repository-induced ecosystem impacts would be responsive to the application of the holistic ecosystem approach as some are doing in the case of global warming and the environmental implications to ecosystem integrity and biodiversity (Van Cleve et al., 1990; Field et al., 1992; Harte et al., 1992, 1995; Peterjohn et al., 1993, 1994; Harte and Shaw, in press).

It might be expected that in complying with the requirements of the National Environmental Policy Act (NEPA) at Yucca Mountain, the DOE would adopt a systematic ecosystem approach for environmental impact assessment (EIA). Such approaches are available (e.g., Beanlands and Duinker, 1984; Duinker and Baskerville, 1986; Westman, 1987; Cairns and Crawford, 1991; Golley, 1993), but the DOE (1988a, 1992) continues to pursue an approach based alone on population biology and community ecology and lacking integration with abiotic environmental sciences such as hydrology, geology, and climatology (Winsor and Malone, 1990; Malone, 1990b; Lemons and Malone, 1994; NWTRB, 1994). The DOE approach is seen here as being contrary to principles of environmental ethics and standards of professional environmental practice. To understand this, it is instructive to consider some key issues of ethics and professional practice before turning attention to the Yucca Mountain Project and applied ecosystem science.

ETHICS AND STANDARDS FOR PROFESSIONAL ENVIRONMENTAL PRACTICE

As noted in the introduction above, environmental professionals should conduct their practice cognizant that the synthesis of authentic facts and values consistent with interdisciplinary concepts is a professional responsibility. Some professional codes of ethics and standards of professional practice recognize this (e.g., Shrader-Frechette, 1994; ACEC, 1995; ESA, 1995; Lemons, 1995; NAEP, 1995; NDEP, 1995). For example, Table 2 lists some fundamental principles of ethics and standards of practice adopted by environmental professional organizations such as the National Association of Environmental Professionals (NAEP).

The principles listed in Table 2 set the scene for this case study of ecosystem science, ethics, and standards of professional practice using the Yucca Mountain Project ecology program (DOE, 1986, 1988a, 1992, 1994b). Specifically, the approach taken involves using principles of ethics and standards of environmental practice to question the absence within the DOE ecology program of an interdisciplinary ecosystem-based approach to EIA.

My first premise is that the Yucca Mountain ecology program is not being conducted consistent with environmental codes of ethics and sound professional practice. A second premise is that this fault has adverse consequences for both the nuclear waste repository program and the long-term environment. The principal fundamental feature of the Yucca Mountain ecology program on which these premises are based is the program's failure to apply the ecosystem approach advocated by Schulze and Zwolfer (1987), Westman (1987), Golley (1993, 1994), and others in accordance with interdisciplinary, integrated environmental management as set forth by Savory (1988), Cairns and Crawford (1991), Allen and Hoekstra (1992), and Golley (1993, 1994).

Table 2. Fundamental Principles of Ethics, Standards of Practice, and Guidance for Environmental Professionals Relevant to the Yucca Mountain Case and This Commentary

- Environmental professionals must conduct themselves in a manner consistent with the principles of environmental ethics and objectivity.
- Environmental professionals must accept only assignments for which they are qualified, and they must alert clients when another professional's expertise will be required for an assignment.
- Environmental professionals must incorporate the best principles of the environmental sciences for reducing environmental harm and enhancing environmental quality. This includes recognizing that environmental management and practice involve the interdisciplinary consideration of all environmental factors (biotic, abiotic, natural, and cultural). Thus, environmental professionals must recognize and foster the participation of other professionals in interdisciplinary teams for performing environmental impact assessment.
- Environmental professionals must support their findings and advice to clients with authentic data, analyses, and plans based on objective procedures. If uncertainties remain in important environmental insights and advice presented to clients, the uncertainties must be acknowledged. If subjective judgment is used to advise a client where authentic data are unavailable, that fact must be acknowledged, and the judgmental procedures followed must be made clear.
- Environmental professionals must determine that all project activities are consistent with the intent of and comply with all applicable laws, regulations, and standards, especially the National Environmental Policy Act.
- Environmental professionals must seek common, adequate, and sound technical grounds for communication with and respect for the contributions of other professionals in developing and executing policies, plans, activities, and projects.
- Environmental professionals must encourage development of their profession and participate in maintaining its integrity and competence.

Source: ACEC (1995), ESA (1995), NAEP (1995), and NDEP (1995).

I support these premises first by turning to issues of ecosystem science regarding the Yucca Mountain Project. Second, I explain the potential adverse consequences of the Yucca Mountain ecology program as it now stands. Third, I show how the ecosystem approach could be applied to correct the asserted shortcomings that are of concern within the DOE's nuclear waste repository project.

ECOSYSTEM SCIENCE AND THE YUCCA MOUNTAIN PROJECT

In this section, the existing ecology at Yucca Mountain is summarized. Following that, fundamental principles of the holistic ecosystem approach to addressing environmental problems are discussed. This serves as a basis for subsequently understanding why comprehending the holistic ecosystem and assessing its long-term future as opposed to studying the present biotic structure alone is consistent with the environmental challenges posed by a high-level nuclear waste repository.

The Yucca Mountain Ecology Program

The Yucca Mountain site (Figure 1) is located within a narrow biotic zone (2-5 km wide) where the Mojave Desert and the Great Basin Desert meet. The vegetation of this transitional desert ecotone was described by Beatley (1975), but prior to the interest in the Yucca Mountain site as a location for a nuclear waste repository, little environmental information existed regarding the area.

Following passage of the Nuclear Waste Policy Act of 1982 that set forth the repository project, an environmental assessment was issued for the Yucca Mountain site (DOE, 1986). Ecological information for the assessment was based on biological surveys focused primarily on four principal plant communities recognized at Yucca Mountain. Live trapping of small mammals was carried out to determine species composition and relative abundance. Preliminary surveys were conducted for the presence of the desert tortoise (*Gopherus agassizii*), a species later designated as threatened under the Endangered Species Act. In all, the biological surveys at Yucca Mountain prior to 1986 were meant to identify protected biota. Ecosystem analysis was not attempted for the DOE's 1986 environmental assessment.

Additional ecology field activities were initiated by the DOE at Yucca Mountain in 1990 and continue to the present (DOE, 1988a, 1992, 1994b; Parker et al., 1990). The activities include studies of the population biology of the desert tortoise and the community ecology of vegetation and small mammals. No special consideration is being given to the ecology of the 7 km^2 hydrothermal impact zone atop the site shown in Figure 2.

While the issue of the long-term ecosystem integrity at Yucca Mountain is a formidable one, it is likely to be no more problematic than the requirement to predict climatic, geologic, and hydrologic conditions over a period of 10,000

years. Without such information, it is doubtful if sufficient insight into the potential for environmental feedbacks to influence repository integrity and nuclear waste isolation will be available for the ultimate decision to proceed with developing a repository. This decision is anticipated to be made by the DOE in the late 1990s.

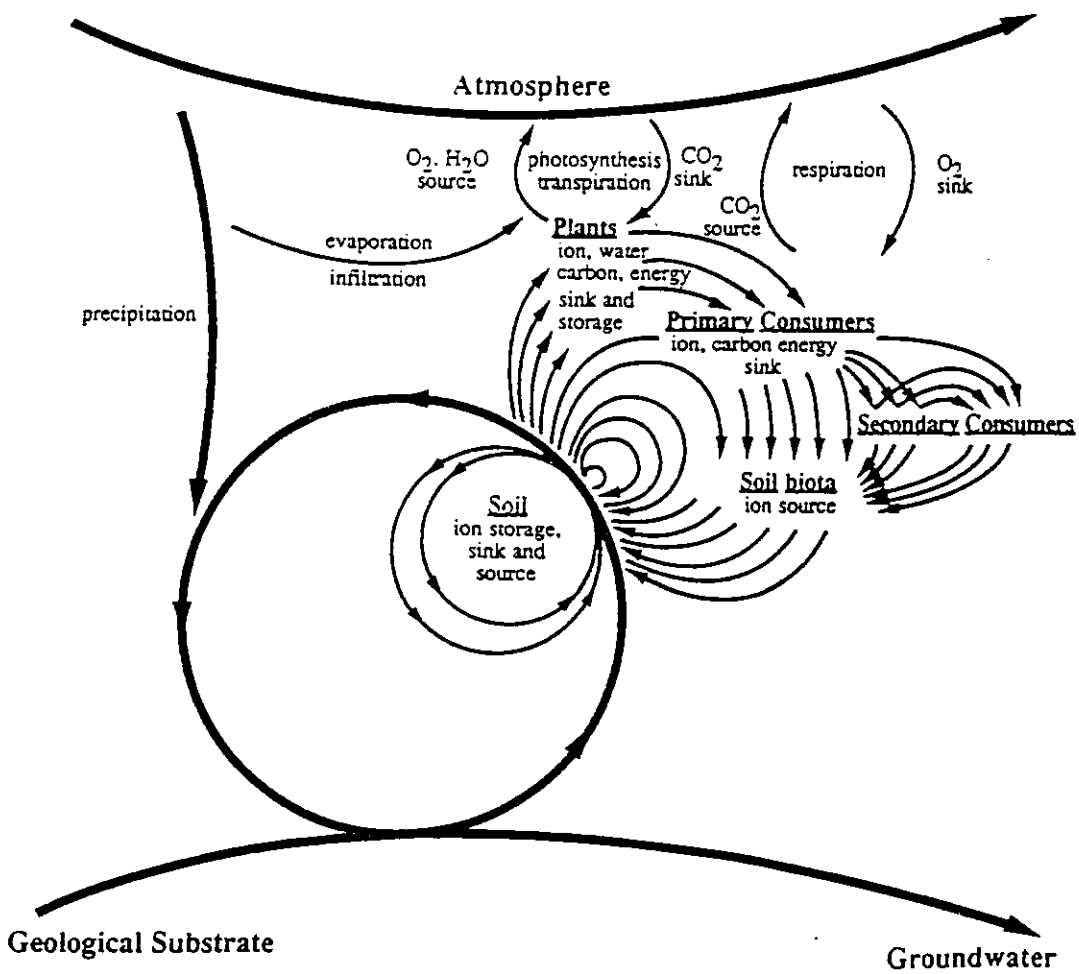
The following section of this commentary discusses the fundamentals of ecosystem analysis in the context of the Yucca Mountain Project and suggests that an ecosystem approach, as opposed to one based only on the lower hierarchies of population biology and community ecology, is both necessary and practical.

The Ecosystem Approach

Here the term "ecosystem" means the integrated, process-functional system discussed by McIntosh (1985) and elaborated on by others (e.g., Schulze and Zwolfer, 1987; Allen an Hoekstra, 1992; Golley, 1993). Ecosystems include the inter-acting complexes of the biotic and abiotic environment and are viewed as open systems that are dependent on the abioti environment. Additionally, ecosystems exhibit organizatio and self-regulation where the biotic components influence the abiotic environment. This two-way interaction involves numerous feedback mechanisms, as suggested by Figure 3

The process-functional concept of ecosystems is more realistic than one that focuses on biotic structure alone. Thus insights into ecosystems and their integrity can be seen mor effectively in terms of dynamic process-oriented transformations of materials and energy rather than as things, i.e., biota, in a place at a given time (Woodley et al., 1993; Harte et al. 1995).

Figure 3. Conceptual Configuration of an Integrated Process-Function Ecosystem



Source: After Schulze and Zwolfer, 1987, with permission of the publisher

In most ecosystems, plants occupy a key position because of their autotrophy. Sometimes animals can dominate an ecosystem and in such cases are designated as "keystone species" (Mills et al., 1993). An example of this is the role played by burrowing rodents in some arid and semiarid ecotones (Brown and Heske, 1990) similar to the Yucca Mountain site where the dissemination of seeds of annual grasses and forbs depends on the rodents. If something happens to the rodents, the nature of the ecosystem changes. With respect to Yucca Mountain, the role that rodents play and the effects that elevated subsurface temperatures could have on them are unknown. This is an example of the myriad of ecological phenomena that can be overlooked in the absence of an ecosystem approach to EIA.

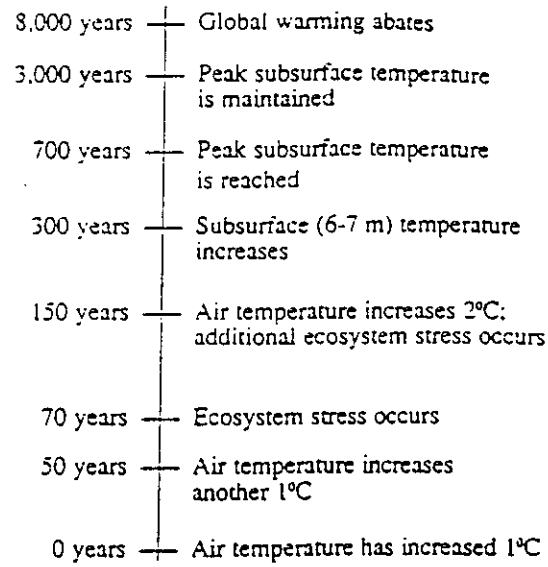
Ecosystem Perturbation

Over long periods of time, natural ecosystems characteristically maintain themselves in equilibrium with respect to functional processes. If a perturbation occurs, such as global warming (e.g., Peters and Lovejoy, 1992; Peterjohn et al., 1994; Harte, 1994), this balance will be upset, and processes throughout the ecosystem will be altered in an effort by the system to achieve a new equilibrium. If a functional steady-state condition is not reached, the ecosystem will become progressively dysfunctional, and if the situation persists long enough, the ecosystem will break down (Rapport et al., 1985; Costanza et al., 1992). This will result in the environment being altered to an extent that the ecosystem will be unable to recover. Such a situation likely would result from increased underground temperatures above a nuclear waste repository at Yucca Mountain (Harte, 1994; Tausch et al., 1994).

At Yucca Mountain, some of the future environmental changes likely to occur are shown in Figure 4, based on Peters (1992), Peters and Lovejoy (1992), Buscheck and Nitao (1993), Buscheck (1994a, 1994b), Harte (1994), and Harte et al. (1995). The timeline shows that while subsurface temperatures at the Yucca Mountain site would be increasing, atmospheric temperature associated with global warming also might be increasing. There is no understanding of the environmental interactions of these two perturbations because such a dual temperature change, both above and below the ground surface, has never been addressed. However, Whitford (1992) and West et al. (1994) have shown how critical the three-way relationships among climate, soil, and vegetation are to the functional integrity of desert ecosystem processes such as maintaining nutrient and water budgets. Understanding such matters in the context of the long-term environment at Yucca Mountain is important (Lemons and Malone, 1991; Ferhenger, 1994; Harte, 1994; NWTRB, 1994).

A difficulty in environmental science has been predicting what will happen in the future to disturbed ecosystems (e.g., Rapport et al., 1985; Westman, 1987; Costanza et al., 1992; Harte et al., 1992). Central to that is the concept of scale, which pertains to both time and space (Allen and Hoekstra, 1992). The issue of the future ecosystem at Yucca Mountain under a regime of elevated subterranean temperature is large-scale with respect to the time period involved and small-scale with respect to the areal space that may be affected. Size is not the principal critical characteristic with respect to a thermally altered ecosystem at Yucca Mountain. Rather, the most important aspect of the problem is the long-term capability of the environment at the site to sustain ecosystem integrity. Traditional discussions of ecosystem response to perturbations such as temperature change generally have not considered the complexity of feedback mechanisms associated with functional processes and with maintaining ecosystem integrity (Mooney, 1991; Field et al., 1992; Woodley et al., 1993). Why this is essential to to the Yucca Mountain case and how it could be accomplished by the ecosystem approach are addressed in the next two sections of this paper.

Figure 4. Postulated Temperature Timeline at Yucca Mountain Under a Regime of Global Warming and Subsurface Heat from a Hot Nuclear Waste Repository (not drawn to scale)



Source: Peters (1992), Peters and Lovejoy (1992), Buscheck and Nitao (1993), Buscheck (1994a, 1994b), Harte (1994), Harte et al. (1995)

POTENTIAL LONG-TERM ENVIRONMENTAL IMPACTS AT YUCCA MOUNTAIN

A reasonable question to ask is why the Yucca Mountain Project should invest in an ecosystem approach when only a relatively small (7 km^2) thermal impact area at the site would be likely to experience long-term impacts from a nuclear waste repository. In other words, with such a vast extent of arid lands in the vicinity of the site, how could the loss of such

a small area be significant? In response to this question, it is necessary to consider what is likely to happen at Yucca Mountain during the thousands of years after a geologic repository is completed, filled with waste, and permanently sealed. To facilitate this, some rational assumptions about the affected area of concern must be considered before proceeding to a scenario for the potential consequences.

Although scientific uncertainty abounds in the Yucca Mountain Project, Buscheck (1994a, 1994b) and Buscheck and Nitao (1993) believe that heat from radioactive decay in a repository beneath Yucca Mountain will reach the surface and will cause increased soil temperatures for up to 10,000 years. During the time that subterranean temperatures are increasing, atmospheric temperature above the surface also may be rising due to global warming (Peters and Lovejoy, 1992). Most climatologists believe that changing climatic conditions will cause global temperatures to increase by 3° ± 1.5°C (Peters, 1992). This is expected to hold as well for the Great Basin region (Giorgi et al., 1992; Murphy and Weiss, 1992) where Yucca Mountain is located.

Whitford (1992) and West et al. (1994), for example, have shown how critical interactions among the atmosphere, soil, and vegetation are to desert ecosystems and how changes in one component of the ecosystem will induce responses in the other components. Noble (1993) has shown that ecotones, such as the Yucca Mountain site, can be expected to respond to climate change before other areas do. Under the regime of global warming, the vegetation of the northern Mojave Desert, now occurring in the valley floors and on the slopes of Yucca Mountain (Beatley, 1975; DOE, 1986; Malone, 1991), would be expected to move to the summit of the ridge (Murphy and Weiss, 1992; Woodward, 1992; Tausch et al., 1993). Such shifts in dominant vegetation as a consequence of climate warming were suggested by Harte et al. (1995) and subsequently demonstrated (Harte and Shaw, in press). Unanswered in the case of Yucca Mountain is whether or not the vegetation that now inhabits the valleys and slopes at the site would remain or be replaced by species from even hotter environments like those currently occurring in the Death Valley region 60 km south of Yucca Mountain.

A 7 km^2 thermally affected area at Yucca Mountain could be significantly altered so that it would constitute a disturbed and dysfunctional area inhabited only by invaders like tumbleweed (*Salsola kali*) and red bromegrass (*Bromus rubens*). At best, the affected area would adapt into a semiautonomous system of its own with different structural and functional attributes from its initial condition and the surrounding ecosystem (Tausch et al., 1994). Discerning the nature of the existing ecosystem and projecting its integrity far into the future are the issues that face the Yucca Mountain ecology program.

In light of the uncertainty involved, and lacking information to the contrary, it must be assumed that a reasonable worst-case situation could occur at Yucca Mountain. The postulated scenario depicted in Figure 5 was constructed from existing information and professional views (Bull, 1991, 1993; Peters and Lovejoy, 1992; Buscheck and Nitao, 1993; Buscheck et al., 1993; Tausch et al., 1993, 1994; Buscheck, 1994a, 1994b; Harte, 1994; Harte et al., 1995; Harte and Shaw, in press). Reflected in the scenario is knowledge that at Yucca Mountain a likely route for radioactive waste to reach the environment is via the groundwater aquifer that lies 225 m beneath the repository horizon. Subterranean heat at Yucca Mountain is expected to drive groundwater in the unsaturated zone above the repository to the surface in the form of water vapor. During the winter this is likely to result in greater than normal fog above the repository and consequently increased precipitation. In the summer, despite the potential for water vapor to have a slight cooling effect, the water would evaporate rapidly because of normal aridity enhanced by increased ambient temperatures from global warming. Very few, if any, higher plant species might be expected to survive these conditions, and eventually such an ecosystem likely would

Figure 5. Model for an Environmental Response at Yucca Mountain from a Hot Nuclear Waste Repository

Subsurface temperature and local climate are altered.

↓

Vegetation is reduced and winter precipitation is increased.

↓

Runoff and infiltration increase.

↓

Erosion and bedrock exposure increase.

↓

Vegetation is eliminated.

↓

Erosion and infiltration are maximized.

↓

Would the performance of a repository be influenced?

Source: Bull (1991, 1993), Peters and Lovejoy (1992), Buscheck and Nitao (1993), Buscheck et al. (1993), Buscheck (1994a, 1994b), Harte (1994), and Tausch et al. (1994).

become dysfunctional and barren of both vegetative cover and soil (Bull, 1991, 1993; Peters and Lovejoy, 1992; Tausch et al., 1993, 1994).

Land forms exist today that are similar to what could occur in the future at Yucca Mountain (Bull, 1991, 1993). Under such conditions, both erosion and infiltration would accelerate, and greater amounts of water would move downward toward the repository horizon, altering the geohydrology of the site (Buscheck and Nitao, 1993; Buscheck, 1994a). This response would be intensified by heat-induced upwelling of the repository overburden, which would enhance the naturally occurring fractures in the rock overburden and further increase the rate of water infiltration to the repository horizon (Buscheck, 1994a).

Following from this scenario is the question of whether or not such environmental impacts would affect the performance of a repository. It fits with what is known about the Yucca Mountain environment that accelerated movement of precipitation toward a repository and into the aquifer beneath it would result from removal of the vegetation and soil above the repository. The consequences of this perturbed environment on the ability of a geologic repository at Yucca Mountain to isolate radionuclides for at least 10,000 years is not being addressed by the Yucca Mountain Project (Dixon, 1994, 1995; Fehringer, 1994; NWTRB, 1994). In view of the theory that water in a repository could result in a nuclear disaster (Benjamin, 1994; Bowman, 1995; Bowman and Venner, 1995), it is contingent under NEPA regulations (40 CFR 1502.22[a]) regarding "reasonably foreseeable" impacts for the DOE to assess such a scenario. To do so based on the concept of ecosystem-based environmental analysis would be consistent with the state of the art of ecosystem science. This assertion is discussed in the next section.

A RESOURCE-BASED APPROACH FOR ADDRESSING THE YUCCA MOUNTAIN CASE

Approaches to applied ecosystem research suitable for the Yucca Mountain case have emerged recently from the issue of global warming and questions about long-term future environmental conditions and ecosystems. Notable in this respect is the resource-based approach of Field et al. (1992). This approach to ecosystem analysis addresses the functional responses of natural settings to alterations in environmental forcing factors that drive an ecosystem like those involved with climate change (e.g., CO_2, temperature, moisture).

The Conceptual Framework

Field et al. (1992) demonstrated that the effects of increased temperature and CO_2 and changes in soil moisture on terrestrial ecosystems can be analyzed in terms of the resources required by organisms for growth. These resources include, among other things, light, oxygen, CO_2, water, nutrients, and carbon compounds. Results of experimental studies of the responses of ecosystems to changes in soil fertility, water availability, or temperature provide a starting point for assessing the impact on ecosystem integrity likely to result from long-term changes in environmental conditions.

The resource-based approach addresses a broad range of ecosystem types and complements the unified concept of ecosystem (Allen and Hoekstra, 1992), both of which together respond to the call by Mooney (1991) for new ecosystem-based strategies for addressing phenomena like changes in climate and ambient temperature. Others are using similar approaches for field research regarding ecosystem responses to changing environmental conditions such as temperature (e.g., Van Cleve et al., 1990; Peterjohn et al., 1993, 1994; Harte et al. 1995; Harte and Shaw, in press), and their methods have been judged appropriate for the Yucca Mountain case (Fehringer, 1994; Harte, 1994; NWTRB, 1994; Tausch et al., 1994). For example, experimental studies of ecosystem perturbation by artificially raising subterranean temperatures to simulate nuclear waste impacts to the surface environment could be performed to provide the data needed under the resource-based approach (Fehringer, 1994; Harte, 1994; NWTRB, 1994). Once the direction and magnitude of the ecosystem responses are sufficiently understood quantitatively, ecosystem network modeling, such as advocated by Allen and Hoekstra (1992) and applied by others (e.g., Peters and Lovejoy, 1992), can be used to predict the long-term potential of the Yucca Mountain ecosystem.

What the Yucca Mountain Ecology Program Should Be Doing

The worst-case scenario at Yucca Mountain (Figure 5) is, according to NEPA regulations (40 CFR 1502.22[a]), reasonably foreseeable. The NEPA regulations further state (40 CFR 1502.22) with respect to "incomplete or unavailable information" needed to dispel concern about a reasonably foreseeable impact that the information must appear in a NEPA environmental impact statement (EIS) unless obtaining the data would involve "exorbitant" costs (Fogleman, 1990; Bartlett and Malone, 1993; Cox at al., 1993). Thus, to avoid having to assume the worst-case scenario in the EIS for the Yucca Mountain Project, the DOE needs a restructured reoriented ecological program that would provide information dispelling the scenario and its potential consequences.

The ecology program for the Yucca Mountain Project should begin with an analysis of the present ecosystem at the site, conduct experimental temperature studies, understand the responses of ecosystem processes to dual forces of temperature increases, and forecast the long-term consequences to the repository environment. To accomplish this requires recognizing concepts like ecosystem integrity, ecological feedback, and nonequilibrium ecology as well as ecosystem processes like nutrient, heat, and water budgets (Winsor and Malone, 1990; Cairns and Crawford, 1991; Allen and Hoekstra, 1992; Field et al., 1992; Hornbeck and Swank, 1992; Slocombe, 1993b; Harte et al. 1995). Additionally, functional processes and system components that are critical

to ecosystem integrity at Yucca Mountain should be identified through experiments on heat perturbation. Finally, the Yucca Mountain ecology program should use process-based simulation modeling for impact assessment based on likely alterations of ecosystem processes (Winsor and Malone, 1990; Allen and Hoekstra, 1992). The fundamentals of such an ecosystem approach to EIA and forecasting were set forth by Beanlands and Duinker (1984), Duinker and Baskerville (1986), and Westman (1987).

With regard to field studies on ecosystem responses to alterations in subterranean temperatures, experimental heat perturbations induced by tunnel-installed electric heating cables (Peterjohn et al., 1993, 1994; Harte, 1994) or piped geothermal water (Tausch et al., 1994) would be practical. Buscheck et al. (1993) have proposed *in situ* heater tests on rocks from the repository horizon at Yucca Mountain to confirm their thermal models. Such studies would provide insight to the possibility of homeostatic temperature feedback by water vapor moving upward from a repository (Buscheck 1994a, 1994b). It is not practical to conduct long-term realistic studies of the effects of a nuclear waste repository. However, studies of five years' duration would provide insights to potential long-term environmental consequences at Yucca Mountain.

This course of study, applied in conjunction with methods involving watershed ecosystem analysis (Hornbeck and Swank, 1992), has been recommended for the Yucca Mountain Project by a group of White House-appointed reviewers (Fehringer, 1994; NWTRB, 1994) as well as by others (Winsor and Malone, 1990; Lemons and Malone, 1991, 1994; Field, 1994; Harte, 1994). However, the recommendations are considered impractical and unnecessary by the DOE (Dixon, 1994) as well as by the community ecologists and population biologists responsible for the Yucca Mountain ecology program (O'Farrell, 1994). The DOE believes that the schedule for the EIS for a repository is too critical to allow for the costs and time delays involved with the ecosystem approach for EIA at Yucca Mountain (Dixon, 1994).

ETHICS, PROFESSIONAL PRACTICE, AND YUCCA MOUNTAIN

In comparing the actions of the Yucca Mountain ecology program with the ethical principles and standards of sound practice for environmental professionals given in Table 2, the following points emerge.

- The Yucca Mountain ecology program is not being pursued in a manner consistent with the principles of environmental ethics.
- The population biologists and community ecologists involved with the program have stepped outside their expertise with respect to advising the DOE that the Yucca Mountain ecology program does not need to be based on ecosystem analysis. Moreover, the advice given by the environmental professionals is biased toward the DOE view that it is untimely for the repository project schedule to implement an ecosystem approach. This policy appears to be based on undocumented subjective judgment alone and not to be supported by facts and analyses consistent with scientific objectivity.
- The Yucca Mountain Project is inconsistent with the intent of NEPA regarding interdisciplinary approaches to EIA and does not recognize the principles of holistic environmental management.
- The environmental professionals engaged in the Yucca Mountain ecology program have discounted the importance of scientific uncertainty in their assessment of the plausibility of a worst-case environmental scenario that could jeopardize the acceptable performance of a geologic repository at Yucca Mountain.
- The failure of the Yucca Mountain ecology program to be integrated with other environmental programs such as climate forecasting, hydrogeology, and hydrothermal studies in the Yucca Mountain Project is inconsistent with an interdisciplinary approach to environmental impact analysis.
- The personnel involved with the DOE ecology program have not heeded the advice of outside expert reviewers such as the White House-appointed NWTRB with respect to the Yucca Mountain ecology program and have not sought the counsel of appropriate outside environmental experts.
- The preceding points are inconsistent with fostering the environmental profession and preserving its integrity by virtue of competent practice.

Considering the nature and significance of the Yucca Mountain Project, especially regarding the environmental quality of future generations, it is reasonable to hold the project to high standards of environmental ethics and professional practice. This particularly is the case regarding incorporation of the best principles of environmental science in an effort to resolve the issue of the worst-case scenario (Figure 5) and the risks of widespread radioactive contamination that would result from an explosion in a repository for high-level nuclear waste at Yucca Mountain (Benjamin, 1994; Bowman, 1995; Bowman and Venneri, 1995).

My commentary contends that the Yucca Mountain Project stands to benefit from the application of principles of environmental ethics, appropriate expertise, and sound professional environmental practice. These ideals are encouraged by professional organizations like the NAEP. If the environmental managers of the Yucca Mountain Project were members of an association with an adequate code of ethics and standards of practice, they could be called upon by the

association to explain the ecology program in light of comments like those expressed herein. Unfortunately, this is not the case.

The final section of my commentary addresses the role of professional organizations like the NAEP regarding such matters.

ECOSYSTEM MANAGEMENT, ENVIRONMENTAL ETHICS, AND THE NAEP

Advocates of integrated, interdisciplinary environmental management (e.g., Baldwin, 1985; Savory, 1988; Dorney and Dorney, 1989; Cairns and Crawford, 1991; Grumbine, 1994a, 1994b; Knight and Bates, 1995;) recognize the need for their discipline to remain abreast of modern ecosystem science and to incorporate ecosystem analysis as a matter of policy. This is occurring now in most federal landholding agencies where the approach to environmental resource management advocated here is being implemented in response to Vice President Gore's National Performance Review (GPO, 1993; GAO, 1994b). To this end, a Presidential Executive Order has been recommended (OEP, 1994; IEMTF, 1995) that would require relevant federal agencies to develop, adopt, and implement ecosystem-based management of resources, both natural and cultural (socioeconomic). Legislation was introduced in the U.S. Senate in the form of the Ecosystem Management Act of 1994 (S. 2189) to require that all federal lands, such as the Yucca Mountain site, be managed in accordance with the principles of ecosystem science.

Some agencies foresaw this action and began taking steps in that regard three years ago (e.g., FS, 1992, 1994; BLM, 1994; DOD, 1994; EPA, 1994; FWS, 1994, 1995; GAO, 1994a). The DOE took steps in this respect with a draft policy that would require all agency projects, including the Yucca Mountain Project, to be based on the principles of ecosystem management to protect the environment (DOE, 1994a). The draft policy stated that it would be based on concepts of ecosystem sustainability and biodiversity. Implementation of the policy by the DOE would have constituted a major shift in an agency currently driven by the concepts of nuclear technological sustainability and development, as opposed to ecosystem sustainability. As of July 1995 the DOE policy has not been implemented. Other federal agencies are pursuing ecosystem management policies and programs that merge natural and socioeconomic sustainability as well as biodiversity (Grumbine, 1994a, 1994b; Knight and Bates, 1995).

Thus, for the Yucca Mountain Project the DOE is proceeding with an EIS for the nuclear waste repository that overlooks ecosystem analysis and management and instead is based on population biology and community ecology alone (Dixon, 1995). In the DOE's approach, no meaningful attention is given to interactions between the biotic and abiotic aspects of the environment. This is consistent with precepts of sustainable technological development and inconsistent with approaches based on precepts of environmental ethics and sound professional practice. Others have shown that the conflict between technological development and ecosystem management is unnecessary, because reasonable ecosystem approaches for avoiding the conflict are available (e.g., Golley, 1993, 1994; Slocombe, 1993a).

The case of the Yucca Mountain Project illustrates that there remains a need for skilled and ethically motivated environmental professionals to resolve complex and portentous issues involving the environment of future generations. This does not mean to suggest that the only capable environmental professionals are ecosystem ecologists or that there are no limits to what applying the ecosystem approach can accomplish (Hilborn and Ludwig, 1993; Shrader-Frechette and McCoy, 1993, 1994). It does mean, as some professional codes of ethics support (Table 2), that cognizance of interdisciplinary concepts and practices, such as the ecosystem approach, should be encouraged, pursued, and applied wherever appropriate. In the context of the Yucca Mountain Project, it means that population biologists and community ecologists involved with the DOE ecology program are remiss if they do not appreciate and advocate an ecosystem approach to long-term EIA. Ecologists who specialize in hierarchies of lower order than the ecosystem are of course essential to the interdisciplinary ecosystem approach, as are experts in other environmental disciplines (Baldwin, 1985; Dorney and Dorney, 1989; Cairns and Crawford, 1991; Allen and Hoekstra, 1992; Grumbine, 1994a, 1994b; Knight and Bates, 1995). The point is that interdisciplinary guidance consistent with the ecosystem approach should be fundamental to activities like the Yucca Mountain ecology program.

Golley (1993, 1994) suggested that the ecosystem perspective and approach can lead to an environmental value system that influences environmental law and political agendas. Golley also pointed out that the ecosystem perspective is necessary for guiding environmental resource managers as well as for understanding long-term environmental issues. Thus, Golley views the ecosystem concept as a foundation for environmental ethics. This view anchors ecosystem-based ethics in tangible experience with nature involving authentic and factual ecosystem science and competent professional expertise, as encouraged by this commentary. Indeed, the discipline of environmental management has recognized this. For example, Baldwin (1985), Savory (1988), Dorney and Dorney (1989), Cairns and Crawford (1991), and Grumbine (1994a) have well articulated and applied the ecosystem concept to holistic resource management.

The adoption by most federal agencies of concepts such as resource management, ecological sustainability, and preservation of biodiversity based on principles of ecosystem management (GAO, 1994a; Grumbine, 1994a; Knight and Bates, 1995) is evidence that the ecosystem perspective of Golley (1993) is materializing rapidly. Some may view this

transition to ecosystem-based environmental policy and practice as being as significant as the passage of NEPA was in 1969. This is because the implementation of environmental policy based on the ecosystem approach may make it possible for NEPA finally to achieve what it was envisioned to do by those involved in drafting the act, i.e., to see environmental resources and impacts assessed and managed in an interdisciplinary, holistic context with ecosystem-level science at the core of the effort. Thus, NEPA sought to give the nation an environmental ethic (Bartlett and Malone, 1993), and now the ecosystem approach advocated by Golley (1993, 1994), Slocombe (1993a, 1993b), Grumbine (1994a), and many others to environmental assessment and management offers a way of realizing and applying that ethic.

The necessity for all environmental professionals to think and practice in accordance with the exemplary principles of both ethics and standards of professional practice is recognized by professional environmental organizations like the NAEP. Such groups should, therefore, endorse and foster the application of concepts and principles of ecosystem management, especially where the science of environmental impact assessment and compliance with NEPA are concerned. The need is to transpose awareness and practice of this ecosystem-based environmental ethic to institutions like the DOE and to activities like the Yucca Mountain Project.

This issue is of course far larger than the DOE's Yucca Mountain Project, which served here to illustrate a major challenge facing environmental professionals and organizations like the NAEP. The task at hand is to take action with respect to fostering exemplary ethics and competency among all environmental professionals and to assure that interdisciplinary science and the ecosystem approach play a strong role in achieving sound and accountable environmental practice. Those who direct and govern professional environmental organizations must continue taking concrete steps to meet this challenge.

REFERENCES

(ACEC) American Consulting Engineers Council of the United States. 1995. Code of Ethics. ACEC, Washington, DC.

Allen, T.F.H., and T.W. Hoekstra. 1992. *Toward a Unified Ecology*. Columbia University Press, New York.

Baldwin, J.H. 1985. *Environmental Planning and Management*. Westview Press, Boulder, CO.

Bartlett, R.V., and C.R. Malone, eds. 1993. Science and the National Environmental Policy Act. *The Environmental Professional* 15(1): 1-160.

Beanlands, G.E., and P.N. Duinker. 1984. An Ecological Framework for Environmental Impact Assessment. *Journal of Environmental Management* 18: 267-277.

Beatley, J.C. 1975. Climates and Vegetation Patterns Across the Mojave/Great Basin Desert Transition of Southern Nevada. *American Midland Naturalist* 93: 53-70.

Benjamin, R.W. 1994. Personal Letter to C.D. Bowman. Nuclear Physicist, Westinghouse Savannah River Company, Aiken, SC. December 20.

(BLM) U.S. Bureau of Land Management. 1994. Ecosystem Management in the BLM: From Concept to Commitment. BLM/SC/GI-94/005+1736. BLM, Washington, DC.

Bowman, C.D. 1995. Telephone interview. Nuclear Physicist, Los Alamos National Laboratory, Los Alamos, NM. March 6.

Bowman, C.D., and F. Venneri. 1995. Underground Autocatalytic Criticality from Plutonium and Other Fissile Material. LA-UR 94-4022. Los Alamos National Laboratory, Los Alamos, NM.

Brown, J.H., and E.J. Heske. 1990. Control of a Desert-Grassland Transition by a Keystone Rodent Guild. *Science* 250: 1705-1707.

Bull, W.B. 1991. *Geomorphic Responses to Climatic Change*. Oxford University Press, New York.

Bull, W.B. 1993. Telephone interview. Professor, Department of Geomorphology, University of Arizona, Tuscon, AZ. October 14.

Buscheck, T.A. 1994a. Presentation to the U.S. Nuclear Waste Technical Review Board and the U.S. Department of Energy Yucca Mountain Project. Research Scientist, Earth Sciences Department, Lawrence Livermore National Laboratory, Livermore, CA. March 22.

Buscheck, T.A. 1994b. Telephone interview. Research Scientist, Earth Sciences Department, Lawrence Livermore National Laboratory, Livermore, CA. January 13.

Buscheck, T.A., and J.J. Nitao. 1993. Repository-Heat-Driven Hydrothermal Flow at Yucca Mountain, Part I: Modeling and Analysis. *Nuclear Technology* 104: 418-448.

Buscheck, T.A., D. Wilder, and J.J. Nitao. 1993. Repository-Heat-Driven Flow at Yucca Mountain, Part II: Large-Scale *In Situ* Heater Tests. *Nuclear Technology* 104: 449-471.

Cairns, J., Jr., and T.V. Crawford, eds. 1991. *Integrated Environmental Management*. Lewis Publishers, Chelsea, MI.

Costanza, R., B.G. Norton, and B.D. Haskell, eds. 1992. *Ecosystem Health: New Goals for Environmental Management*. Island Press, Washington, DC.

Cox, D.K., T.M. Keevin, F.T. Norris, and D.J. Schaeffer. 1993. When Is a Cost Exorbitant Under NEPA? *The Environmental Professional* 15(1): 145-149.

Dixon, W.R. 1994. Environmental Program Update presented to the U.S. Nuclear Waste Technical Review Board. Assistant Manager for Environment, Science, and Health, Yucca Mountain Project Office, U.S. Department of Energy, Las Vegas, NV. March 22.

Dixon, W.R. 1995. Environmental Program Update presented to the U.S. Nuclear Waste Technical Review Board. Assistant Manager for Environment, Science, and Health, Yucca Mountain Project Office, U.S. Department of Energy, Las Vegas, NV. January 10.

(DOD) U.S. Department of Defense. 1994. Implementation of Ecosystem Management in the Department of Defense: Ecosystem Management Principles. DUSD (ES)/EQ-CO, August 8. Office of the Under Secretary for Defense, DOD, Washington, DC.

(DOE) U.S. Department of Energy. 1986. Environmental Assessment: Yucca Mountain Site, Nevada. DOE/RW-0073. DOE, Washington, DC.

(DOE) U.S. Department of Energy. 1988a. Environmental Program Overview. DOE/RW-0207. DOE, Washington, DC.

(DOE) U.S. Department of Energy. 1988b. Site Characterization Plan, Yucca Mountain Site, Nevada. DOE/RW-0199. DOE, Washington, DC.

(DOE) U.S. Department of Energy. 1992. Yucca Mountain Site Characterization Environmental Field Activity Plan for Terrestrial Ecosystems. YMP/91-41. DOE, Las Vegas, NV.

(DOE) U.S. Department of Energy. 1994a. Draft Land and Facility Use Policy and Requirements. Agency-wide memorandum, August 26. Associate Deputy Secretary for Field Management, DOE, Washington, DC.

(DOE) U.S. Department of Energy. 1994b. Site Environmental Report for Calendar Year 1993. Yucca Mountain Site. Nye County, Nevada. DOE. Las Vegas, NV.

Dorney, R., and L. Dorney. 1989. *The Professional Practice of Environmental Management*. Springer-Verlag, New York.

Duinker, P.N., and G.L. Baskerville. 1986. A Systematic Approach to Forecasting in Environmental Impact Assessment. *Journal of Environmental Management* 22: 271-290.

(EPA) U.S. Environmental Protection Agency. 1994. Report of the National Advisory Council Committee on Ecosystem Management. Office of the Administrator. EPA. Washington, DC.

(ESA) Ecological Society of America. 1995. Code of Ethics. ESA. Washington, DC.

Fehringer, D.J. 1994. U.S. Nuclear Waste Technical Review Board Comments on the Yucca Mountain Ecology Program. Letter to W. Dixon. Yucca Mountain Project Office. DOE. Las Vegas, NV. August 18.

Field, C.B. 1994. Telephone interview. Research Scientist. Department of Plant Biology. Carnegie Institute of Washington. Stanford, CA. February 23.

Field, C.B., F. Chapin III, P. Matson, and H.A. Mooney. 1992. Responses of Terrestrial Ecosystems to the Changing Atmosphere: A Resource-Based Approach. *Annual Review of Ecology and Systematics* 23: 201-235.

Fogleman, V.M. 1990. *Guide to the National Environmental Policy Act: Interpretations, Applications, and Compliance*. Quorum Books. Westport, CT.

(FS) U.S. Forest Service. 1992. Taking an Ecosystem Approach to Management. WO-WSA-3. U.S. FS. Washington, DC.

(FS) U.S. Forest Service. 1994. An Ecological Basis for Ecosystem Management. General Technical Report RM-246. U.S. FS. Fort Collins, CO.

(FWS) U.S. Fish and Wildlife Service. 1994. An Ecosystem Approach to Fish and Wildlife Conservation: An Approach to More Effectively Conserve the Nation's Biodiversity. FWS. Washington, DC.

(FWS) U.S. Fish and Wildlife Service. 1995. An Ecological Basis for Ecosystem Management: Concept Development. FWS. Washington, DC.

(GAO) U.S. General Accounting Office. 1994a. Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach. GAO/RCED-94-111. GAO. Washington, DC.

(GAO) U.S. General Accounting Office. 1994b. Management Reform: Implementation of the National Performance Review. OCG-95-1. GAO. Washington, DC.

Giorgi, F., G.T. Bates, and S.J. Nieman. 1992. Simulation of the Arid Climate of the Southern Great Basin Using a Regional Climate Model. *Bulletin of the American Meteorological Society* 73: 1807-1822.

Golley, F.B. 1993. *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts*. Yale University Press. New Haven, CT.

Golley, F.B. 1994. Grounding Environmental Ethics in Ecological Science. In *Ethics and Environmental Policy: Theory Meets Practice*. F. Ferre and P. Hartel, eds. University of Georgia Press. Athens, GA. pp. 9-20.

(GPO) U.S. Government Printing Office. 1993. Reinventing Environmental Management: Accompanying Report of the National Performance Review. GPO-355-681. GPO. Washington, DC.

Grumbine, R. Edward. 1994a. What Is Ecosystem Management? *Conservation Biology* 8(1): 27-38.

Grumbine, R. Edward, ed. 1994b. *Environmental Policy and Biodiversity*. Island Press. Washington, DC.

Harte, J. 1994. Presentation to the U.S. Nuclear Waste Technical Review Board and the U.S. Department of Energy Yucca Mountain Project. Research Scientist. Earth Sciences Department. Lawrence Livermore National Laboratory. Livermore, CA. March 22.

Harte, J., and R. Shaw. In Press. Shifting Dominance Within a Montane Vegetation Community: Results of a Climate-Warming Experiment. *Science* (in press).

Harte, J., M.S. Torn, and D. Jensen. 1992. The Nature and Consequences of Indirect Linkages Between Climate Change and Biological Diversity. In *Global Warming and Biological Diversity*. R.L. Peters and T.E. Lovejoy, eds. Yale University Press. New Haven, CT. pp. 325-343.

Harte, J., M.S. Torn, F. Chang, B. Feifarek, A.P. Kinzig, R. Shaw, and K. Shen. 1995. Global Warming and Soil Microclimate: Results from a Meadow-Warming Experiment. *Ecological Applications* 5(1): 132-150.

Hilborn, R., and D. Ludwig. 1993. The Limits of Applied Ecological Research. *Ecological Applications* 3(4): 550-552.

Hornbeck, J.W., and W.T. Swank. 1992. Watershed Ecosystem Analysis as a Basis for Multiple-Use Management. *Ecological Applications* 2: 238-247.

(IEMTF) Interagency Ecosystem Management Task Force. 1995. The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies. White House Office of Environmental Policy. Washington, DC.

Kirchner, G. 1990. A New Hazard Index for the Determination of Risk Potentials of Disposed Radioactive Wastes. *Journal of Environmental Radioactivity* 11: 71-95.

Knight, R.L., and S.F. Bates, eds. 1995. *A New Century for Natural Resources Management*. Island Press. Washington, DC.

Lemons, J. 1987. Environmental Science and Values. *The Environmental Professional* 9(4): 277-278.

Lemons, J. 1995. Shrader-Frechette's Schemata for Scientific Research: Implications for Environmental Professionals. *The Environmental Professional* 17(1): 72-77.

Lemons, J., and C. Malone. 1991. High-Level Nuclear Waste Disposal and Long-Term Ecological Studies at Yucca Mountain. *BioScience* 41(10): 713-718.

Lemons, J., and C. Malone. 1994. Integrated Environmental Management and Assessment of the Environmental Program at the Potential High-Level Nuclear Waste Repository at Yucca Mountain, Nevada. In *Implementing Integrated Environmental Management*. J. Cairns, Jr., T.V. Crawford, and H. Salwasser, eds. Virginia Polytechnic Institute and State University, Blacksburg, VA. pp. 41-59.

Lemons, J., C. Malone, and B. Piasecki. 1989. America's High-Level Nuclear Waste Repository: A Case Study of Environmental Science and Public Policy. *International Journal of Environmental Studies* 34(1): 25-42.

Malone, C.R. 1989. Environmental Review and Regulation for Siting a Nuclear Waste Repository at Yucca Mountain, Nevada. *Environmental Impact Assessment Review* 9(2): 77-95.

Malone, C.R. 1989-90. Environmental Performance Assessment: A Case Study of an Emerging Methodology. *Journal of Environmental Systems* 19(2): 171-184.

Malone, C.R. 1990a. Geologic and Hydrologic Issues Related to Siting a Repository for High-Level Nuclear Waste at Yucca Mountain, Nevada, USA. *Journal of Environmental Management* 30: 914-929.

Malone, C.R. 1990b. Implications of Environmental Program Planning for Siting a Nuclear Waste Repository at Yucca Mountain, Nevada. *Environmental Management* 14(1): 25-32.

Malone, C.R. 1990c. Performance Assessment and Long-Term Environmental Problems. *Project Appraisal* 5(3): 134-138.

Malone, C.R. 1991. The Potential for Restoring the Yucca Mountain Site to a Stable Ecological Condition. *The Environmental Professional* 13(3): 216-224.

McIntosh, R.P. 1985. *The Background of Ecology: Concept and Theory*. Cambridge University Press, Cambridge, England.

Mills, S.L., M.E. Soule, and D. Doak. 1993. The Keystone-Species Concept in Ecology and Conservation. *BioScience* 43(4): 219-224.

Mooney, H.A. 1991. Biological Response to Climate Change: An Agenda for Research. *Ecological Applications* 1(2): 112-117.

Murphy, D.D., and S.B. Weiss. 1992. Effects of Climate Change on Biological Diversity in Western North America: Species Losses and Mechanisms. In *Global Warming and Biological Diversity*. R.L. Peters and T.E. Lovejoy, eds. Yale University Press, New Haven, CT. pp. 355-368.

(NAEP) National Association of Environmental Professionals. 1995. Purpose and Objectives, Certified Environmental Professional (CEP) Program, Membership and Qualifications, Code of Ethics and Standards of Practice for Environmental Professionals. NAEP, Washington, DC.

(NDEP) Nevada Division of Environmental Protection. 1995. Environmental Manager Certification Program. NDEP, Carson City, NV.

Noble, I.R. 1993. A Model of the Responses of Ecotones to Climate Change. *Ecological Applications* 3(3): 396-403.

(NWTRB) U.S. Nuclear Waste Technical Review Board. 1994. Report to the U.S. Congress and the Secretary of Energy. NWTRB, Arlington, VA.

(OEP) White House Office of Environmental Policy. 1994. Ecosystem Management Initiative Overview. March 4. OEP, Washington, DC.

O'Farrell, T.P. 1994. Discussion with the U.S. Nuclear Waste Technical Review Board. Director, Yucca Mountain Environmental Study Project Office, EG&G Energy Measurements, Las Vegas, NV. March 21.

Parker, G.J., J.R. Krumell, K.E. LaGory, G.J. Marmer, and S.P. Goel. 1990. The Environmental Protection Program for Site Characterization at Yucca Mountain, Nevada. *The Environmental Professional* 12(3): 185-195.

Peterjohn, W.T., J.M. Melillo, F.P. Bowles, and P.A. Steudler. 1993. Soil Warming and Trace Gas Fluxes: Experimental Design and Preliminary Flux Results. *Oecologia* 93: 18-24.

Peterjohn, W.T., J.M. Melillo, P.A. Steudler, K. Newkirk, F. Bowles, and J.D. Aber. 1994. Responses of Trace Gas Fluxes and N Availability to Environmentally Elevated Soil Temperatures. *Ecological Applications* 4(3): 617-625.

Peters, R.L. 1992. Introduction. In *Global Warming and Biological Diversity*. R.L. Peters, and T.E. Lovejoy, eds. Yale University Press, New Haven, CT. pp. 3-14.

Peters, R.L., and T.E. Lovejoy, eds. 1992. *Global Warming and Biological Diversity*. Yale University Press, New Haven, CT.

Rapport, D.J., H. Regier, and T. Hutchinson. 1985. Ecosystem Behavior Under Stress. *American Naturalist* 125(5): 617-640.

Savory, A. 1988. *Holistic Resource Management*. Island Press, Washington, DC.

Schulze, E.D., and H. Zwolfer, eds. 1987. *Potentials and Limitations of Ecosystem Analysis*. Springer-Verlag, New York.

Shrader-Frechette, K.S. 1993. *Burying Uncertainty: Risk and the Case Against Geological Disposal of Nuclear Waste*. University of California Press, Berkeley, CA.

Shrader-Frechette, K.S. 1994. *Ethics of Scientific Research*. Rowman & Littlefield Publishers, Lanham, MD.

Shrader-Frechette, K.S., and E.D. McCoy. 1993. *Method in Ecology: Strategies for Conservation Problems*. Cambridge University Press, Cambridge, England.

Shrader-Frechette, K.S., and E.D. McCoy. 1994. Ecology and Environmental Problem-Solving. *The Environmental Professional* 16(4): 342-348.

Slocombe, D.S. 1993a. Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development. *Environmental Management* 17(3): 289-303.

Slocombe, D.S. 1993b. Implementing Ecosystem-Based Management. *BioScience* 43(9): 612-622.

Tausch, R.J., P.E. Wigand, and J.W. Burkhardt. 1993. Plant Community Thresholds, Multiple Steady States, and Multiple Successional Pathways. *Journal of Range Management* 46: 439-447.

Tausch, R.J., P.E. Wigand, and J.W. Burkhardt. 1994. Personal conversation. Research Scientists, U.S. Forest Service, Desert Research Institute, and Department of Range, Wildlife, and Forestry, University of Nevada System, Reno, NV.

Van Cleve, K.W., W.C. Oechel, and J.L. Hom. 1990. Response of Black Spruce (*Picea mariana*) Ecosystems to Soil Temperature Modifications in Interior Alaska. *Canadian Journal of Forest Research* 20: 1530-1535.

West, N.E., J. Stark, D.W. Johnson, M. Abrams, J.R. Ross, D. Heggem, and S. Peck. 1994. Effects of Climate on the Edaphic Features of Arid and Semiarid Lands of Western North America. *Arid Soil Research and Rehabilitation* 8: 307-351.

Westman, W.E. 1987. *Ecological Impact Assessment and Environmental Planning*. Wiley Interscience, New York.

Whitford, W.G. 1992. Effects of Climate Change on Soil Biotic Communities and Processes. In *Global Warming and Biological Diversity*. R.L. Peters and T.E. Lovejoy, eds. Yale University Press, New Haven, CT. pp. 93-117.

Winsor, M., and C. Malone. 1990. State of Nevada Perspective on Environmental Program Planning for the Yucca Mountain Project. *The Environmental Professional* 12(3): 196-207.

Woodley, S., J.J. Kay, and G. Francis, eds. 1993. *Ecological Integrity and the Management of Ecosystems*. St. Lucie Press, Waterloo, Canada.

Woodward, F.I. 1992. A Review of the Effects of Climate on Vegetation: Ranges, Competition, and Composition. In *Global Warming and Biological Diversity*, R.L. Peters and T.E. Lovejoy, eds. Yale University Press, New Haven, CT. pp. 105-123.

(FS) USDA Forest Service. 1992. Taking an Ecological Approach to Management. WO-WSA-3. FS, Washington, DC.

(FS) USDA Forest Service. 1994. An Ecological Basis for Ecosystem Management. GTR RM-246. FS, Fort Collins, CO.

(FWS) U.S. Fish and Wildlife Service. 1994. An Ecosystem Approach to Fish and Wildlife Conservation: An Approach to More Effectively Conserve the Nation's Biodiversity. March. FWS, Washington, DC.

(FWS) U.S. Fish and Wildlife Service. 1995. An Ecosystem Approach to Fish and Wildlife Conservation: Concept Document. February. FWS, Washington, DC.

(GAO) U.S. General Accounting Office. 1994. Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach. GAO/RCED-94-111, GAO, Washington, DC.

Gore, A. 1993. Reinventing Environmental Management. Accompanying report of the National Performance Review. September. U.S. Government Printing Office, Washington, DC.

Grumbine, R.E. 1994a. What is Ecosystem Management? *Conservation Biology* 8: 27-38.

Grumbine, R.E. (ed.). 1994b. *Environmental Policy and Biodiversity*. Island Press, Washington, DC.

Keystone Center. 1995. Keystone National Policy Dialogue on Ecosystem Management. February 22-24. The Keystone Center, Keystone, CO.

Knight, R.L. and S.F. Bates (eds.). 1995. *A New Centuary for Natural Resources Management*. Island Press, Washington, DC.

Malone, C.R. (1995). The Federal Initiative on Ecosystem Management. *NAEP News* 20: in press.

Pearman, D.W., Jr. 1994. Land and Facility Use Management Policy and Requirements. August 26. U.S. Department of Energy, Washington, DC.

Savory, A. 1988. *Holistic Resource Management*. Island Press, Washington, DC.

Slocombe, D.S. 1993a. Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development. *Environmental Management*. 17: 289-303.

Slocombe, D.S. 1993b. Implementing Ecosystem-Based Management. *BioScience* 43: 612-622.

U.S. Senate. 1994a. Ecosystem Management: Status and Potential. Senate Print 103-98, December. U.S. Government Printing Office, Washington, DC.

U.S. Senate. 1994b. The Ecosystem Management Act of 1994. S. 2189. U.S. Senate, Washington, DC.

Walker, J.B. 1995. Letter to J. Glickman, U.S. Department of Energy. March 7. Nuclear Waste Project Office, Carson City, NV.

ATTACHMENT G

ENVIRONMENTAL COMMENTS ON THE EIS NOI FOR THE YUCCA MOUNTAIN PROJECT

1. Background

Choices about what knowledge to base public decisions on and how the knowledge is used influence human society. With respect to protecting the environment, the National Environmental Policy Act (NEPA) focuses on this concept and seeks to improve the use of knowledge in public affairs (**cf. "Science and the National Environmental Policy Act",*The Environmental Professional* 15: 1-160, 1993**), such as disposing of nuclear waste. In the context of the U.S. Department of Energy (DOE) Yucca Mountain Project this aspect of NEPA is of paramount importance because of the many uncertainties associated with isolating nuclear waste for 10^6 years. Fortunately, the timing for the Yucca Mountain environmental impact statement (EIS) coincides with a transition in federal environmental policy that is making the resource management process more open to stakeholder participation and collaborative decisionmaking (**"The Federal Ecosystem Management Initiative", *The Environmental Professional* 18: 1-235, 1996**). This ongoing initiative stands to benefit stakeholders in the Yucca Mountain Project by making available knowledge relative to the NEPA process that otherwise might be denied, i.e., if DOE adheres to the relevant environmental policies established by the Secretary of Energy in 1994.

The seeds within DOE for the transition away from autocratic, closed environmental decisionmaking driven by the desire to make proposed projects succeed are the ***Secretarial Policy on the National Environmental Policy Act*** of June 13, 1994 and the agency's December 21, 1994, ***Land and Facility Use Policy***. The latter, issued by the Secretary of Energy and explained in ***Department of Energy - Stewards of a National Resource***, is a resource stewardship policy that invokes ecosystem management to integrate DOE's mission, economics, ecologic, social, and cultural factors. The intent is that a comprehensive resource management plan be prepared for each DOE site, which should include Yucca Mountain. Other federal agencies took steps prior to DOE's action to adopt ecosystem management in complying with the White House National Performance Review (***Creating a Government That Works Better & Costs Less*, September 1993**) that called for agencies to adopt "a proactive approach to ensuring a sustainable economy and a sustainable environment through ecosystem management." The action steps for accomplishing this

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were set forth in ***The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies***, the June 1995 report of the Interagency Ecosystem Management Task Force which participating agencies, including DOE, agreed to implement.

In the past, effective policies were lacking within DOE for creating and providing knowledge for the public and for opening the agency's environmental decionmaking process. This was despite NEPA's mandate for federal agencies (a) to utilize a systematic, interdisciplinary approach to protecting the environment, (b) to ensure the integrated use of environmental information in planning and decisionmaking, and (c) to initiate and use ecological information in the planning and development of resource-oriented projects. These directives are meant by NEPA to be made apparent in EISs for projects that might significantly affect the human environment, including that for both present and future generations. They are included in the ***Secretarial Policy on the National Environmental Policy Act*** of June 13, 1994.

The emergence of initiatives like ecosystem management now render it federal policy that the public be provided the knowledge envisioned and explicitely mandated by NEPA. This essentially moral framework gives direction to the links between knowledge and action that must be forged under the NEPA Section 102 mandate. This is part of the ethical dimension explicitly written into NEPA in terms of a call for results conditioned by context-specific knowledge including input from affected parties (stakeholders) and by the ethical concerns articulated in NEPA Section 101. Thus, in view of DOE's commitment to comply with the substantive spirit of NEPA and to adopt ecosystem management, it is crucial that these policies be reflected in the EIS IP and achieved by the EIS for the Yucca Mountain Project.

A policy conceptually related to ecosystem management is the November 19, 1993, ***Common Sense Initiative*** undertaken by the U.S. Environmental Protection Agency (EPA) (**cf. *NAEP News* 20(5): 10-11**). The ecosystem management initiative adopted by DOE, as well as by EPA, and the EPA's ***Common Sense Initiative*** share a recognition that ecosystems are an integrated system of air, water, land, and biota requiring holistic environmental management. They also recognize that human society, ethics, and democratic principles regarding protection of resources are rapidly moving away from the traditional adversarial relationship with federal agencies and toward opening environmental decisionmaking to stakeholders in collaboration with government.

A preview of DOE's response to the ecosystem management initiative illustrated the developing awareness within the federal government of its responsibilities to the public regarding environmental information and decisionmaking (***Ecosystem***

Management: Federal Agency Activities, Congressional Research Service, 94-339 ENR, April 19, 1994). A subsequent description of DOE's current policy regarding the ecosystem management initiative will appear early in 1996 ("The Federal Ecosystem Management Initiative," *The Environmental Professional* 18: 1-235, 1996). Both presentations discuss the importance of DOE's ecosystem management policy and note that NEPA "gave the nation an environmental mandate but no definite plan to achieve environmental goals. Now, the ecosystem approach offers a plan to move towards achievement of essentially the same environmental goals." Additionally, DOE views implementation of ecosystem management as part of the agency's pursuit of Environmental Total Quality Management (TQM) (cf. *Applying Total Quality Management to Environmental Activities*, Workbook for a conference sponsored for and supported by DOE, January 25-27, 1991, La Jolla, California, and, *Environmental TQM, Second Edition*, McGraw-Hill, Inc., 1995). Environmental TQM is viewed by DOE headquarters as being equivalent to ecosystem management in that both concepts seek to sustain ecosystems for supporting economic development and communities for future generations (i.e., sustainable development, cf. *Toward Sustainable Development*, Island Press, 1994). This is evident in DOE's adoption of the same framework for ecosystem management to achieve sustainable development as that set forth by the White House, which is:

- Define and identify ecosystems of concern;
- Involve stakeholders to develop a shared vision of an ecosystem's desired future condition;
- Characterize the ecosystem, its holistic environmental condition, and trends for the ecosystem;
- Establish ecosystem goals;
- Develop and implement an action plan for achieving the goals;
- Monitor conditions and evaluate results; and
- Adapt management according to the new information.

The framework established by DOE's *Land and Facility Use Policy* should apply to the NEPA process underway for the Yucca Mountain Project. This much has been acknowledged by the project's management (W.E. Barnes' letter of November 9, 1995, to the State of Nevada Department of Administration). In this letter, Mr. Barnes, manager of the Yucca Mountain Project,

asserts that ecosystem management is and has alway been practiced by the DOE at Yucca Mountain. Yet Mr. Barnes also asserts that the site-wide resource management plan, being prepared by the Nevada Test Site in accordance with principles of ecosystem management consistent with the Secretary's resource management policy of December 21, 1994, does not apply to the Yucca Mountain Project. Moreover, Mr. Barnes stated that there is no intention to prepare such a management plan for the project, which contradicts his assertion that the Yucca Mountain Project embodies the ecosystem management concept. (Barnes' letter responded to an August 28, 1995, inquiry from the State of Nevada Department of Administration about the consistency between the Yucca Mountain Project and both DOE headquarters policy and the Nevada Operations Office policy regarding implementing ecosystem management as set forth by the White House and adopted by DOE's own ***Land and Facility Use Policy***.)

Over the years that the Yucca Mountain Project's environmental program has been underway, the State of Nevada and the Nuclear Waste Technical Review Board have consistently faulted the program because it lacks an ecosystem approach to environmental protection (cf. ***The Environmental Professional,*** **Vol. 17: 271-284**). Instead, the program relies on a piecemeal, compartmentalized approach based on population biology and community ecology totally without benefit of interdisciplinary integration. This is the result of (**a**) environmental management that is unqualified in EIA and ecosystem management regarding compliance with the substantive spirit of NEPA and (**b**) support contractors who are equally unqualified with respect to the scientific as well as the ethical aspect of environmental practice. (As noted later in these comments, in the context of the Yucca Mountain Project's ongoing NEPA process, these discrepancies contradict ***40 CFR 1502.6*** and ***40 CFR 1502.24*** concerning interdisciplinary studies and scientific integrity and are therefore inconsistent with the ***Secretarial Policy on the National Environmental Policy Act*** of June 13, 1994.)

Thus, the Yucca Mountain environmental program lacks scientific integrity and credibility due in part to the absence of competent environmental professionals capable of interdisciplinary teamwork and bound to codes of environmental ethics and best standards of professional environmental practice. To its credit, the NTS environmental program, on the other hand, benefits from qualified environmental management. This accounts for the NTS's adoption of ecosystem management upon which to base resource management planning in the course of complying with NEPA on a site-wide basis, except for the portion of the site occupied by the Yucca Mountain Project. Unfortunately, the Yucca Mountain Project fails to require attention to scientific, ethical, and professional precepts in carrying out the NEPA process. This

situation exists in part because of the September 1, 1994, ***Memorandum of Agreement*** between the DOE Nevada Operations Office and the Yucca Mountain Project Office that sets the two apart with respect to environmental protection, compliance decisionmaking, and the NEPA process.

As noted, the Yucca Mountain NEPA compliance program is driven by the desire to implement the project, the decision for which is already made on the part of the DOE. As a consequence of this predetermined decision, little importance is likely to be given to the EIA planning process regarding cognitive reform measures implicit in DOE's ***Secretarial Policy on the National Environmental Policy Act*** and in the ***Land and Facility Management Policy***, the latter of which explicitely embraces ecosystem management and collaborative environmental decisionmaking betweem DOE and its stakeholders. However, the preparation of the Yucca Mountain EIS IP will provide DOE the opportunity to redress this and other shortcomings of its environmental program.

The manner in which EIA and the EIS planning processes are undertaken for the Yucca Mountain Project represents a major determinant of the outcome of the NEPA process because planning for the EIS IP plays a central role in structuring and applying knowledge to carry out EIA to support environmental decisionmaking. Adequate implementation planning must assure that all practical alternatives within the project will be pursued in light of sufficient, credible scientific information for EIA and long-term environmental protection. This requires an effective interdisciplinary approach to EIA for (a) acquiring empirical baseline information, (b) empirical information about potential adverse impacts of the proposed action, (c) reducing EIA uncertainties through environmental risk analysis, and (d) developing adequate plans for monitoring, managing, and mitigating potential negative impacts up to 10° years. The only manner by which the last requirement can be achieved over such a great spans of time is by strict adherence to impact avoidance (cf. ***The Environmental Professional*** 12: 196-207).

Traditionally DOE relies heavily on subjective "expert" judgement for its EIA process instead of pursuing empirical and quantitative approaches. Consequently, views regarding impacts fail to rely on systematic empirically based findings and instead are derived from personal opinion. This problem is further compounded by the absence of any formal methodology for treating subjective judgement for EIA and for maintaining a sound, defendable basis for inference and decisionmaking. Without a consistent means of guiding the application of personal opinion through the Yucca Mountain EIA process, a critical source of uncertainty and imprecision is left untreated to degrade the predictive credibility of the process and procedures that created

the project's EIS, and ultimately the EIS itself. This is the flawed scenario currently being pursued for the Yucca Mountain Project.

If the DOE continues to assert, as Mr. Barnes did, that its environmental program at Yucca Mountain is based on ecosystem management without first restructuring the environmental program, in the end the EIA process will rely on subjective opinion that is neither visible nor formal to the extent that current practice and the ecosystem approach to environmental management dictate. In this case, environmental impact analysts will fail to separate objective fact from personal opinion and instead will switch between the two conditions as the need arises to falsely justify a predetermined decision to develop the project. This situation would thus repeat the mistakes evident throughout the DOE's 1986 statutory EA for the Yucca Mountain site (**DOE/RW-0073, May 1986**). Such a strategy, which the Yucca Mountain environmental program currently is repeating, will fail to convince stakeholders of DOE's good faith in carrying out EIA as well as call the credibility of the EIS into question on grounds of not conforming to the norms of sufficiency. If this scenario prevails, DOE ultimately will compound and perpetuate its lack of integrity regarding the NEPA process because there will be no direct measure to extract from the Yucca Mountain EIS for deriving a value of integrity. Thus, in the end the EIS will lack credibility and fail to achieve "full compliance with the letter and spirit of" NEPA as stipulated by the ***Secretarial Policy on the National Environmental Policy Act*** of June 13, 1994.

The complimentary policy frameworks of NEPA and of ecosystem management offer DOE an opportunity to furnish stakeholders with the knowledge needed for responsible environmental decisionmaking for the Yucca Mountain Project. Ecosystem management principles are consistent with NEPA's policy, and their implementation in the Yucca Mountain Project would provide stakeholders the basis for obtaining information necessary for social choice that more readily allows ethically based, rational decisionmaking. Thus, knowledge provided by the DOE through the NEPA process should create links between the affected public and federal resource management policy. As noted later, this is being achieved by other federal agencies in the Yucca Mountain region (e.g., the Department of Defense, Bureau of Land Management, Fish and Wildlife Service, National Park Service, and the USDA Forest Service) and by DOE itself for the NTS (**cf. *Five-Party Cooperative Agreement*, May 1994**, for federal lands surrounding the NTS, and Yucca Mountain, that includes the State of Nevada as a party). The Yucca Mountain Project stands as an exception to how public land and resources are being managed throughout southern Nevada.

Achieving NEPA's ethical policy goals for the Yucca Mountain Project will require a new environmental rationality and ethic that historically has been missing from DOE's NEPA process. Credible execution of the NEPA process rests on a recourse to competently executed science. As noted, this demands control of the process by professionals bound by codes of ethical behavior and standards of practice that assure proper weight being given to environmental factors. Fostering greater environmental sensitivity in planning and decisionmaking is essential for the Yucca Mountain Project if DOE headquarters and the Secretary wish to be taken seriously with respect to its new ecosystem-based ***Land and Facility Management Policy***.

2. **Purpose of the Comments**

Environmental documentation within the DOE routinely is prepared to justify decisions already made, and the Yucca

Mountain Project is no exception to that rule. The following comments recognize that fact and discuss how this must be avoided in the course of pursuing legitimate environmental impact assessment (EIA) for the Yucca Mountain Project EIS that is consistent with the ***Secretarial Policy on the National Environmental Policy Act*** of June 13, 1994. The intent of the State of Nevada is that the issues raised here be explicitely dealt with by the DOE in its EIS implementation plan (EIS IP) for the project. If the DOE fails to do so its NEPA process for the project will be seen by the State of Nevada as another token, insufficient compliance effort that is fundamentally flawed and lacks credibility, and ignores the stakeholders in the process.

3. **NEPA Process and Review**

The national policy set forth by NEPA encourages (**a**) harmony between man and the environment, (**b**) minimizing harm to the environment, (**c**) fostering man's well being, and (**d**) enhancing knowledge about ecosystems. Included among the goals is protecting the environment for the benefit of future generations. These are important substantive objectives that an EIS for a repository at Yucca Mountain must address in the forthcoming EIS IP (***40 CFR 1500.1*** **and the** ***Secretarial Policy on the National Environmental Policy Act*****, June 1994**). To assure that is done, the DOE should upgrade its NEPA process by incorporating valid independent peer review of the EIS IP and the draft and final EISs for the Yucca Montain Project. The issue of independent peer review of EIA and the EIS and how it will be resolved must appear in the EIS IP.

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4. **Qualified Interdisciplinary Expertise**

Another important aspect of NEPA that must be evident in the EIS IP is that an EIS must be prepared by an interdisciplinary team (***40 CFR 1502.6***), not simply by a group of people with different disciplinary backgrounds. To date, the DOE has not established such a team and instead is pursuing a rigidly compartmentalized approach. The EIS IP must demonstrate how the necessary methodology, scientific accuracy, and professional integrity (***40 CFR 1502.29***) will be achieved for the Yucca Mountain Project EIS with or without an integrated approach and what expertise will be involved (***40 CFR 1502.17***).

This issue is especially important with respect to DOE's excessive reliance on contractors to fulfill its NEPA responsibilities. In the case of the Yucca Mountain Project, the DOE has minimal environmental expertise among its staff, a critical matter in terms of achieving appropriate oversight of the work performed by environmental contractors. It is interesting to note that with respect to high priority projects that "present unusually controversial or sensitive issues," such as the Yucca Mountain Project, heavy reliance on support contractors is counter to the ***Secretarial Policy on the National Environmental Policy Act*** of June 1994. Section IV. A on pages 5 and 6 of the policy states that DOE "personnel rather than contractors will be used, to the maximum extent practicable." The deficiency regarding qualified environmental management for the Yucca Mountain Project, if not corrected, will result in an EIS that consists of a perfunctory paper-compliance approach to the NEPA process and a continuing lack of a proper environmental ethic on the part of both the DOE and its contractors.

Thus, it is essential that the EIS IP confront how existing weaknesses in environmental expertise and ethics will be overcome so that scientifically and objectively sound EIA will result from the NEPA process. A part of achieving this is the aforementioned necessity of the DOE having an independent oversight review body to appraise the EIA process, including the EIS IP and the environmental documentation aspects of the Yucca Mountain Project. This is crucial if the DOE is to overcome its traditional lack of enviromental credibility and its inattention to stewardship of resources as the Secretary of Energy sought to establish with the ***Land and Facility Use Policy*** of December 21, 1994. How the Yucca Mountain Project will apply ecosystem management to integrate DOE's mission, economics, ecologic, social and cultural factors in a comprehensive resource management plan the Yucca Mountain site must appear in the EIS IP, contrary to Mr. Barnes' view (**W.E. Barnes' letter of November 9, 1995, to the State of Nevada Department of Administration**).

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5. **Council on Environmental Quality**

Another means of achieving credibility and public trust is for the DOE to implement the Council on Environmental Quality (CEQ) NEPA referral process whereby the CEQ becomes involved when there is a threat of the NEPA process or its outcome being fundamentally at odds with NEPA's mandate (cf. **"Science and the National Environmental Policy Act", *The Environmental Professional* 15: 1-160, 1993)**. Such a threat clearly exists due to the unique timeframe that the Yucca Mountain EIS must address and NEPA's mandate regarding responsibilities to future generations. A particularly relevant part of this concern is DOE's persistent refusal to adopt an ecosystem approach to understanding the long-term consequences of a heat-disturbed ecosystem above the repository.

A related reason for the CEQ to become involved in the NEPA process is the inability of the DOE to responsibily address cumulative impacts in the timeframe of 10^3 to 10^6 years regarding anticipated releases of radionuclides into the groundwater environment underlaying Yucca Mountain and release carbon-14 into the atmosphere. For the DOE as an institution, cumulative impact assessment (***40 CFR 1508.7***) has always been a difficult and neglected aspect of the EIA process. In this respect the CEQ is committed to working with federal agencies to find ways to look at the issue, and how DOE will take advantage of the opportunity should be reflected in the Yucca Mountain EIS IP.

6. **Cumulative Impacts, Connected Actions, and Segmentation**

In DOE's NEPA process, cumulative impacts (***40 CFR 1508.7***) typically are ignored or brushed aside with cursory personal opinion that such effects will not occur. In the case of potential long-term radiation health impacts from the Yucca Mountain Project, the EIS IP must address cumulative effects supported by scientific data and analysis. Adequate peer review of the Yucca Mountain NEPA process should focus on assessment of cumulative impacts.

Additionally, ***40 CFR 1508.25*** states that an agency should analyze "connected actions" in one EIS. The CEQ regulations are directed at avoiding improper segmentation, wherein the significance of the environmental impacts of an action as a whole would not be evident if the action were to be broken into component parts and the impacts of those parts analyzed separately. The EIS IP for the Yucca Mountain Project must address this matter with respect to the disconnected EIA between the NTS and the repository project and the exclusion of Yucca Mountain from the regional environmental resource management plan underway for the NTS site-wide EIS. This is especially important

with respect to (a) groundwater issues and past testing of nuclear weapons at NTS and (b) the ongoing environmental restoration program at the site.

7. **Truly Significant, Reasonably Foreseeable Long-Term Impacts**

With respect to NEPA's focus on cognitive reform regarding understanding ecosystems, the Yucca Mountain EIS IP must provide for the improved utlization of knowledge of ecosystems and their resources. This is because potential adverse environmental and human health consequences are associated with the "truly significant" issue *(40 CFR 1500.1)* of "reasonably foreseeable" long-term (10^6 years) impacts (*40 CFR 1502.22*) of a repository on the ecosystem above the facility and the secondary impacts of an altered ecosystem on repository performance. At sufficiently high thermal loads of nuclear waste the ecosystem is likely to experience impacts from the heat of radioactive decay. Coupled with anticipated increases in ambient temperature resulting from global climate change (warming) higher temperatures will induce ecosystem responses that are not understood for the Yucca Mountain ecosystem. The EIS IP therefore must contain provisions for understanding how increased temperatures both above and beneath the ground surface at Yucca Mountain will affect the environment (*40 CFR 1502.15 and 1508.8*) and how the environmental consequences (*40 CFR 1508.16*) will influence protection or impsct mitigation (*40 CFR 1508.20*) with respect to resources like groundwater for future generations.

Thus,. in keeping with NEPA's mandate for creating knowledge about ecosystems, the DOE is challenged to understand how the ecosystem at Yucca Mountain will respond to dual sources of heat stress and how in turn altered ecosystem conditions might influence long-term repository performance. The information needed to meet the challenge of scientific integrity (*40 CFR 1502.24*) and to assess signifance (*40 CFR 1508.27*) must be empirical, quantitative, and should be made available within the period being allocated by DOE for preparing the EIS. The challenge cannot be met with DOE''s traditional application of subjective expert judgement to EIA in cases of unavailable information (40 CFR 1508.22). Plans for resolving this issue in a manner that withstands independent expert peer review must be presented in the EIS IP.

8. **Succeeding (Future) Generations**

Many EISs prepared by the DOE do little to substantively protect the environment, particularly in regards to future generation where, aside from such concerns as transportation accidents, most of the threat posed by geologic disposal of

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nuclear wastes lies. In the case of the Yucca Mountain Project, consideration of long-term cumulative impacts to the environment and therefore to humans poses a serious threat to NEPA compliance and is a "truly significant" issue that the NEPA process must address (*40 CFR 1500.1* and the ***Secretarial Policy on the National Environmental Policy Act***, June 13, 1994). The undeniable knowledge that such consequencies eventually will materialize poses a fundamental conflict with NEPA's mandate that each generation be a trustee of the environment for succeeding generations. This is an issue that the EIS IP must confront and set forth the means for resolving via EIA and the NEPA process.

9. **Supplemental Information**

As noted above, the Yucca Mountain environmental program has been faulted over the years by oversight bodies for not initiating ecosystem-based studies necessary for understanding the long-term consequences that a repository might have on future generations. It probably is too late to gain quantitative empirical insight to that issue in accordance with DOE's current NEPA schedule. However, the need for such studies remains critical. Therefore, the EIS IP should present plans for obtaining the information and presenting it later in a supplemental statement (*40 CFR 1502.9(c)(1)*. Ongoing research of a related nature regarding global warming demonstrates that such studies are feasible, that significant adverse impact are reasonable foreseeable, and that the costs of acquiring such information are not exorbitant (***40 CFR 1502.22, The Environmental Professional* 15: 1-160, 1993**, and ***The Environmental Professional* 17: 271-284, 1995**).

10. **Environmental Risk Analysis**

Central to NEPA is the ability to make predictions about environmental outcomes resulting from alternative courses of action such as thermal loading scenarios for a repository at Yucca Mountain. The soundness of decisionmaking is dependent on this predictive capability. In turn, the soundness of the very long-term predictions, such as the Yucca Mountain Project faces, depends on the inclusiveness, representativeness, and explanatory power of simulation models derived from sound empirical information. Gaps in knowledge should be eliminated whereever possible. Decisionmaking, on the other hand, like that under NEPA, should be based on best practicable methodology, i.e., environmental risk aanalysis. The extent of uncertainty that can be tolerated in EIA for the Yucca Mountain Project and that is unlikely to be resolved by risk assessment must be made clear in the EIS by a methodology presented in the EIS IP.

Functional characteristics of ecosystems are important components of ecosystem health and are closely related to resource management goals. For this reason, it is important to assure the long-term protection of ecosystem function as well as ecosystem structure. The best way to assess the protection of ecosystem function is to develop models to predict effects of stress on function, to make decisions among alternatives and take preventive action based on the model's predictions. The importance of establishing methods for determining ecosystem function and resilience transcends scientific interest because methods are important to environmental risk managers as tools needed to predict impacts and protect sustained societal use of ecosystems and long-term productivity. Increased awareness of information on ecosystem function and new ways of viewing ecosystem protection will improve the decisions made under NEPA (**cf.** ***The Environmental Professional*** **15: 1-160, 1993 and** ***The Environmental Professional*** **18: 1-235, 1996**).

Ecological risk assessment is a scientific process for estimating, with a known degree of certainty, human effects on the integrity of ecosystems, i.e., ecological function and resilience. At this stage of the Yucca Mountain Project there is extensive scientific uncertainty with respect to the potential threat that excessive heat associated with thermal loading would pose to the ecosystem and in turn to a nuclear waste repository at Yucca Mountain. Ecological risk analysis should be used by DOE to reduce that uncertainty and the approach to its use should be part of a long-term ecosystem studies plan presented in the EIS IP. Otherwise, the DOE must pursue the worse-case scenario for a repository at Yucca Mountain that could result from a combination of global climate change and a high thermal load (**cf.** ***The Environmental Professional*** **17:271-284**).

The steps in this risk-approach are for the DOE to (**a**) define the end point conditions that must be protected, (**b**) characterize the environment that will exist under global warming, and (**c**) assess the hazard to the Yucca Mountain ecosystem that will result from thermal loading and threaten repository performance and the long-term health of the groundwater and future generations. The extensive uncertainty that presently exists in all three step can be reduced only by empirical scientific studies. Any effort to resolve the uncertainties by subjective opinion alone will be unsatisfactory. Thus, it is essential that DOE present study plans in the EIS IP for an ecosystem-based approach in the context of ecosystem management. This will provide a capability for resolving EIA uncertainty with respect to the thermal loading issue through the use of predictive models of long-term ecosystem outcome.

11. Environmental Life Cycle Assessment

In 1993 the U.S. EPA took steps to encouraged waste management activities to apply environmental life cycle assessment to environmental protection (cf. ***Life Cycle Design Guidance Manual*, EPA/600/R-92/226, January 1993, and, *Life-Cycle Assessment: Guidelines and Principles*, EPA/600/R-92/245, February 1993**). Life cycle assessment is a holistic approach that analyzes the entire system around waste disposal. Applied to the Yucca Mountain Project, it would encompass raw materials used for manufacturing nuclear waste canisters and transporting the waste to a repository, as well as reporisory construction, operation, and closure. All the downstream and upstream effects of the operation of waste disposal would be factored into EIA to provide a holistically view of the environmental consequences associated with the Yucca Mountain Project.

This departure away from DOE's present piecemeal, compartmentalized approach to the NEPA process would be a departure from evaluating nuclear waste options that look at single components of the effort in step-wise manner. Such a procedure could be initiated by integrating EIA into DOE's systems engineering program. This would permit the systems engineering analyses to address alternatives within the project that would allow the best environmental decisions to be made to the benefit of the holistic repository program. To this end, the EIS IP should present a framework for environmental life-cycle assessment that would assure environmental decisionmaking in the full long-term context of the Yucca Mountain Project.

12. Resource Management

As noted earlier, the White House has instructed federal agencies to adopt ecosystem management as the basis for protecting public land and resources. The DOE, while tardy in adopting the ecosystem approach for its policy of managing land and facilities, now has joined the other federal agencies in doing so. The first DOE site to take steps in this respect was the NTS where a site-wide EIS now in preparation will encompass a resource management plan founded on ecosystem management. It is unfortunate the the Yucca Mountain Project has excluded itself from this activity and vows not to initiate resource management activities (***Memorandum of Agreement Between DOE Nevada Operations Office and the Yucca Mountain Site Characterization Office*, UN-27, September 1, 1994, and, W.E. Barnes' letter of November 9, 1995, to the State of Nevada Department of Administration**). This is particularly so in view of the fact that all public land adjacent to and surrounding Yucca Mountain is being managed in accordance with ecosystem management (Figure 1) (cf. ***Five-Party***

Cooperative Agreement, May 1994).

The letter from Mr. Barnes, Manager of the Yucca Mountain Project, asserted that the project already has incorporated the principles and concepts of ecosystem management into its program. As evidence of this, Mr. Barnes refers to the *Yucca Mountain Project Environmental Management Plan*, YMP/93-04) and the *Yucca Mountain Project Annual Site Environmental Report* procedure as reflecting the principles of ecosystem management and sufficing for the project's compliance with such DOE policies as the *Secretarial Policy on the National Environmental Policy Act*, June 13, 1994 and the agency's December 21, 1994, *Land and Facility Use Policy*. Neither of the documents cited by Barnes has been revised to reflect an ecosystem approach consistent with either of the Secretary of Energy's policies regarding such matters.

Because the Yucca Mountain Project has ignored independent expert advice about adopting an ecosystem approach to its environmental program (cf. *The Environmental Professional* 17:271-284, 1995), the EIS IP for the project should explain its rationale for "complying" with the Secretary of Energy's directive in the *Land and Facility Use Policy* that, "Our (land) stewardship will be based on the principles of ecosystem management and sustainable development."

13. **Post-closure Project Monitoring**

The DOE's Yucca Mountain environmental program has conducted environmental monitoring meant to detect significant adverse impacts of site characterization activities. Because monitoring did not commence sufficiently before the environmental disturbance activities began, there is not adequate environmental baseline information reflecting natural temporal variability against which to compare the results of the site charactization effects monitoring. Moreover, the limited monitoring that has occurred is too thinly spread over the diverse transitional desert ecotone at Yucca Mountain to credibly characterize environmental conditions. Additionally, with such limited monitoring it is not possible to separate human perturbations from natural temporal environmental variability characteristic of ecosystems. Thus, observed conditions cannot be attributed to either human intervention or to wide-ranging natural differences in temporal patterns, in which case, like the Yucca Mountain Project, the monitoring data are not credible for EIA prediction.

The DOE sought to correct this situation by altering the monitoring design while at the same time curtailing environmental monitoring activities, all to no avail. Despite these shortcomings, the Yucca Mountain Project plans to base EIA for

the repository EIS on a restriced amount of environmental information.

It is, therefore, essential that the EIS IP explain the rationale behind this impact assessment scheme and how the DOE perceives the information being made statistically credible in the face of its present limitations. This will provide the DOE an opportunity to address the assertions by Mr. Barnes that the field program is consistent with an ecosystem approach. Describing in the EIS IP how the environmental monitoring and the EIA activities currently underway, and defended by the DOE as being adequate, will provide the opportunity to address issues of long-term thermal impacts on the ecosystem at Yucca Mountain and the potential threat to repository performance. The EIS IP also should explain how the environmental program will compensate for the lack of process-based ecosystem simulation modeling necessary for predicting long-term impacts to the Yucca Mountain ecosystem.

14. **Policy and Guidance for the NEPA Process**

The EIS IP must list and discuss the policies and guidance (e.g., from the DOE Office of NEPA Oversight) to be followed regarding NEPA compliance for the Yucca Mountain EIS. Because of the intent of the Nuclear Regulatory Commission (NRC) to adopt DOE's EIS, the NRC's NEPA policy and guidance to be satified must be included.

Ongoing site characterization activities heavily rely on numerous requirements documents that guide the Yucca Mountain Project. The role that these and similar requirements will play in describing all phases of the proposed action (construction, operation, closure, post-closure monitoring) and carrying out EIA for NEPA compliance also must be identified and discussed in the EIS IP. The EIS IP should be clear about the role and use of this information in guiding EIA for repository project.

With respect to compliance with routine media-based environmental regulatory requirements, a statement in the EIS IP and ultimately in the EIS itself that the proposed action would be in compliance with applicable regulations, DOE Orders, and NRC licensing will not substitute for a presentation of impacts. The adage that "the whole is greater than the sum of the parts" is true with respect to ecosystem-based EIA. Thus, credible and responsible NEPA compliance requires a holistic, ecosystem approach to EIA whereas media-based environmental regulations address only restricted components of the integrated environment. The EIS IP that is to follow from comments such as these must demonstrate DOE's recognition that NEPA is the only environmental law requiring holistic, integrated environmental impact assessment. The DOE's ***Land and Facility Use Policy*** and the ***Secretarial Policy on the National Environmental Policy Act***

commit the Yucca Mountain Project to: "Full compliance with the letter and spirit of the National Environmental Policy Act (NEPA), our national charter for protection of the environment, is an essential priority for the Department of Energy, consistent with our core values." (**Secretary of Energy** ***National Environmental Policy Act Policy Statement***, June 13, 1994.

customs cannot be taken for granted. Thanks to DOE's commitment and encouragement from other agencies, however, ecosystem management at the Nevada Test Site is becoming a reality, and the prospects for implementing it at other DOE sites are encouraging.

DOE's success joins a growing number of initiatives throughout the federal government that are employing an ecosystem approach for managing our nation's resources.[5] Collectively, these efforts can help sustain public lands for the benefit and enjoyment of generations to come.■

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NOTES

1. DOE, *Accelerating Cleanup: Focus on 2006*, DOE/EM-0327 (Washington, DC: DOE, 1997); DOE, *Environmental Restoration and Waste Management Site-Specific Plan: Fiscal Years 1994-1998* (Las Vegas: DOE Nevada Field Office, 1997).

2. DOE, "Framework for the Resource Management Plan," in *1996 Final Environmental Impact Statement for the Nevada Test site and Off-Site Locations in the State of Nevada*, NV DOE/EIS 0243 (Las Vegas: DOE Nevada Field Office, 1996).

3. D.S. Slocombe, "Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development," *Environmental Management* 17 (1993), pp. 289-303; R.E. Grumbine, "What Is Ecosystem Management?" *Conservation Biology* 8 (1994), pp. 27-38.

4. S.L. Yaffee et al., *Ecosystem Management in the United States* (Washington, DC: Island Press, 1996).

5. Interagency Ecosystem Management Task Force, *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies* (Washington, DC: White House Office of Environmental Policy, 1995-1996).

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ATTACHMENT H

VIEWS ON THE FEDERAL INITIATIVE ON ECOSYSTEM MANAGEMENT AND THE U.S. DEPARTMENT OF ENERGY

Introduction

In recent years, fundamental changes have been occurring in the concepts of managing environmental resources. Traditionally, resource management was undertaken to maximize yield of or to protect one or more resource components. Concepts of a holistic, intergrated environment and of a harmony between man and his environment played small roles in conventional resource management. However, this is now changing with the evolving concept of ecosystem management that strives to manage the environment consistent with principles of ecological, economic, and social sustainability and of mutual harmonious benefit among those sectors of human society. Thus, ecosystem management involves environmental management that (1) recognizes social and economic viability within functioning ecosystems, (2) is at a scale compatible with natural processes, (3) is cognizant of nature's time frames, and (4) is realized through effective partnerships among private, local, state, and federal interests.

The goal of ecosystem management is to preserve, restore, or simulate ecosystem integrity (as defined by ecosystem structure and function) consistent with maintaining socioeconomic sustainability (Grumbine 1994a, Keystone Center 1995, Slocombe 1993a and 1993b). Thus, the concept of ecosystem management recognizes human needs and the importance of developing a vision that integrates ecological and cultural factors and therefore involves a recognition of the interrelationship of a healthy economy and a healthy environment. It focuses on policies that foster both a sustainable economy and sustainable ecosystems that support biodiversity.

Ecosystem management policies and activities within the federal land management agencies, including the U.S. Department of Energy (DOE), have been described (CRS 1994). Basically, the DOE approach is said by Breed (1994) and by Pearman (1994) to be founded on maintaining the natural sustainability and biological diversity of ecosystems while support sustainable economis development and communities. This would involve a regional planning strategy that integrates stakeholder and community concerns and goals and draws on DOE's foundation of knowledge regarding ecological interactions and environmental compatibility of technology development and human use.

The Federal Initiative

A number of things are responsible for the ongoing fundamental changes in how environmental resources are being managed in the federal sector. In short, the two most important factors are the recent emergence of ecosystem science and the concurrent widespread realization that traditional resources management was not working. These two occurrances are well documented by Grumbine (1993b), Knight and Bates (1995), and Savory (1988).

Among the initial signs of the federal ecosystem management initiative was an extensive national workshop in 1992 sponsored by the USDA Forest Service that reflected the ecosystem approach to resources management (FS 1992). This was followed in 1994 by a notable report that documented the need for the Forest Service to alter its management procedures to formally embrace ecosystem management (FS 1994). Several other federal land management agencies followed suit in 1994 and 1995 (e.g., BLM 1994, FWS 1994 and 1995). These actions and their recent status and potential are documented in U.S. Senate (1994a), CRS (1994 and 1995), and GAO (1994).

A crucial step toward a federal ecosystem management initiative was taken by the Clinton Administration under the National Performance Review. In an accompanying report to the review, Vice President Al Gore proposed that federal stewardship of public environmental resources be founded on the concept and principles of ecosystem planning and management (Gore 1993). The Gore report called for a Presidential Executive Order by September 1994 directing federal land management agencies to implement ecosystem management. Next, the report called for a high-level Interagency Ecosystem Management Task Force to develop a number of cross-agency ecosystem management demonstration projects. The Executive Order was drafted to be issued in late 1994. However, an outcome of the 1994 congressional elections was that the anticipated Executive Order on Ecosystem Management was deferred.

In the meantime, the Interagency Ecosystem Management Task Force was established with the Director of the White House Office of Environmental Policy as the head and Assistant Secretaries from 12 departments and agencies. Representatives from the Office of Management and Budget and White House Office of Science and Technology Policy also serve on the task force. The task force formed the Interagency Ecosystem Management Working Group to assist in its work, to conduct case studies, and to develop a report on implementing an ecosystem-based approach to managing environmental resources. In turn, the working group created teams to address scientific, legal, institutional, public participation and budgetary issues relative to the federal ecosystem management initiative. At the same time, case studies of ecosystem management in practice were initiated in Southern Appalachia, Coastal

Louisiana, the Anacostia River Watershed, Prince William Sound, the Great Lakes, South Florida, and the Pacific Northwest Forests.

The report of the Interagency Ecosystem Management Working Group is to be issued in mid-1995. It will be a landmark in the federal ecosystem management initiative that will influence land and facility management in federal agencies like the DOE.

It also should be noted that in 1994 during the 103rd Congress a bill (S. 2189) was introduced by Sen. Mark Hatfield (R - Oregon) to establish the Ecosystem Management Act of 1994 (U.S. Senate 1994b). The bill would have amended the Federal Land Policy Management Act of 1976 to provide for ecosystem management. The objectives of the bill basically were consistent with the work of the Interagency Ecosystem Management Task Force and Working Group and the hoped for Executive Order on Ecosystem Management. Like the proposed Executive Order, however, the fate of the bill in the 104th Congress is uncertain. What remains certain for the present, at least, is the federal ecosystem management initiative is alive and well within the relevant federal departments and agencies.

Ecosystem Management in the DOE

The Rule

According to Breed (1994) the DOE comprehends and is adopting ecosystem management throughout its programs and facilities. Breed supports this position by noting two DOE Orders that promote and assure a proactive ecosystem management approach to maintaining a sustainable environment and a sustainable economy. DOE Order 5400.1(1.5a), on Environment, Safety, and Health, ensures incorporation within the agency of national environmental protection goals to advance restoring and enhancing environmental quality on DOE lands. DOE Order 4320.1B, on Land and Facility Use Management, is the basis for a broad planning perspective for addressing the regional and local conditions surrounding DOE sites and for identifying present land uses and future opportunities for performing planning analyses. Under this framework, the DOE is seeking to achieve Total Quality Environmental Management for sustaining ecosystems and for supporting economic development and communities for future generations.

In August 1994, consistent with the position expressed by Breed (1994), the DOE took steps toward revising its policy under DOE Order 4320.1B (Pearman 1994). This action involved issuance of a draft Land and Facility Use Management Policy that, when adopted and implemented, would have replaced the current site development planning policy. The stated impetus for the action was to conform DOE internal policy with the then pending Executive Order on Ecosystem Management. The policy's objectives were laudable, i.e., for DOE to manage all land and facilities as valuable national

resources in accordance with the principles of ecosystem management and sustainable development. The draft policy sought to integrate mission, ecological, economic, and social factors in a comprehensive plan for each DOE site that would guide land and facility use decisions. Comprehensive plans developed for each site were to consider the site's larger regional context and be developed with stakeholder participation.

Since the draft policy emerged in August 1994 nothing more has been seen of it outside of the DOE. Inquiries have been made to DOE headquarters about the status of the policy and of the ecosystem management initiative it hearlded. None of these overtures has been responded to by the DOE. Similarly, a request was made to no avail for other information such as resource documents on "Role of Future Use in Ecosystem Management" and "Department of Energy - Stewards of a National Resource" (Walker 1995). With one exception to be discussed later, all traces of the ecosystem management initiative within the DOE seem to have disappeared with the White House decision subsequent to November 1994 not to issue its Executive Order on Ecosystem Management.

The seeming reticence of the DOE to be forthcoming with information relative to ecosystem management policy is contrary to other federal land management agencies. For example, the DOE is not participating along with other agencies in a National Policy Dialogue on Ecosystem Management being sponsored by the Keystone Center (1995). Additionally, the DOE alone has not consented to contribute a policy position paper to a special professional publication that will address such matters and activities with respect to federal ecosystem management initiative (Malone 1995). Thus, while other federal land management agencies and the White House continue to pursue ecosystem management and are forthcoming about their policies and programs, the DOE remains silent.

The Exception

The exception to this rule has been the action taken in the field by the DOE with respect to preparing an Environmental Impact Statement (EIS) for the Nevada Test Site (NTS). In its Notice of Intent for the EIS, the DOE Nevada Operations Office proposed to prepare a Resource Management Plan (RMP) for the NTS that would address ecosystems and facilities at the site in a framework of mutual sustainability (DOE 1994). Upon receiving comments from stakeholders associated with the NTS, it became apparent to the DOE that what the stakeholders envisioned as an acceptable RMP, one based on the concepts of ecosystem management, exceeded the DOE's capabilities at the time. Rather than reneging on its offer to prepare an RMP, the DOE committed to including a framework for a management plan in the EIS and to pursuing the the RMP subsequent to the EIS (DOE 1995).

What is particularly reassuring to the stakeholders in the NTS

EIS process is that the DOE has agreed to base the RMP on the principles of ecosystem management and to participate with stakeholders in the framing of the RMP as well as in its execution. Thus, other federal agencies, state and local governments, concerned citizens, and public interests will become involved in an ecosystem management approach to planning for the future management of natural resources and facilities at the NTS. This contrasts markedly with the reticence of DOE headquarters regarding agency-wide policy on ecosystem management.

The ongoing EIS process for the NTS is the first ever at a DOE site that will adopt and lead to implementing the concepts and principles of resource management planning based on ecosystem management. Perhaps this initiative will lead the way to the DOE actually realizing the otherwise seemingly hollow commitments to Total Quality Environmental Management described by Breed (1994) for a broad planning perspective that addresses regional and local conditions surrounding DOE sites. To achieve this, DOE headquarters must take steps to achieve a unified planning agenda by coordinating and integrating disparate elements of ecosystem management within the agency. While it is too late in the federal initiative on ecosystem management for the DOE to be a leader, as anticipated by Breed (1994), the agency must take steps at all of its sites for identifying present land uses and future options. This will of necessity involve efforts to achieve consensus decisionmaking with stakeholders regarding a sustainable environment that addresses ecological as well as socioeconomic components.

REFERENCES

Breed, B. 1994. Department of Energy. In *Ecosystem Management: Federal Agency Activities*. Congressional Research Service, Washington, DC. pp. 43-49.

(BLM) Bureau of Land Management. 1994. Ecosystem Management in the BLM: From Concept to Commitment. BLM/SC/GI-94/005+1736. BLM, Washington, DC.

(CRS) Congressional Research Service. 1994. Ecosystem Management: Federal Agency Activities. 94-339 ENR, April 19. CRS, The Library of Congress, Washington, DC.

(DOE) U.S. Department of Energy. 1994. Nevada Test Site Enivronmental Impact Statement Notice of Intent. *Federal Register* 59(153), Wednesday, August 10.

(DOE) U.S. Department of Energy. 1995. Implementation Plan for the Nevada Test Site Enivronmental Impact Statement. DOE/NV-390 UC-700, Revision 0, February. DOE, Washington, DC.

ATTACHMENT I

Integrated Weapons-Site Cleanup

The Department of Energy is using ecosystem management to help clean up our nation's nuclear weapons sites.

BY CHARLES R. MALONE

In 1951, the Atomic Energy Commission, forerunner to the present-day U.S. Department of Energy, was looking for a place to test its newly developing arsenal of nuclear weapons. It selected a remote tract of the Mojave Desert in southern Nevada, 50 miles (80 kilometers) northwest of Las Vegas. For the next four decades, the Nevada Test Site would serve as the nation's nuclear testing ground.

The Nevada Test Site covers 1,350 square miles (3,500 square kilometers), which is roughly the size of the state of Rhode Island. Until 1962, when aboveground testing was banned, the Atomic Energy Commission conducted about 100 aboveground nuclear tests on the site. During the next three decades, until nuclear testing was banned altogether in 1994, more than 800 underground tests were conducted on the site. Today, the site is largely used for disposing of low-level DOE wastes. The Yucca Mountain site, which is being studied as a possible respository for high-level nuclear wastes from nuclear weapons and nuclear reactors throughout the United States, straddles the test site's western perimeter.

The Nevada Test Site is one of 140 sites in DOE's nuclear weapons complex—which includes such familiar names as Savannah River, Oak Ridge, Hanford, and Idaho Falls—that are remnants of the Cold War legacy. Now that the Cold War is over, DOE has begun cleaning up the Nevada Test Site.

The Nevada Test Site contains more contaminated surface rock soil, and groundwater than any other site in the DOE weapons complex. The amount of radioactivity in the environment from weapons testing is estimated at 300 million curies, spread over about 300 square miles (800 square kilometers). DOE's goal is to remove enough of the contamination from the soil and groundwater to make the environment safe for future use. Cleanup began in 1997 and will extend to 2007, at a cost of $1.3 billion.[1]

Future uses being considered include developing the site for producing clean-burning fuels, decontaminating low-level nuclear wastes, or training emergency workers who deal with highly destructive weapons.

Ecosystem Management

As part of the restoration of the Nevada Test Site, DOE developed a resource management plan to ensure the long-term sustainability of the site.[2] The main goals of the plan are to

- Manage and sustain natural resources.
- Maintain native ecosystems, biota, and habitats.
- Protect undisturbed areas.
- Develop baseline environmental information needed for cleanup, land use planning, and ecosystem management.
- Site new facilities only on environmentally suitable, previously disturbed lands.
- Foster sustainable economic development.

Traditional resource management focuses on managing a single resource such as water, livestock, or timber. Wildlife management and operating reservoirs for navigation and flood control are traditional resource management approaches.

Ecosystem management, which is at the heart of DOE's resource management plan, focuses instead on managing the ecosystem as a whole, including its fauna, flora, soils, groundwater, and air. Ecosystem management recognizes that humans are a fundamental component of ecosystems; it appreciates the importance of the diversity and complexity of ecosystems; and it strives to maintain the processes that tie the physical, chemical, and biological components of the ecosystem together.[3]

As a resource tool, ecosystem management has been applied successfully in a variety of other settings.[4] In the Pacific Northwest, for example, where logging has abused forests and streams for decades, ecosystem management is being used to identify sensitive areas that should be restored, areas where logging should be banned, and areas where logging can occur, provided it balances environmental and economic objectives.

Similarly, ecosystem management has been successfully applied to livestock grazing in arid lands to help restore abused sensitive habitats and to avoid further damage.

An analogy may help to further clarify the difference between traditional resource management and ecosystem management. Think of traditional resource management as like trying to fix an automobile carburetor without even turning on the engine. Ecosystem management, on the other hand, is like making fine-tuning corrections while the engine is running. A good mechanic will listen to the engine, adjust the carburetor, and make any other changes necessary—such as replacing spark plugs—to make the engine run smoothly and quietly.

An ecosystem manager, like our good mechanic, has a holistic perspective. Rather than just looking after the trees or the wildlife or water quality, the ecosystem manager considers each of these, along with other components, as part of a greater whole; and he or she manages the whole to ensure it is operating smoothly and efficiently.

Implementing the Model

DOE has begun inventorying natural resources at the Nevada Test Site, and it is protecting critical areas such as habitat for endangered species. Natural springs and seeps, for instance, play an especially important role in desert ecosystems and are therefore being restored to as near natural conditions as practical.

DOE is also removing soil from contaminated land and is reclaiming these disturbed sites for eventual reuse. By restoring contaminated lands and using them for further development, DOE can avoid development on ecologically valuable, undisturbed lands, which have not been contaminated.

The involvement of stakeholders—such as the state of Nevada, nearby communities, other federal land managers, and area landowners—has long been a missing element in planning for the Nevada Test Site. Applying the ecosystem management model helps correct this problem. Today, regional stakeholders are contributing to decisions about economic development and cultural, social, and long-term environmental trends that will shape the Nevada Test Site's future. While DOE is currently using ecosystem management only for the Nevada Test Site, the approach is also an appropriate tool for cleaning up other contaminated DOE lands. Ecosystem management can be used to assess environmental risks, set cleanup priorities, help determine the appropriate level of cleanup needed for various land uses, and evaluate alternative solutions for remediating contaminated land.

Some DOE managers will doubtless view ecosystem management as overly problematic, especially given the degree of intradepartmental, interagency, and stakeholder cooperation required to make ecosystem management succeed. Further complicating the application of ecosystem management is DOE's notoriously fragmented bureaucracy; coordination among its programs is contrary to prevailing, long-established DOE custom. Moreover, the attitude of openness to public and private stakeholders, which is integral for effective ecosystem management, is contrary to DOE's history of isolating itself from outsiders.

Even at the Nevada Test Site, these issues are not fully resolved. For example, the Timber Mountain Caldera National Natural Landmark on the Nevada Test Site remains off-limits to visitors even though a number of people have expressed interest in being allowed access to the area's unique geological features. Likewise, some mountainous areas on the site that support herds of desert bighorn sheep large enough for hunting are closed to the public despite efforts of the Nevada Division of Wildlife to have the areas opened for public use.

Nonetheless, progress toward incorporating outside recommendations into DOE decision making is occurring at the Nevada Test Site, and there are decided grounds for hope.

Reversing Old Customs

Change often comes slowly and stubbornly within traditionally conservative organizations like DOE, and progress in using ecosystem management to reverse outdated

ATTACHMENT J

The Southern Nevada Initiative: A Case of Federal Ecosystem Management in the United States

Charles R. Malone

The need for sustainable development in the U.S. is expressed in the concept and emerging practice of ecosystem management. Grumbine (1992, 1994) has documented the rise and application of ecosystem management from the 1930s to the early 1990s, and Malone (1998a) has described the federal policy that has developed since the mid-1980s. Current U.S. policy on ecosystem management arose from the White House Interagency Ecosystem Management Task Force (IEMTF 1995-1996). A Memorandum of Understanding executed by the White House and signed by all federal land management agencies (OEP 1995) established the policy of preserving ecosystem integrity while sustaining human economies and maintaining a base of natural resources for future generations of humans.

The extent of involvement of the U.S. land management agencies in ecosystem management is indicated by a recent examination of 105 ecosystem-based projects out of a total of 619 identified across the U.S. (Yaffee et al. 1996). Forty-five percent of the projects examined were initiated by federal agencies, 40% by state agencies, 6% by local agencies, and 24% by nongovernment organizations. Of the federal projects involved, 16 were administered by the U.S. Forest Service, 16 by the U.S. Fish and Wildlife Service (USFWS), six by the U.S. Bureau of Land Management (USBLM), and nine by the U.S. Environmental Protection Agency. Federal agencies, while initiating 45% of all the projects examined, were involved in 88% of the total number. Overall, 52% of the 105 projects surveyed resulted directly from federal policies and programs.

An emerging ecosystem-based management project in southern Nevada offers an opportunity to examine a case study of federal ecosystem management from its conception. All the lands involved are managed by federal agencies and occur within the natural boundaries of the southern Nevada hydrographic region (Figure. 1). Included are all or a major portion of three large federal reservations dedicated to single-purpose uses: the Nevada Test Site (NTS) managed by the U.S. Department of Energy (USDOE); the Nellis Air Force Range managed by the U.S. Air Force (USAF); and the Desert National Wildlife Range managed by the USFWS. A fourth federal agency, the USBLM, manages the remaining multiple-use public lands contiguous to the three reservations.

Increasing natural resources demands are being placed on all federal lands in southern Nevada as a result of rapid growth associated with the city of Las Vegas. For example, the USDOE is addressing future uses of the NTS for private ventures while down-sizing national defense missions at the site (Malone 1998b). Ecosystem management in the region presents the agencies involved with an

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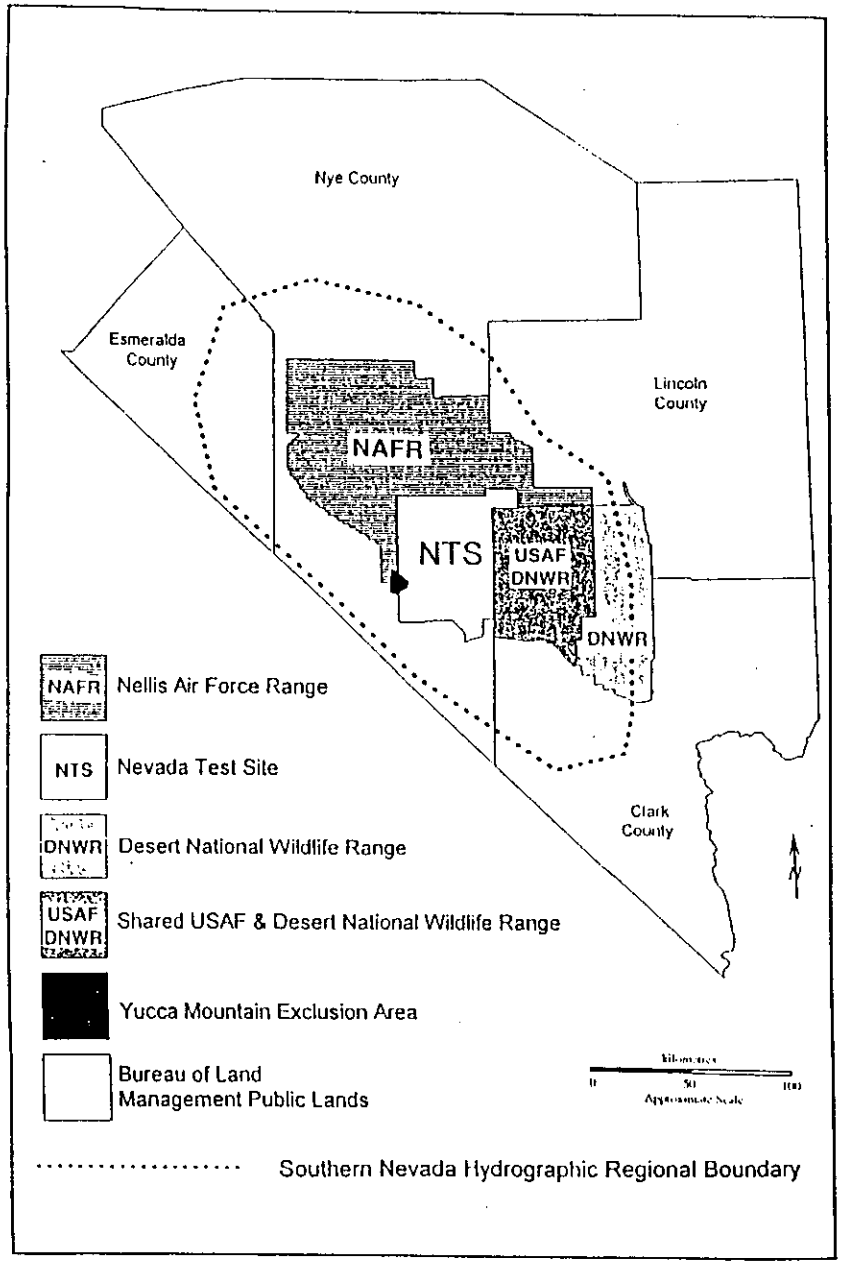

Figure 1: Map showing the boundary of the southern Nevada hydrographic region and the federal administrative jurisdictions included. The region is being addressed by the Southern Nevada Ecosystem Management Initiative, except for the Yucca Mountain Exclusion Area that has been set aside for geologic disposal of U.S. high-level nuclear waste.

opportunity to demonstrate land resource stewardship in an area long neglected in this respect. Thus, it is in the federal government's interest to promote the emerging initiative. The same is true for Nevada's state government. The present study was undertaken to encourage both levels of government in that respect.

Following is a discussion of the U.S. federal ecosystem management initiative as represented by concepts and theories as reflected principally by the IEMTF (1995-1996), Malone (1998a), The Keystone Center (TKC 1996), and Yaffee et al. (1996). Where these sources are insufficient, for example with respect to science, literature outside the federal initiative is used. The results are used to critique components of the southern Nevada initiative and to suggest how the initiative can be strenghened. An analytical framework is proposed for the southern Nevada initiative for supporting sustainable development through ecosystem management.

The Federal Initiative and Evaluative Criteria

A standard definition of ecosystem management has not been accepted, but most general definitions, including the popular ones of the Ecological Society of America (ESA 1996), Grumbine (1994), Slocombe (1993), and Vogt, et al. (1997) are compatible. As this paper examines a case of federal ecosystem management in the context of U.S. policy, the definition is paraphrased from the IEMTF as:

> *Ecosystem management: (1) is a method for sustaining or restoring natural systems and their functions and values within a geographic framework defined by ecological boundaries; (2) integrates ecological, socioeconomic, and institutional factors; and (3) is driven by goals collaboratively developed by key stakeholders.*

The IEMTF (1995-1996) study is a good starting point for understanding the characteristics of federal policy on ecosystem management. Principal among the topics addressed were interagency coordination, establishing communication and partnerships among key stakeholders, developing a vision of desired conditions, and characterizing current ecosystem and socioeconomic conditions. The role of science in ecosystem management, particularly regarding the status of ecological theory, was not well developed by the IEMTF. Otherwise, the study provided a fundamental understanding of ecosystem management at the federal level.

Supplementing the IEMTF study is a survey by Yaffee et al. (1996) of ecosystem management projects in the U.S. The authors characterized the projects and noted factors that have contributed to the success of ecosystem management. Foremost among these was collaboration for building support among all stakeholders in the public, private, and government sectors. Also important were the availability of human resources, funding, and political support. These and other identified factors correspond to the principal concepts of ecosystem management established by the IEMTF, but like the IEMTF study, the survey did not emphasize science and theory.

Another supplementary study that provided general insight into ecosystem management in the U.S. was that of The Keystone Center (TKC 1996). The study involved the principal federal land management agencies and public and private stakeholder groups associated with the federal ecosystem management initia-

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tive. Like the IEMTF study and the survey conducted by Yaffee and colleagues, The Keystone Center activity emphasized the social aspects of ecosystem management rather than the scientific ones.

The scant mention of science in ecosystem management by The Keystone Center is consistent with the findings of an earlier review of the emerging federal initiative performed by the U.S. General Accounting Office (USGAO 1994). This is an issue here in that to develop evaluative criteria it was necessary to turn outside the federal initiative for insight into scientific and theoretical constructs for ecosystem management. This was done by using a report on ecosystem management by the Ecological Society of America (ESA 1996) and a detailed and comprehensive book on ecosystem management by Vogt et al. (1997).

The evaluative criteria selected for the southern Nevada case are presented in Table 1. Among them, the natural system and science have a role more in balance with the social system than may be apparent to some. This is because science underpins land ethics, defining the management unit, agreeing on desired ecosystem conditions, and using an interdisciplinary approach. From the broad perspective, it is clear that science must be keep at the forefront of consideration as initiatives are developed. Thus, interdisciplinary teams responsible for ecosystem management must include professionals with an understanding of science, management, social, and institutional issues (ESA 1996).

Fundamental explanations of the first five criteria in Table 1 are provided by IEMTF (1995-1996), The Keystone Center (TKC 1996), and Yaffee et al. (1996). These are the criteria reflecting the social elements of ecosystem management. Increasing attention by ecologists is being given to the non-ecological aspects of ecosystem management (e.g., Gunderson et al. 1995, Loomis 1993, Yaffee 1994). Specific attention to the scientific roots of the concept, including issues such as biological diversity and bioregionality, ecosystem function, integrity, and dynamics, and uncertainty, have been discussed by the Ecological Society of America (ESA 1996) and by Vogt et al. (1997). These sources also touch on human aspects of ecosystem management and reflect the pervasiveness of ecological science in the interdisciplinary mix.

The Southern Nevada Initiative

The Southern Nevada Ecosystem Management Initiative emerged in 1996-1997 and includes public lands in a region of the state conspicuous for its growth and development. The lands involved are within the natural boundaries of the southern Nevada hydrographic region (Figure 1) and comprise 33,800 km², an area that constitutes 12% of the state. Within the region are two large national security facilities, the Nevada Test Site managed by the USDOE and the Nellis Air Force Range managed by the USAF. Together these two reservations comprise 45% of the land involved in the regional initiative. The remainder of the land is managed by the USFWS, and the USBLM, with the latter being responsible for 40% of the total area within the region.

Four federal actions comprise the origins and components of the southern Nevada initiative. The first was a 1996 environmental impact statement prepared by the USDOE for the Nevada Test Site (NTS). The USDOE also introduced a framework for resources management based on the ecosystem approach

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1. **Renews Land and Environmental Ethics:**
   A. Recognizes the fundamental connection between human communities and the environment;
   B. Adopts a holistic approach to protecting ecosystem integrity that integrates environment and development;
   C. Sustains ecosystems, biodiversity, socioeconomics, and community goals;
   D. Includes humans as components of ecosystems and encourages responsible use of natural resources;
   E. Integrates ecological protection and restoration with human needs;
   F. Manages human needs and desires within the capacity of ecosystems to meet them;
   G. Minimizes and repairs impacts to the land and reconnects isolated parts of landscapes.

2. **Fosters Voluntary Partnerships and Cooperation Between Stakeholders:**
   A. Establishes partnerships with key stakeholders, including government, the public, nongovernment organizations, and private landowners;
   B. Enhances interagency and intergovernmental coordination;
   C. Involves public, private,and government stakeholders early;
   D. Improves public communication, public access to information, and public involvement in resource management decisions;
   E. Develops shared visions for sustaining human economies and the natural resources on which they depend;
   F. Develops a shared vision of desired ecosystem conditions among stakeholders;
   H. Builds widespread stakeholder participation, communication, collaboration, and cooperation;
   I. Assures that private land owners, communities, and agencies understand each other's concerns.

3. **Establishes Proper Roles and Arrangements for Institutions:**
   A. Inventories regional agencies and institutions and their procedures, definitions, and interactions;
   B. Explores possible reorganization and redefinition of institutions and processes to improve planning and management;
   C. Implements top down planning to change approaches to land management;
   D. Seeks adequate resources and support from government agencies and other stakeholder institutions.

Continued . . .

Table 1. Criteria (precepts) and characteristics of ecosystem management that describe the U.S. federal initiative.

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Continued . . .

4. **Defines the Management Unit, Processes, and Goals:**
   A. Adopts a regional spatial scale to establish ecological boundaries that span jurisdictions;
   B. Determines kinds of information needed to define the unit;
   C. Recognizes the importance of historic land conditions and the trends in natural landscapes, i.e., the temporal scale;
   D. Sets realistic goals and develops consensus with stakeholders;
   E. Recognizes the role of environmental impact assessment in resources management;
   F. Establishes leadership and accountability for institutional streamlining, cooperation, coordination, and conflict resolution.

5. **Adopts An Interdisciplinary (Ecological, Socioeconomic, Institutional) Approach:**
   A. Enhances information gathering and data management capabilities such as geographic information systems;
   B. Develops a holistic and integrated understanding of the management unit;
   C. Includes multidisciplinary data collection and monitoring of present ecosystem conditions, behavior, and function;
   D. Explores methods for organizing, synthesizing, and communicating interrelationships of data collected;
   E. Uses the best science available and performs research to improve knowledge for adapting management practices;
   F. Monitors and evaluates actions to determine if goals and objectives are being achieved.

6. **Develops Sound Ecological Models and Understanding:**
   A. Strengthens the role of ecosystem science in resource management and considers humans as ecosystem components;
   B. Recognizes ecosystem complexity and connectedness, limits and stresses, dynamics, and uncertainty;
   C. Establishes baseline conditions for ecosystem functioning and sustainability against which change can be measured.
   D. Seeks to understand how the landscape works and determines landscape sensitivity to future land management;
   E. Recognizes temporal and spatial scales in ecosystem patterns and processes.

Table 1 (Continued): Criteria (precepts) and characteristics of ecosystem management that describe the U.S. federal initiative.

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(USDOE 1996). The program was initiated a year later and the USDOE expects to have a first interation of the plan completed in late 1998.

Coincident with the NTS activity were two resources management actions taken by the USAF for the Nellis Air Force Range located on three sides of the NTS (Figure 1). These were an integrated natural resources management plan (INRMP) followed by a stakeholders dialogue on ecosystem management conducted by The Keystone Center, a nongovernmental organization. The INRMP (USAF 1997b) took a traditional, non-ecosystem approach while the dialogue (TKC 1998) emphasized conserving biological diversity through ecosystem management and resulted in a more expansive approach to natural resources management.

Both the USDOE resources plan and The Keystone Center dialogue adopted ecosystem management and embraced regional management as well. The USAF management plan did not. However, this plan recognized the necessity of interagency coordination among the federal land management agencies involved on the Nellis Air Force Range. Through interagency agreements, the USDOE, the USBLM, and the USFWS assist the USAF with resources management on the Nellis Range. With initiation of resources management at the NTS and the Nellis Range, the USDOE and the USAF recognized the need for a formal interagency management arrangement. Accordingly, in late 1997, a Five-Party Cooperative Agreement reflecting ecosystem-based resources management was reached (USAF 1997c). Although the agreement includes the NTS, the Nellis Range, and the USFWS wildlife refuge, it does not extend to adjacent USBLM lands to encompass all of the natural unit formed by the southern Nevada hydrographic region.

It is clear from the language of the cooperative agreement that the intent is to achieve ecosystem management in southern Nevada. However, the means for achieving ecosystem management are left open. Motivating the USDOE and the USAF regarding the federal ecosystem management policy is the need to retain federal lands for national security purposes. Included with the Nellis Range is a large portion of the USFWS's Desert National Wildlife Refuge that is shared with the USAF. Also within the region is the 280 km² site for the USDOE Yucca Mountain Project. The comparatively small site is environmentally significant because it is being considered for a geologic repository for disposing of high-level nuclear waste. Despite the potential for environmental contamination, the DOE has excluded the Yucca Mountain site from its ecosystem management program for the NTS. The ethical and scientific implications of the decision have been discussed by Malone (1995).

The goal for an ecosystem management initiative in the southern Nevada hydrographic region would be to manage public land resources in a manner that maintains federal missions and the public's interests in the environment. Management of public lands is a highly visible issue in the rapidly growing southern part of the state. The issues that need to be addressed are maintaining national security missions, conserving ecosystems, and balancing these issues with competing land uses. Ecosystem management is an appropriate approach in view of the region's limited resources for recreation, water supplies, and fragile natural resources that require careful management (Rundel and Gibson 1996).

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Evaluation of the Initiative

The four component actions of the emerging initiative were analyzed according to the six criteria in Table 1. Following that, a composite evaluation was made regarding the nature of the emerging initiative. The results of the evaluations are given in Table 2. Most conspicuous in the Table is lack of a sufficient conceptual perspective on science to support an analytical model that can pull the initiative together.

Among the components, The Keystone Center stakeholders dialogue for the Nellis Range (TKC 1998) excelled in the attention given to land and environmental ethics and placed its participants on a sound footing in that respect. Additionally, the dialogue offered cooperation and a broad perspective of views on ecosystem management for the Nellis Range because of the array of stakeholders involved. However, the involvement of a large number of non-scientists among the stakeholders in the dialogue resulted in a narrow perspective on science and interdisciplinary approaches to ecosystem management.

As for the USDOE's resources management program for the NTS, considerations of ethics and stakeholder involvement were marginal. The agency reached out to some stakeholders, principally units of government, on a selective and modest basis regarding resources issues and goals. However, collaboration and cooperation among non-governmental stakeholders on the USDOE's part have

Criteria	RMP	INRMP	TKCD	5-PCA	OVERALL
Ethics (1)*	+	-	++	-	+
Cooperation (2)	-	+	++	+	+
Institutions (3)	+	+	+	+	+
Management Unit and Process (4)	+	—	+	-	+
Interdisciplinary (5)	+	—	+	+	+
Science (6)	+	—	-	-	-

Ranking: ++ satisfactory + marginal - weak — deficient

* The numbers in parentheses following each criterion denotes the precept number from Table 1 that is consistent with the criteria in this table.

Table 2: Ranking of the four components of the Southern Nevada Ecosystem Management Initiative with respect to the evaluative criteria in Table 1. The components are: Resources Management Plan (RMP), Integrated Natural Resources Management Plan (INRMP), The Keystonce Center Dialogue (TKCD), and the Five-Party Cooperative Agreement (FPCA).

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been restrained. In the context of a regional initiative, a strength of the USDOE resources management activity is that it was designed to follow through directly with implementation. As a consequence, the NTS management plan is being implemented as it is developed (Malone 1998b) and could be considered as an example to be followed throughout the southern Nevada hydrographic region.

The Nellis Range resources management program (USAF 1997a) commenced well after the USDOE action and is about two years behind the NTS ecosystem-based management program. The planning activity was found by The Keystone Center dialogue (TKC 1998) to be remedial with respect to the concept and principles of ecosystem management. Several factors contributed to the shortcoming, including a lack of understanding of ecosystem management by the USAF in Nevada as well as a lack of interest, management processes and commitment for such an effort. At Nellis, this is reflected in insufficient personnel, expertise, and budgetary resources for natural resources management. An example of the consequences of these weaknesses is that only 40% of the 11,800 km2 Nellis Range has been surveyed for threatened and endangered plants (USAF 1997a). This stands in contrast to the NTS and the national wildlife refuge for which natural resources surveys have been completed (TKC 1998).

A burden falls on the Five-Party Cooperative Agreement for implementing an ecosystem management initiative. Lacking at the outset was sufficient emphasis on land ethics, recognition of the need for bioregionality in ecosystem management, and a management process. The cooperative agreement includes only lands within the boundaries of the federal reservations involved and offers no framework for a management process, leadership, and recognition of the role of science in ecosystem management. As the initiating agency for the cooperative agreement, the USAF in Nevada will chair the arrangement for at least the first year. Judging from the Nellis resources management plan, there is scant basis for optimism regarding sound and timely results from the cooperative agreement.

As matters stand in mid-1998, the USDOE resources management process for the NTS provides the only incentive for using the Five-Party Cooperative Agreement. The USAF and other agencies participating in the Five-Party Cooperative Agreement have before them much of the basis for framing a regional ecosystem management initiative. With this in mind, a preliminary set of precepts complementing Table 1 is given in Table 3 for an ecosystem-based initiative in southern Nevada. These were developed from the nature of the southern Nevada hydrographic region and the four existing components for an initiative evaluated in Table 2.

The preliminary precepts aim to strengthen the initial evaluation of the emerging initiative by demonstrating how a broad set of criteria characteristic of ecosystem management, such as those in Table 1, can be applied in a specific bioregional context. If the component actions evaluated in Table 2 had benefited from an organized planning procedure such as is implied by the precepts in Table 3, the evaluation would have resulted in far fewer negative marks. Table 3 also indicates the point discussed previously regarding the pervasiveness of science throughout ecosystem management. Implications of interdisciplinary and scientific considerations are associated with most of the precepts, particularly with those involving a renewal of land and environmental ethics.

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- Support and sustain existing federal defense missions by assuring the missions are managed to effectively and efficiently use the natural resources available. (1, 5, 6)
- Maintain existing federal facilities through proactive integrated resources management planning to accomodate future uses of a site. (1, 5, 6)
- Sustain regional native ecosystems, with emphasis on important biota and their habitats. (1, 6)
- Manage water resources for existing and future human uses while protecting native ecosystems in wet areas. (1, 5, 6)
- Coordinate, cooperate, and share scientific data across jurisdictional boundaries throughout the regional landscape. (2, 3, 6)
- Collaborate with key regional stakeholders to reconcile conflicts and to develop priorities and that acknowledge and consider national interests. (3, 4, 5, 6)
- Identify and manage resources at the appropriate spatial scale, such as the common regional landscape. (4, 6)
- Monitor progress, evaluate impacts, and adapt based on new information on the basis of benchmarks for monitoring and evaluating outcomes. (5, 6)
- Site new facilities to be on or near previously disturbed lands and in areas with suitable soil, slope, drainage, and other natural features. (1, 5, 6)

Table 3: Proposed precepts for the Southern Nevada Ecosystem Management Initiative. The numbers in parentheses following each statement denotes the precept number from Table 1 that is consistent with the one in this table.

A Proposed Scientific Framework

To progress further, the emerging Southern Nevada Ecosystem Management Initiative needs to develop a framework for implementing ecosystem management. Existing weaknesses in the initiative could be strengthened if a strong methodology were adopted for continued planning of the initiative. Hornbeck and Swank (1992) advocate watershed analysis as a basis for recommending land uses consistent with holistic ecosystem management. Among the advantages obtained through watershed ecosystem analysis is that knowledge and information are made available to a wide audience including the scientific community, government institutions, and public and private interest groups. This feature of

a management strategy is consistent with the need for stakeholder involvement in ecosystem management.

A framework for implementing ecosystem management based on watershed and landscape analysis has been put forth by Montgomery et al. (1995). Evolving from recent experiences in the U.S. Pacific Northwest, the strategy is consistent with the views of Hornbeck and Swank (1992) as well as with the criteria and characteristics of ecosystem science discussed above. The approach couples management objectives to landscape capabilities by combining knowledge of the physical environment with information on the biotic component. Land management decisions thus can be made that consider the balances between using public lands for national security, economic development and recreation, and sustaining ecosystems and natural resources.

A representation of the landscape approach to ecosystem management for southern Nevada is shown in Table 4. The framework represented, adapted from Montgomery et al. (1995), reflects matters of geophysical structure, ecosystem function, disturbance history, and current and potential future land conditions. Types of information needed about ecological characteristics and conditions is reflected in the Table's two column listing of critical issues and the scope of inquiry into them. The issues identified in the analytical framework can be addressed by alternative management and land uses pursued by the appropriate methodologies. As explained by Hornbeck and Swank (1992) and by Montgomery et al. (1995), such an approach allows input of socioeconomic considerations for balancing natural resource objectives in pursuing sustainable development through ecosystem management.

An early step toward a landscape approach would be for the federal agencies in southern Nevada jointly to use compatible methods and to synthesize existing environmental information available regarding the southern Nevada hydrographic region. Some useful studies of ecosystems and watershed structure have been conducted for the NTS and the Yucca Mountain site (USDOE 1996). Each agency involved has its own information regarding conditions within its jurisdiction, but developing a synthesis of the data has not been attempted. Were this to be done early in the emerging ecosystem-based initiative, the resource managers involved could determine if a satisfactory information base exists that is representative of the southern Nevada hydrographic region. If needed, supplementary baseline studies could be initiated, for example, on the Nellis Range, the national wildlife refuge, and adjacent public lands. In this manner, the need for studies of ecosystem function among different biotic patterns within the region would emerge. As matters stand, the functional differences among the Great Basin, the Mohave Desert, and the ecotone between the two provinces are poorly understood (Rundel and Gibson 1996).

Once landform and ecological functions are better known, an understanding would emerge about the sensitivity of landscape processes to environmental changes and disturbances. Following the analytical framework of Montgomery et al. (1996), models based on information about watershed characteristics and conditions would allow functional linkages across the regional landscape to be established. In this manner, the lands managed by the different federal agencies could be integrated into the context of regional ecosystem management. Desired landscape conditions then could be identified and management techniques could be adopted for achieving the conditions throughout the region.

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It should be noted that a framework consistent with Table 4 and landscape analysis is implied by the resources management plan for the NTS (USDOE 1996; Malone 1998b). This can be seen by comparing Table 4 with the column in Table 2 that evaluates the USDOE plan. Frameworks similar to that in Table 4 or to the management plan for the NTS could be adopted by other land managers in the southern Nevada hydrographic region. This would support establishing regional ecosystem-based models that would help select management techniques suited to achieving desired landscape conditions. Identifying desired conditions and designating management practices through stakeholder

CRITICAL ISSUES	SCOPE OF INQUIRY
Understand landscape structure and function • hydrology and geohydrology • soils • carrying capacities	**Use ecological heirarchy and ecosystem analysis techniques** • ecosystems • watersheds • landscapes
Discern historical conditions and uses • native ecosystems • ecotones and edges • disturbances and contaminants	**Collect data to perceive past history** • existing sources • additional needs • special species
Establish existing conditions • wet areas • ecotones and edges • disturbances and contamination	**Study current landscape as a result of past legacies** • habitats and biota • roadless areas • ecosystem surveys
Determine alternative land uses • national security • commercial development • recreation • biodiversity refuges	**Scenario generation and analysis** • short, mid-, and long term • restoration of ecosystems and springs
Ascertain resources/management needs for sustaining natural resources and economies • professional expertise • management and accountability • interagency cooperation • stakeholder involvement	**Design strategies for achieving desired landscape and human conditions** • resource management plan • goals • implementation plan • peer review and public participation

Table 4. Preliminary analytical framework of critical issues and the scope of inquiry for regional ecosystem management. Beneath each horizontal block examples are listed that are specific to the southern Nevada hydrographic region.

involvement could occur under the Five-Party Cooperative Agreement. The capabililities for developing ecological models rests with the federal agencies, as does resolution of the issues of leadership and commitment to ecosystem management.

Conclusions

The emergence of ecosystem management in southern Nevada presents the federal government with an opportunity to demonstrate land resource stewardship in a region long neglected in this respect. A regional initiative in that regard would be timely because of increasing contention over public land use from development and recreational interests in the Las Vegas area. The USDOE currently is applying the ecosystem approach to pursue alternative land uses of the NTS for private economic ventures. Also, the USAF is considering ecosystem management to sustain its mission at the Nellis Range. It is in the federal government's broader interests to promote and strengthen the ecosystem management initiative that is emerging in southern Nevada. Similarly, Nevada's state government has a stake in the success of the emerging Southern Nevada Ecosystem Management Initiative. However, the state has neither the institutional means nor a policy on ecosystem management to lend assistance. This could be remedied if the state government were to adopt a policy endorsing the federal ecosystem management initiative. Such a policy would be justified by the fact that 85% of Nevada is owned by the federal government.

Among the existing components for moving toward a mature ecosystem management initiative in the southern Nevada hydrographic region are many of the fundamental elements for pursuing sustainability. Some elements, however, are undeveloped or missing. Most apparent in this regard are expertise, leadership, and commitment on a regional scale. This especially is of concern with respect to the Five-Party Cooperative Agreement through which cooperation among the relevant government agencies must occur. The newly established agreement is the means by which the Southern Nevada Ecosystem Management Initiative should continue to develop. A solid foundation for the compact is essential for establishing the cooperation needed among involved government parties. It will fall to the participants in the agreement — with stakeholder collaboration and influence — to establish a regional analytical framework for implementing an ecosystem-based approach that integrates science, management, socioeconomics, and institutions.

Concern remains about the DOE's Yucca Mountain Project which views the ecosystem-based process as being overly complicated and problematic. Additionally, threats are perceived in the openness embodied in the concepts of achieving sustainable development through ecosystem management. Reversing outdated customs of secrecy and technocracy through ecosystem management is a matter of environmental ethics and institutional trust that cannot be taken for granted. Additional concerns exist, such as achieving federal interagency cooperation as intended by the Five-Party Cooperative Agreement. Likewise, effective communication between federal agencies and the public is needed to create public trust and form parternships vital to the success of all ecosystem management initiatives.

Society increasingly values public lands not merely for economic commodities but for the various services provided by natural ecosystems. Likewise, federal

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land management agencies are viewed by the public as facilitators of cooperative efforts to achieve sustainable development through ecosystem management. And, the policies being implemented by federal agencies should be responsive to growing debates over the use and management of public natural resources. If the obstacles to achieving sustainable development through ecosystem management are overcome, the Southern Nevada Ecosystem Management Initiative can join a growing number of successes in the U.S. To succeed, long-term commitments to the initiative must be made by all involved parties and land managers in the region.

Public and private stakeholders in southern Nevada are encouraged by the resources management opportunity presented by the recent cooperative agreement. However, much remains to be achieved by the government institutions responsible for ecosystem management in southern Nevada. Recourse to political processes remains an alternative course to be followed by public and private interests. The state government should be an instrument that stakeholders could turn to in this respect. A potential role for the state exists by virtue of the federal policy on ecosystem management established by the White House in 1995-1996. Similar executive action by the state would facilitate the opportunity presented for collaboration among all stakeholders in southern Nevada. A state policy supporting the federal ecosystem management initiative would be justified on the basis that 85% of the lands in Nevada are owned and managed by the federal government.

References

ESA (Ecological Society of America). 1996. "The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management." *Ecological Applications*. 6(3): 665-691.

Grumbine, R.E. 1992. *Ghost Bears: Exploring the Biodiversity Crisis*. Washington, DC: Island Press.

———. 1994. "What Is Ecosystem Management?" *Conservation Biology*. 8(1): 27-38.

Gunderson, L.H., C.S. Holling, and S.S. Light, eds. 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York, NY: Columbia University Press.

Hornbeck, J. W. and W. T. Swank. 1992. Watershed ecosystem analysis as a basis for multiple-use management of eastern forests. *Ecological Applications*. 2(3): 238-247.

IEMTF (Interagency Ecosystem Management Task Force). *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies in 1995-1996*. Vols. I, II, III. The White House Office of Environmental Policy, Washington, DC.

Knight, R.L. and S.F. Bates, eds. 1995. *A New Century for Natural Resources Management*. Washington, DC: Island Press.

Loomis, J.B. 1993. *Integrated Public Lands Management: Principles and Applications to National Forests, Parks, Wildlife Refuges, and BLM Lands*. New York, NY: Columbia University Press.

Malone, C.R. 1995. "Ecology, Ethics, and Professional Practice: The Yucca Mountain, Nevada, Project as a Case Study." *The Environmental Professional*. 17(3): 271-284.

Malone, C.R. 1998a. "The Federal Ecosystem Management Initiative in the U.S." In *Environmental Sustainability: Case Studies on the Prospects of Science and Ethics*. J. Lemons, R. Goodland, and L. Westra, eds. Dordreche, The Netherlands: Kluwer Academic Publishers, 203-217.

Malone, C.R. 1998b. "Implications of Resources Management at the Nevada Test Site." *Federal Facilities Environmental Journal*. 9(1): 51-62.

Montgomery, D.R., G.E. Grant and K. Sullivan. 1995. "Watershed Analysis as a Framework for Implementing Ecosystem Management." *Water Resources Bulletin*. 31(3): 369-386.

OEP (Office of Environmental Policy). 1996. Memorandum of Understanding to Foster the Ecosystem Approach. White House, Washington, DC.

Rundel, P.W. and P. Gibson. 1996. *Ecological Communities and Processes in a Mojave Desert Ecosystem: Rock Valley, Nevada*. Cambridge, England: Cambridge University Press.

Sampson, F.B. and F.L. Knopf. 1996. "Putting 'Ecosystem' Into Natural Resources Management." *Journal of Soil and Water Conservation*. 51(4): 288-292.

Slocombe, D.S. 1993. "Implementing Ecosystem-Based Management." *BioScience*. 43(9): 612-622.

TKC (The Keystone Center). 1996. *Keystone National Policy Dialogue on Ecosystem Management: Implementing Community-Based Approaches*. Keystone, CO: The Keystone Center.

———. 1998. *Final Report of the Keystone Dialogue on Nellis Air Force Range Stewardship*. Keystone, CO: The Keystone Center.

USAF (U.S. Air Force). 1997a. *Integrated Natural Resources Management*. AFI 32-7064. USAF, Washington, DC.

———. 1997b. *Integrated Natural Resources Management Plan - Nellis Air Force Base/Nellis Air Force Range*. Nellis Air Force Base, NV.

———. 1997c. *Five-Party Cooperative Agreement*. USAF, Nellis Air Force Base, Las Vegas, NV.

USBLM (U.S. Bureau of Land Management). 1994. *Ecosystem Management in the BLM: From Concept to Commitment*. USBLM, Washington, DC.

USDOE (U.S. Department of Energy). 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada: Volume 2. Framework for the Resource Management Plan*. DOE/EIS 0243. US DOE, Las Vegas, NV.

USFWS (U.S. Fish and Wildlife Service). 1994. *An Ecosystem Approach to Fish and Wildlife Conservation and The Role of Refuges in an Ecosystem Approach*. USFWS, Washington, DC.

USGAO (U.S. General Accounting Office). 1994. *Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach*. USGAO, Washington, DC.

Yaffee, S.L., A. Phillips, I. Frentz, P. Hardy, S. Maleki, and B. Thorpe. 1996. *Ecosystem Management in the United States*. Washington, DC: Island Press.

Vogt, K.A., J.C. Gordon, J.P. Wargo, and D.J. Vogt. 1997. *Ecosystems: Balancing Science and Management*. New York, NY: Springer-Verlag New York, Inc.

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ATTACHMENT K

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Implications of Resources Management at the Nevada Test Site

Charles R. Malone

The U.S. Department of Energy's Nevada Test Site (NTS) is taking steps to implement the department's policy on long-term stewardship of land and facilities. They are following an approach consisting of comprehensive resources management based on the federal ecosystem management initiative. Results of the program will be applied to planning new facilities and future land uses at the NTS. One important aspect will be the NTS Environmental Restoration Program, a critical factor in future uses of the site. Information acquired through resources management planning can be used at the NTS for evaluating environmental risks, deciding cleanup priorities and alternative remedial strategies, and for future land use planning. The NTS land and facilities resources management program might serve as a model for other DOE sites.

The U.S. Department of Energy (DOE) has embarked on a creative program of environmental stewardship at the Nevada Test Site (NTS). Sustaining both DOE missions and natural resources through comprehensive, integrated resources management is both the framework and the goal of the program.[1] This objective responds to DOE Policy 430.1 concerning land and facility use planning. Adopted in 1996, the policy aims at achieving sustainable development through ecosystem management. Activities at the NTS that will benefit from this initiative are the Environment Registration (ER) Program and the National Environmental Policy Act (NEPA) process. With both the ER Program and NEPA, the resources management program will significantly enhance human and ecological health risk assessments. These are crucial elements of setting cleanup priorities, evaluating alternative cleanup solutions, siting new facilities, and planning for long-term uses of the NTS.

The ecosystem-based approach to resources management at the NTS is consistent with what would be needed for a DOE-wide effort toward a comprehensive method for environmental protection and resources

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management at DOE nuclear weapons complex sites. The essential administrative components for such an approach to environmental management, including DOE Policy 430.1, already exist within the DOE's national resources stewardship program.[2] The stewardship program, announced in late 1994, addresses DOE land and facilities. By mid-1997, the stewardship policy and a corresponding implementing order (DOE Order 430.1) were in place. Both directives concern achieving sustainable development through ecosystem management. For example, DOE Policy 430.1 states:

> It is the Department of Energy's policy to manage its land and facilities as valuable national resources. Our stewardship will be based on the principles of ecosystem management and sustainable development. We will integrate mission, economic, ecological, social, and cultural factors in a comprehensive plan for each site that will guide land and facility decisions. Each comprehensive plan will consider the site's larger regional context and be developed with stakeholder participation. This policy will result in land and facility uses that support the Department's critical missions, stimulate the economy, and protect the environment.

A novel aspect of the policy includes developing goals and objectives jointly between the DOE and its stakeholders.

The DOE framed its creative environmental stewardship policy in the context of managing site life-cycles as a way to sustain site development, future uses, and associated natural resources.[3] A novel aspect of the policy includes developing goals and objectives jointly between the DOE and its stakeholders. Equally novel is that the comprehensive land and facility use plans to be developed for each DOE site will consider the site's larger regional context. These enlightened principles for managing DOE's resources, natural and man-made, stem from the ecosystem management concept that arose from the White House's 1993 National Performance Review.[4] In the DOE, implementing the reformative resource principles in the context of life-cycle asset management will occur through DOE Order 430.1, which calls for the comprehensive land-use planning process mentioned in DOE Policy 430.1.

The idea that the DOE's innovative land and facility stewardship process would affect the DOE ER Program was presented in a booklet that accompanied the Secretary of Energy's announcement of the resources stewardship policy in 1994 (see note 2). Entitled *Department of Energy—Stewards of a National Resource*, the publication included a section that addressed the DOE ER and Waste Management Programs in the context of determining human health risks and setting remediation goals for long-term land use decisions. The cleanup program is vital to comprehensive land use planning for future uses of all DOE sites.

Future reuse of lands and facilities managed by the DOE will involve stakeholder participation, a defining principle of ecosystem management. This aspect of the applied ecological approach is new to the DOE, but the DOE recognizes its importance. Ecosystem management should not be dismissed as an esoteric idea before considering the concept's

defining principles (Exhibit 1). The concept is more about people than it is about traditional ecology.[5] True, ecosystem management is grounded in recent developments of applied ecology, but it grew from lessons learned the hard way concerning improper management of natural resource commodities and collapsing human economies. An often intimidating feature of the concept for federal land management agencies is its keystone principles of openness and of involving diverse stakeholders in cooperative and coordinated environmental decisionmaking. Those principles alone explain why ecosystem management rapidly evolved into the foundation for pursuing sustainable development.

Exhibit 1. Defining Principles of Ecosystem Management as a Means for Achieving Sustainable Development

- Includes humans as part of ecosystems and assumes that humans must depend on and be responsible for sustaining natural resources and human economies.
- Requires partnerships and cooperation between federal, state, and local governments with respect to managing public lands in a sustainable manner.
- Involves open, joint decisionmaking that includes affected stakeholders and interests.
- Uses an interdisciplinary approach that integrates the socioeconomic and ecological goals of regional stakeholders.
- Bases management on ecological regions as opposed to jurisdictional boundaries.
- Recognizes the limits of current ecological knowledge and involves adaptive management policies and practices as information becomes available.

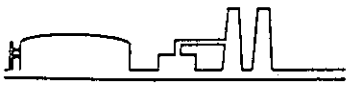
ECOSYSTEM MANAGEMENT AND THE NEVADA TEST SITE

An integrated approach to cleaning up ER sites at the NTS is a timely idea in view of the enlightened federal policy regarding "a proactive approach to ensuring a sustainable economy and a sustainable environment through ecosystem management." The preceding quote defines the postmodern approach to comprehensive environmental protection and resources management and is from a report by Vice President Al Gore that accompanied the White House National Performance Review.[6] From this followed creation of the Interagency Ecosystem Management Task Force (IEMTF) and its June 1995 overview report on using the ecosystem approach to achieve healthy ecosystems and sustainable economies.[7] Subsequently, the White House produced a memorandum of understanding (MOU) to foster ecosystem management, which was signed by all federal land management departments and agencies.

Following the MOU, the federal departments and agencies that had not already done so took steps to initiate the new approach to environmental management. The DOE anticipated the White House policy by announcing its revised land and facility resource policy in late 1994. The DOE Nevada Operations Office saw the useful application of the new management strategy to the NTS ER Program and took steps to relate cleanup activities to the forthcoming directives on land and facilities management during a site-wide Environmental Impact Statement (EIS) process initiated in 1994. To accommodate the DOE land and facilities use policy at the NTS, the Nevada Operations Office developed a comprehensive Resources Management Plan (RMP) for the site (see note 1). In this context, "resources" includes both land and DOE facilities.

During the NTS EIS process, the DOE and interested stakeholders interacted regarding managing land and facilities. This led to a framework for the resources management process based on ecosystem management. The final EIS included the framework as Volume Two. Stakeholders considered the framework document to be sound with respect to the Secretary of Energy's December 1994 policy statement on stewardship of DOE's land and facility resources. The "comprehensive plan for each site" mentioned in the Secretary's statement is the plan mandated by DOE Order 430.1 on Life Cycle Asset Management that is required of each DOE site, which was the goal for the NTS RMP. The goal was stated in the RMP framework document as follows:

> The goal of the Resource Management Plan is to establish a process for managing resources to ensure long-term diversity and productivity of affected ecosystems and sustainable use of land and facilities on the NTS. The process will be based on the principles of ecosystem management and be developed with the participation of surrounding land managers and other interested parties. The DOE/NV will use this process to assess the impact of existing facilities and activities, and evaluate the selection, design, location, and impact of proposed facilities and activities. The plan will identify the criteria for evaluating the compatibility of these activities with human health and safety, ongoing missions, existing infrastructure, cultural and natural resources, public values, and other resource issues and constraints.



When DOE mission requirements at the NTS and the goals for resources conflict, NEPA will evaluate proposed resolutions.

Exhibit 2 illustrates the qualitative goals for managing resources at the NTS as identified in the RMP framework document. As the process develops, the goals will take on more definitive, quantitative characteristics that can be used to identify limits on resource uses and conflicts between alternative uses of the NTS resources. The goals are meant to be used to evaluate DOE activities' effects on resource issues and to identify management actions needed for wise resource use and sound ecosystem management.

When DOE mission requirements at the NTS and the goals for resources conflict, NEPA will evaluate proposed resolutions. In such

Exhibit 2. Goals for Resource Management at the Nevada Test Site That Are To Be Pursued Through the Resource Management Plan, DOE Policy 430.1, and DOE Order 430.1

- Ensure the sustainability of DOE missions, land resources, and existing facilities by managing them in a way that most effectively uses and protects them.
- Accommodate expanded uses of the NTS through proactive planning based on sustainable development.
- Maintain adequate water supplies on the NTS while ensuring long-term sustainability of DOE missions and surrounding ecosystems.
- Site new facilities to minimize human health risks, to take advantage of existing facilities, and to enhance future uses of the site.
- Site new facilities to comply with legal controls on land use, to protect undisturbed ecological areas, and to be in areas with suitable natural features such as soils, slope, and drainage.
- Sustain ecosystems and assets, including existing capital, native biota, uncontaminated water, and cultural resources.
- Achieve these goals in a manner that considers and stimulates local and regional socioeconomic values.

cases, solutions may include canceling a proposed mission, modifying a proposed mission to reduce impacts on a resource, modifying existing missions, or not achieving a goal. Stakeholders would have a voice in the resolution procedures through the informal RMP process, as well as through the mandated NEPA process. Decisionmakers thus would have stakeholder comments and project costs and benefits to consider in resolving a conflict.

A careful analysis of DOE's land and facility use policy and the purpose of the NTS RMP reveals that changes can be expected regarding how the DOE Nevada Operations Office manages the environment and the environmental impact assessment process. This is especially true with respect to public and stakeholder participation in DOE programs at the NTS. The changes will evolve as the NTS RMP process develops. That this will occur is evident from the NTS RMP Project Execution Plan (U.S. DOE 1997b) (see note 1). Presented in the plan is the project work schedule through FY99 with a total budget of $1.8 million. The plan also includes significant details on the work breakdown structure and the schedule (**Exhibit 3**) for accomplishing the RMP.

In accomplishing its goal, the NTS RMP will include baseline conditions for ecosystems as well as for the DOE facilities at the NTS. The ecosystems are not well understood at the NTS because attention has focused principally on regulated components of ecosystems, such as

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Exhibit 3. Schedule for the Resource Management Plan Process for the Nevada Test Site as of Fall 1997

SUMMER 1997—	Briefings to key stakeholders to acquaint them with the NTS RMP process.
FALL 1997—	Resource workshops with stakeholders to identify resource issues and goals.
EARLY 1998—	Identification of resource limitations to achieving sustainable development.
EARLY 1998—	Identification of available resource information and the tools needed to acquire needed information.
MID-LATE 1998—	Monitoring resource use and determining the changing status of resources.
MID-1998—	Assessment of cumulative impacts associated with ecosystem-based resource management.
LATE 1998—	Updating and publishing the first iteration of the RMP.
OUTLYING YEARS—	Reiterations of the RMP based on additional knowledge of ecosystems and on updated information on NTS facilities.

threatened and endangered species. Compensating for the deficit of information on baseline ecosystem conditions cannot be accomplished in just a few years. Thus, the first iteration of the NTS RMP will utilize what information is available, identify additional information needs, and contain plans for establishing comprehensive baseline conditions. Much of this task will be accomplished through a long-term ecosystem monitoring program that is part of the ecosystem management process.

Because of insufficient information on baseline ecosystem conditions at the time the NTS site-wide EIS was prepared, the DOE was unable to apply ecosystem management for that process. The DOE Nevada Operations Office made an informal agreement with stakeholders, including the State of Nevada, to proceed with the traditional DOE approach to the EIS process for the NTS in exchange for a commitment to prepare an RMP once the EIS was completed. This working arrangement between the two sides of the issue is proceeding to the advantage of both. For example, the DOE has a final EIS which can be amended for new facilities at the NTS while the RMP

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is being developed. Stakeholders are assured that the DOE in Nevada will pursue ecosystem management for the NTS, as well as for the region. The regional context will be achieved through cooperative agreements with other government agencies, including those of the State of Nevada. The decisionmaking process also will be open to other stakeholders as provided for by the principles of ecosystem management.

REGIONAL IMPLICATIONS AND OTHER OPPORTUNITIES

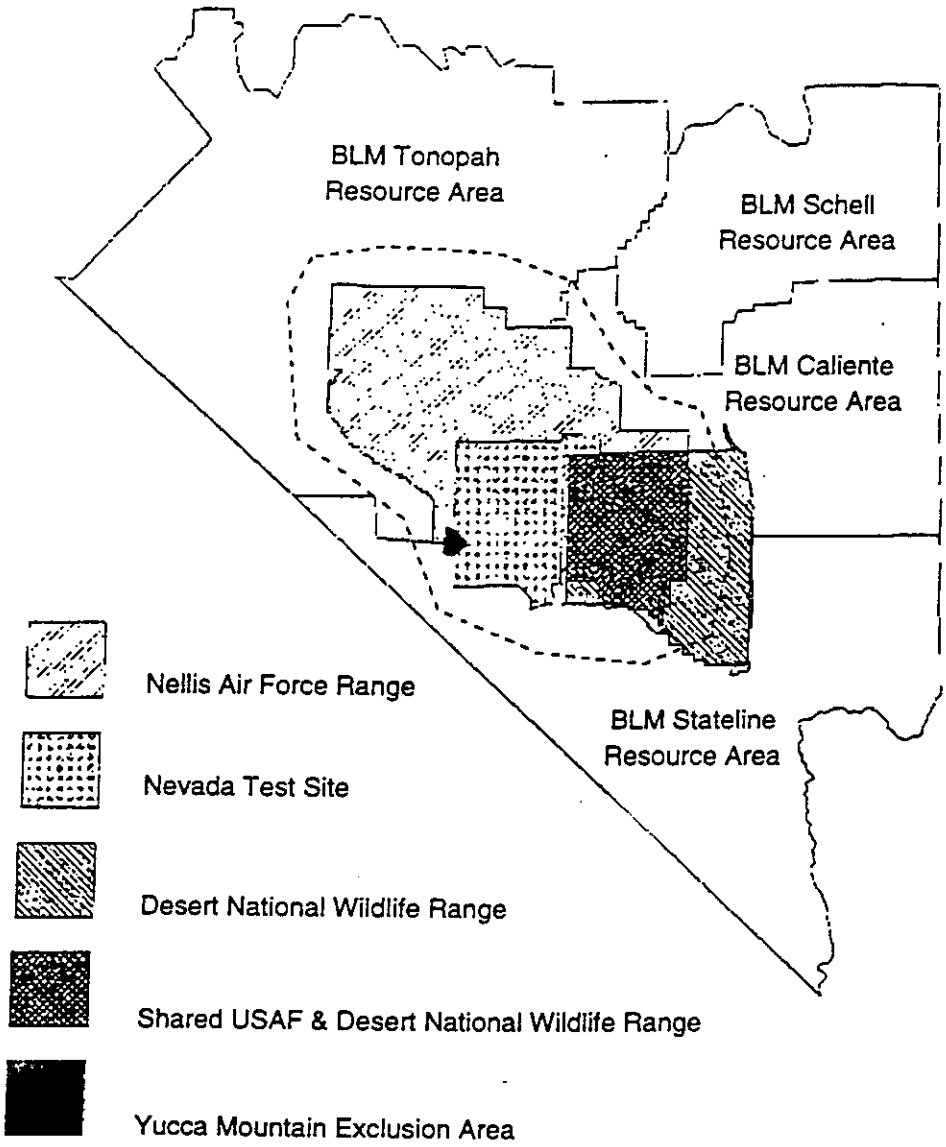
One of the novel aspects of the DOE land and facility use policy was that resources management at DOE sites is to address not only the site itself but also to consider the site's importance on a regional basis.

At this point it is a good idea to consider some of the implications and opportunities associated with ecosystem-based resources management planning at the NTS. Recall that one of the novel aspects of the DOE land and facility use policy was that resources management at DOE sites is to address not only the site itself but also to consider the site's importance on a regional basis. **Exhibit 4** shows the region in southern Nevada shared by the DOE with the U.S. Department of Defense (the Air Force) and the U.S. Department of the Interior's Bureau of Land Management (BLM) and Fish and Wildlife Service (FWS). The Air Force, the BLM, and the FWS have policies and directives regarding ecosystem management. Especially noteworthy in this regard is the Nellis Air Force Range, which is located on three sides of the NTS.

In managing the Nellis range, the Air Force must adhere to integrated natural resources management directives that involve ecosystem management. These mandates are similar to those of the DOE's resources stewardship program. Thus, the Air Force's required Integrated Natural Resources Management Plan (INRMP) is similar to the NTS RMP regarding use of the ecological approach to sustain military missions (i.e., sustainable development). In general, however, the Air Force has less institutional experience and technical expertise in such matters than the DOE has and, for now, must look to others for assistance with respect to ecosystem management. Thus, for preparing the first INRMP document for the Nellis range,[4] guidance is being provided under a partnership agreement with The Keystone Center and The Nature Conservancy. Especially noteworthy is the two private organizations' natural resources stewardship dialogue. The dialogue is similar to earlier generic policy dialogues carried out by The Keystone Center and The Nature Conservancy (see note 5). In this instance, however, the activity is site specific, in that it addresses the Nellis Air Force Range and the common ecological region the range shares with the DOE NTS and other federal lands and agencies. The Air Force's action presents an opportunity to apply the ecosystem approach across jurisdictional boundaries, as does the NTS RMP.

The Nellis range dialogue process involves not only the DOE but the U.S. Department of the Interior, the State of Nevada,[5] and local governments. Key stakeholders also are involved in an effort to achieve a coordinated and cooperative approach to achieving sustainable development in the NTS-Nellis region. Both The Keystone Center and The Nature Conservancy are at the forefront of implementing ecosystem management on public lands. For this reason, chances are reasonably

Exhibit 4. Map of Southern Nevada Showing the Ecological Region, Enclosed by the Dashed Line, That Includes the Nevada Test Site and Other Federal Lands



good that the regional effort in southern Nevada can succeed.

The Nellis range dialogue is anticipated to result in an interagency cooperative agreement that will include the agencies of the Department of the Interior participating in the regional ecosystem management effort. Both the BLM and FWS have policies in place for committing to the ecosystem management processes of the NTS and the Nellis range. This is important because, as Exhibit 4 shows, the western half of the FWS wildlife refuge is shared with the Nellis Air Force Range. The shared

portion of the refuge will be addressed by the Air Force INRMP now underway. Fundamental natural resources management is a process familiar to the Interior agencies, and the add-on principles of postmodern ecosystem management can be accommodated readily.

As for the opportunities the NTS RMP presents to the DOE, two obvious ones concern the baseline environmental data that will be kept current. First, the information will expedite the NEPA process for proposed new facilities by having up-to-date information on the natural resources and existing facilities at the NTS. This means that alternative facility siting decisions and their environmental impact assessments need await only the proposed design specifications. The second opportunity will be the ready availability of much of the environmental information needed for the ER Program. Useful baseline information will include much of the data on environmental conditions necessary for performing human and ecological health risk assessments and for deciding the degree of cleanliness needed for future uses of the NTS.

The DOE could similarly use the NTS RMP regarding its Yucca Mountain site. Located partly on the NTS and partly on lands managed by the Air Force and the BLM (Exhibit 4), Yucca Mountain is the site DOE selected for the world's first geologic repository for permanent storage of the nation's defense and commercial high-level nuclear waste. The DOE has excluded the Yucca Mountain Project from coverage by the NTS RMP process principally to avoid potential delays that the process may incur. For this reason, the site stands as the sole area within the surrounding ecological region that is not included in the regional ecosystem management initiative stemming from the NTS RMP and the INRMP for the Nellis range. This is unfortunate because the health and integrity of the regional ecosystem that includes the Yucca Mountain site is important to the long-term performance of a nuclear repository at the site.[10]

With respect to the DOE's NEPA process, the comprehensive and integrated resources management approach followed by the NTS RMP should improve the interdisciplinary character of related assessments, evaluations, and decisions. Advocates of NEPA have long sought a comprehensive approach to ecosystem management as the Act and its regulations imply. However, there has not been a functional holistic concept for achieving the degree of comprehensiveness and integration NEPA envisions. Only in recent years has the state-of-the-art of ecosystem science reached a state of development to facilitate the applied ecosystem approach.

Only in recent years has the state-of-the-art of ecosystem science reached a state of development to facilitate the applied ecosystem approach.

Essentially the same can be said of the DOE ER Program. Integrated environmental risk assessment and the science of ecosystem restoration are new disciplines that ecosystem management serves well. It is unlikely that achieving an integrated approach for the cleanup program with revised laws and regulatory schemes will come any time soon. The ecosystem management strategy being taken for the NTS RMP can be tested at the NTS. If found promising, the approach can be considered for the DOE nuclear weapons complex cleanup program under the recently launched 10-year Integrated Strategic Planning Program.[11] A useful

characteristic of the NTS RMP approach is that it cuts across DOE's various programs (i.e., defense, environmental health and safety, environmental management, environmental restoration, and waste management) at DOE's nuclear weapons complex sites.

CONCLUSIONS

The DOE's ongoing national resources stewardship initiative stands to benefit the Department in view of enlightened postmodern ideas regarding managing public lands and resources. Planning for integrated resources management such as is underway at the NTS appears to be a credible and effective means for conforming with the DOE's directives regarding resources stewardship. Thus, the NTS RMP approach accommodates the Department's Land and Facility Use Planning Policy (DOE Policy 430.1) and its Life Cycle Asset Management Order (DOE Order 430.1), both of which require ecosystem management as a basis for administering DOE's land and facility resources. This approach to land and facility stewardship would complement the DOE's expanding attitudes concerning openness and collaboration with stakeholders. Existing administrative directives within the DOE are sufficient for undertaking resources management based on ecosystem management.

The NTS RMP approach could serve as a model for other DOE nuclear weapons complex sites.

The NTS RMP approach could serve as a model for other DOE nuclear weapons complex sites. Such a department-wide program would facilitate the DOE's broad initiative regarding future uses of former nuclear weapons complex sites. A paramount issue faced by all DOE sites engaged in the ER Pogram is "How clean is clean enough for what uses?" This is a vital socioeconomic concern regarding DOE's public stakeholders and their perception of the Department's intentions. Such matters are at the heart of the national policy initiative regarding sustainable development and ecosystem management that arose from the White House's 1993 National Performance Review.

The resources stewardship activity coincides with an effort to foster government interagency cooperation in managing regional natural resources. Along with two other federal departments, the DOE is involved with key public land stakeholders in addressing resources management issues within a common ecological region in southern Nevada. To date, a significant benefit of the regional initiative is that predominantly adverse public opinion is improving in the state. This is yet another benefit that can follow from a sincere commitment to human-oriented ecosystem management principles. The same would be true for the Yucca Mountain Project if the DOE would include the prospective repository site in the NTS RMP.

Innovative, progressive resources management planning at the NTS appears to be the first such attempt within the DOE. Another first at the NTS is the DOE's involvement with regional ecosystem management at a former nuclear weapons site. These creative and enterprising initiatives capture the spirit of national resources stewardship set forth by the Secretary of Energy in 1994. They are not to be dismissed lightly as the DOE progresses into the post-Cold War era. Much of what the Depart-

ment still needs to accomplish depends on initiatives similar to those being taken for the NTS. Serious consideration should be given to the appropriateness and advantages that such actions have to offer regarding other nuclear weapons complex sites. ❖

NOTES

1. A "Framework for the Resources Management Plan" was developed as Volume Two of U.S. DOE, Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada, US DOE/NVO, Las Vegas, 1996, NV DOE/EIS 0243. A commitment to prepare a resource management plan for the NTS was included in the Record of Decision for the 1996 NTS final environmental impact statement, Federal Register 61 (16 December 1996), no. 241: 65551-65563. A Resources Management Plan Project Execution Plan, dated June 2, 1997, was made public by the DOE on July 8, 1997.

2. The DOE's national resources stewardship initiative was announced in H. O'Leary, Land and Facility Use Policy, Memorandum to Secretarial Officers and Operations Office Managers, Secretary of Energy, Washington, DC, 21 December 1994. Included with the memorandum was U.S. Department of Energy, Department of Energy: Stewards of a National Resource, US DOE, Washington, DC, December 1994, DOE/FM-0002. The formal stewardship program was established by U.S. DOE, Land and Facility Use Planning Policy, DOE, Washington, DC, 9 July 1996, P 430.1, and by U.S. DOE, Life Cycle Asset Management Order, U.S. DOE, Washington, DC, 24 August 1997, DOE O 430.1.

3. U.S. DOE, Charting the Course. U.S. DOE, Washington, DC, April 1996, U.S. DOE, DOE/EM-0283; Resourceful Reuse: A Guide to Planning Future Uses of Department of Energy Sites, U.S. DOE, Washington, DC, May 1996, DOE/EM-0285.

4. Federal policy for the ecological approach to managing natural resources on federal lands was set forth in Vice President Al Gore, Reinventing Environmental Management: Accompanying Report of the National Performance Review, Creating a Government That Works Better & Costs Less, White House National Performance Review, Washington, DC, September 1993; Interagency Ecosystem Management Task Force 1995-1996, The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies, Vols. I–III. The White House Office of Environmental Policy, Washington, DC.

5. The Keystone Center, The Keystone National Policy Dialogue on Ecosystem Management, The Keystone Center, Keystone, CO, October 1996; The Nature Conservancy, Conserving Biodiversity on Military Lands: A Handbook for Natural Resources Managers, The Nature Conservancy, Arlington, VA, 1996; Ecological Society of America, The Report of the Committee on the Scientific Basis for Ecosystem Management, *Ecological Applications* 6 (1995) no. 3: 665-691; R.E. Grumbine, "What Is Ecosystem Management?" *Conservation Biology* 8(1994) no. 1: 27-38; C.A. Wood, "Ecosystem Management: Achieving the New Land Ethic," *Renewable Resources Journal*, Spring 1994: 6-12.

6. See note 4.

7. Id.

8. Air Force and U.S. Department of Defense policies and directives for INRMP documents are explained in U.S. Air Force, Draft Integrated Natural Resources Management Plan—Nellis Air Force Base/Nellis Air Force Range, Environmental Management Directorate, 99th Air Base Wing, Nellis Air Force Base, Nevada (March 1997).

9. The State of Nevada has encouraged the federal agencies involved to cooperatively address land resource planning and management including the ecological region shared by the Nellis range and the NTS. This occurred in a meeting at the BLM's Las Vegas District office on November 6, 1996. The meeting was hosted by the Bureau of Land Management Resources Advisory Council for southern Nevada.

10. C.R. Malone, "Ecology, Ethics, and Professional Environmental Practice: The Yucca Mountain, Nevada Project as a Case Study," *The Environmental Professional* 17 (1995): 271-

284; C.R. Malone, "The Federal Ecosystem Management Initiative in the U.S.," In J. Lemons, R. Goodland, and L. Westra (eds.), *Environmental Sustainability: Case Studies on the Prospects of Science and Ethics*, Kluwer Academic Publishers, Dordreche, The Netherlands (in press).

11. Details for the U.S. DOE's 10-year Integrated Strategic Planning Program are in US DOE, Accelerating Cleanup: Focus on 2006 (Discussion Paper), DOE, Washington, DC, 1997, DOE/EM-0327.

ATTACHMENT L

THE FEDERAL ECOSYSTEM MANAGEMENT INITIATIVE IN THE UNITED STATES

Charles R. Malone*

1. The Need for Ecosystem Management in the U.S.

In a recent book, *Lost Landscapes and Failed Economies*, Power (1996) argues convincingly that the quality of the natural landscape is an essential part of an area's permanent economic base and should not be sacrificed in short-term efforts to maintain economic interests and pursuits that are ultimately not sustainable. In another book, *Ecosystem Management in the United States* (Yaffee et al. 1996), Yaffee and his students at the University of Michigan list 619 projects that reflect elements of ecosystem management, the emerging new paradigm for achieving sustainable development in the U.S.

Additionally, the President's National Science and Technology Council (NSTC 1995) established an Ecosystem Working Group as part of an effort to address such issues as research and development strategies on global change, biodiversity and ecosystem dynamics, and resource use and management. The NTSC (1995) concluded (1) that pursuit of improved quality of life often threatens the sustainability of ecosystems, (2) continued decreases in productivity and vitality of ecosystems which can result in increased deterioration of ecosystems that are incompletely understood, (3) the basis for human development has been the availability of healthy natural ecosystems and the resources they provide, and (4) that to sustain further human development, the ecological base to support it must be sustained. These are among the many signs that in the U.S. public perception is increasing that the short-term economic value of renewable natural resources is not worth risking damage to ecosystem that can threaten the environment of future generations. Awareness of the need for ecological sustainability is being expressed in the rising popularity of the ecosystem approach to resource management (e.g., ESA 1996a, Grumbine 1994, Slocombe 1993, Wood 1994). The federal government in particular has undertaken an ecosystem management initiative for public lands in an effort to foster ecologic and economic sustainability (CRS 1994, Gore 1993, IEMTF 1995). In the context of the federal initiative, ecosystem management reflects humanistic views of nature which seek to support development that is compatible with the environment.

The concept of ecosystem management suggests different things to different people. The popular version of the idea, addressed here, implies that humans are considered as integral components of ecosystems and that the sustainability of human

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socioeconomics and ecosystems is interwoven. Further, the ethic embodied by ecosystem management means that renewable natural resources are to be managed by each generation such that succeeding ones will have access to comparable resources through time. This humanistic precept is consistent with that of Darling and Dasmann (1969) concerning the ecosystem view of human society and the ecological approach to maintaining the environment.

Sustainable development through human-oriented ecosystem management is seen as a means for restoring and maintaining natural systems and human economies where traditional commodity-directed resource management has failed to do so (Lemons and Brown 1995, Slocombe 1993, van den Bergh and van der Stratten 1994). This approach to resource management that is compatible with human development integrates politics, institutional arrangements, natural resource management, and socioeconomics.

Principal among events in the U.S. that led to ecosystem management as an applied interdisciplinary practice were the grizzly bear controversy in the Greater Yellowstone Ecosystem and northern spotted owl controversy in the Pacific Northwest (Grumbine 1994, Yaffee 1994). In the 1970s and 1980s these events influenced the integration of ecosystem science, conservation biology, traditional natural resource management, socioeconomics, institutional arrangements, and diverse stakeholders interests. By the late 1980s this synthesis had resulted in an ecosystem approach to land management. And, it was during this period that usage of the term "ecosystem management" to mean an integration of the biophysical and human dimensions for managing natural resources became common.

The recent origins of ecosystem management in the U.S. have been documented by Grumbine (1994), Knight and Bates (1995), Slocombe (1993), and Yaffee (1994). The present paper addresses the concept of ecosystem management as it is reflected in the federal ecosystem management initiative in the U.S. Origins and evolution of the ecosystem management concept, its strengths and weaknesses, its role in the pursuit of sustainable development, and the role of professional ethics in ecosystem management, as exemplified by a case study of a major federal program, will be discussed here.

(In the U.S., historical accounts of ecosystem management, including this one, typically ignore the Central and Eastern European origins of the concept through the discipline of landscape ecology after World War II, as documented by Naveh and Lieberman (1994). Landscape ecology is gaining favor in the U.S. because (1) a central feature of the discipline is recognition of the dynamic role of humans in the landscape and the ecological implications (2) a realization that almost all landscapes have been influenced by cultural forces, and (3) cultural, social, aesthetic, and economic considerations are incorporated in landscape ecology. However, in the U.S. the discipline has yet to be integrated extensively from academic circles into application such as the federal ecosystem management initiative.)

2. Nature of the Federal Ecosystem Management Initiative in the U.S.

Since the late 1980s, some federal agency officials, scientists, and natural resource policy analysts have advocated a broader approach to natural resource management than the traditional focus on commodity production. For a decade prior to

that time, the dominant resource management paradigm was "multiple use." However, this management strategy, like the preceding focus on production of commercially valuable commodities, met with only limited success in sustaining ecosystem goods and services. The reason was that under multiple use management the federal land management agencies continued to place priority on managing resources of economic value, e.g., livestock grazing lands and timber production lands, at the expense of ecosystems.

Now, the state of ecosystem science is sufficient to contribute its part to an interdisciplinary nucleus for ecosystem management. For example, it is recognized that ecosystems are open, regulated by events outside their boundaries, do not reach stable equilibrium points, and include humans (Allen and Hoekstra 1992, ESA 1996a, Gunderson et al. 1995, Pahl-Wostel 1995). The knowledge that ecosystems are subject to natural changes and uncertainty lends to a focus on long-term sustainability rather than traditional management to maximize short-term yield.

The popularized form of ecosystem management adopted for the federal ecosystem management initiative is labelled as humanistic or anthropocentric. It typically emphasizes socioeconomics, political science and institutional arrangements more than it does science (e.g., Cortner and Moote 1994, Keystone Center 1996). The contrasting view of ecosystem management is the biocentric view that focuses first on sustaining ecosystems and their biodiversity and only secondarily on the economic benefits to humans derived from sound ecosystems having integrity and resilience (Lackey 1995, Stanley 1995). Biocentric ecosystem management rejects sustainable development as being a fallacy in view of human nature being to seek ever greater economic gains at the expense of the natural environment. The biocentric view says that ecosystems cannot be scientifically managed because their complexity defies human understanding and control (Arrow et al. 1995, Ludwig et al. 1993).

In the U.S. federal initiative, ecosystem management rests on several characteristics and tenets (Table 1). While all the factors in Table 1 are critical to humanistic ecosystem management, one merits special attention regarding human dimensions. This is the interdisciplinary nature of ecosystem management that involves four interacting systems consisting of (1) the natural system including humans, (2) the social system of human values and behavior, (3) the economic system related to land, labor, and capital, and (4) the political system of policy making, laws, and institutional arrangements (Kennedy et al. 1995). Each system is dynamic and can change with a different frequency than the other three thereby complicating the interactions and confounding the matching of land capability with sustainable resource use.

The conceptual basis of the federal ecosystem management initiative is coupled with sustainable development. The vision of sustainable development means maintaining the well being of both humans and the ecosystems that provide renewable natural resources and ecosystem services necessary for socioeconomic progress (IETC 1996, Lemons 1995, van den Bergh and van der Straaten 1994). Science is useful in such efforts, but no matter how interdisciplinary it may be, many decisions about people and environmental objectives must include value judgements. Bridging the objective and subjective natures of ecosystem management is a major challenge to the initiative in the U.S.

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Table 1. Characteristics of humanistic (anthropocentric) ecosystem management.

- Embraces a land ethic based on sustainable ecosystems, natural resources, and economics for future generations and reflects socially defined goals and management objectives that support sustainable resources, communities, and economies.
- Recognizes that ecosystems are complex, dynamic, inherently unstable, and their components, including people, are interrelated.
- Includes humans as part of almost all ecosystems and assumes that humans must depend on and be responsible for natural resources.
- Uses an interdisciplinary approach that integrates biophysical and human dimensions and is based on the best science and information available while recognizing the limits of current knowledge.
- Requires partnerships between federal, state, and local government, landowners, and other stakeholders for collaborative decision making.
- Fosters incentive-based solutions to natural resource and environmental management and downplays regulatory approaches.
- Draws heavily on scientific principles, research, and state-of-the-environment monitoring and requires an improved understanding of ecosystems.
- Must be built on cooperative interagency institutions because ecosystems transcend jurisdictional boundaries.
- Recognizes uncertainty and relies on adaptive management for redirection of programs based on new knowledge.

2.1. EMERGENCE OF THE POLICY

The federal policy on ecosystem management began emerging in 1993 from the White House's National Performance Review (Gore 1993). As part of the review, Vice President Al Gore called for the federal government to adopt an approach for ensuring sustainable economic development while also sustaining the environment through ecosystem management. To carry out the environmental mandate of the National Performance Review, in August 1993 the White House Office of Environmental Policy (OEP) took the lead for the federal initiative on ecosystem management by establishing the Interagency Ecosystem Management Task Force (IEMTF) to carry out Vice President Gore's mandate. The task force examined five major issue areas relevant to ecosystem management including budgetary, institutional, public participation, science and

information, and legal authorities. Case studies of ecosystem management to identify barriers to the approach and to evaluate ways to overcome them.

Numerous recommendations were made by the task force regarding (1) improving interagency coordination, (2) improving partnerships with non-federal stakeholders, (3) improving communication with the public, (4) improving resource allocation and management; supporting the role of science, (5) improving information and data management, and (6) increasing flexibility for adaptive management. The recommendations in these areas are noteworthy because in January, 1996, the White House executed a Memorandum of Understanding to Foster the Ecosystem Approach (OEP 1996) that was signed by the 14 federal agencies that had participated in the interagency task force on ecosystem management.

The idea of using ecosystem management to sustain human development did not suddenly arise in the White House in 1993 or 1995. Prior to that time ecosystem management had been developing within various land management agencies, most notably the USFS and the BLM. In 1992 the USFS conducted a national workshop on the ecological approach to resource management (USFS 1992) and two years later the agency's policy on ecosystem management was articulated in a general technical report (USFS 1994). Meanwhile, the U.S. BLM (1994) and other federal agencies (CRS 1994, USDOE 1995, USFWS 1995, USNBS 1994) also were pursuing ecosystem management as a means for managing public lands.

Students of ecosystem management will be interested in a report developed for the US Senate (1994) and another one prepared by the U.S. General Accounting Office (USGAO 1994). The first of these contains a broad spectrum of views from government, academia, public interest, and commercial interests on ecosystem management and the role of the federal government. The second is a critique both of the ecosystem management concept and how it is being pursued by the federal government.

2.2. ROLE OF INTEGRATION

As being fostered by the federal initiative in the U.S., ecosystem management involves integrating the participation of public and private stakeholders, professionals, policy makers, and government institutions in joint decision making. Strong intergovernmental cooperation and coordination for fostering resource stewardship are essential to ecosystem management. These joint give-and-take processes combines public involvement with interdisciplinary expertise rather than the multidisciplinary approach that to this time has predominated.

Social, economic, and ecologic components of ecosystem management must be addressed over a long timeframe in order to sustain the natural resource base from one human generation to the next. The idea is that ecosystem management emphasizes changing how people perceive natural resources, especially resources on public lands where conflicts are common. Part of the desired change is to have people learn to look farther into the future than their own generation. Thus, pursuing sustainable development through ecosystem management requires changing human values, economics, and ecological realities, ideas, and knowledge, i.e. the human dimension. This means that interdisciplinary knowledge involving sociology, economics, political science, and ecology must be used to better understand the role of humans in the natural environment

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and the importance of natural resources to human socioeconomics, public health, and quality of life.

Unfortunately, the various disciplines involved in human dimensions are not well integrated with the natural sciences that underpin ecosystem management (Sheifer 1996). Achieving a transdisciplinary perspective and practice is essential to the success of humanistic ecosystem management as a means of achieving sustainable development.

3. Concern, Controversy, and Barriers to Ecosystem Management

Ecosystem management continues to be subject to debate and controversy. Concerns include whether or not the concept can deliver what it promises and whether or not human activities and natural processes can be integrated to benefit both (ESA 1996a). The humanistic path toward ecosystem management that is being fostered by the U.S. government is an ambiguous one that fails to be definitive. Thus, there is much rhetoric from federal land management agencies that profess to be engaged in ecosystem management. Many bureaucrats embrace the words associated with ecosystem management but not the philosophy (Lackey 1995).

Part of the difficulty is that there is little agreement among the various parties involved in ecosystem management regarding explicit features and definitive characteristics of ecosystem management. An effort toward reaching agreement is the late 1996 report on the Keystone Center National Policy Dialogue on Ecosystem Management (Keystone Center 1996). This includes the concept's key components, although principal emphasis was given to non-scientific, human dimension aspects of ecosystem management. Most notable about the Keystone Center dialogue on ecosystem management is the emphasis given to such matters as the role of stakeholders in decisionmaking and the organizational structure for implementing ecosystem management centered on human interests and values rather than ecosystem science.

Some critical observers of the ecosystem management concept and the federal initiative are highly skeptical. For example, Ludwig et al. (1993) believe that claims of sustainability are to be distrusted because they defy historical facts about human behavior and may lead to a complacency about ecosystem management or sustainable development. These and other concerns, such as how science handles uncertainty and how it envisions sustainable yield of resources, lead Ludwig and his coauthors to view natural resource problems not as technical problems but as human ones resulting from political, social, and economic systems, much as the Keystone Center (1996) approached ecosystem management.

Another critic, Stanley (1995), raises the matter of the "arrogance" of humanism in the context of the ecosystem management paradigm as it is being popularized and pursued by federal land resource managers. The concept of ecosystem management being popularized and fostered by government agencies is viewed by Stanley as being overly anthropocentric. Anthropocentrism emphasizes the human use of natural resources to the benefit of development and includes ecological as well as socioeconomic considerations. In contrast, the opposing biocentric view considers humans as a component of ecosystems equal to and subject to the same resource constraints as any other biotic component. Under biocentricism the biosphere has limits to its carrying

capacity, and human use of resources ultimately has to be constrained to meet the challenge of sustaining ecosystem integrity (Arrow et al. 1995).

3.1. CONFLICT OVER ECOSYSTEM MANAGEMENT

There are some aspects of ecosystem management that lead to conflict. For example, most ecosystems and landscapes lack precise boundaries and do not ordinarily conform to administrative borders. Land ownership and political boundaries have little scientific meaning in the sense of natural ecosystems and landscapes. Consequently, as public land management agencies seek to apply ecosystem management, private properties and various jurisdictional boundaries are confronted. Institutional mechanisms for managing across jurisdictions under an ecosystem approach are largely unknown (Cortner and Moote 1994).

Other concerns arise such as (1) government encroachment onto private properties that share ecosystems and landscapes with public land, (2) issues of how different government agencies cooperate regarding their management activities and conflicting legal mandates, (3) questions about stakeholder participation in decision making, and (4) the threat that private and commercial users of public land for economic or other benefits will face increasing regulations that compromise their livelihoods (Fitzsimmons 1996, Wood 1994). Regarding the issue of economics, goods and services derived from federal lands provide jobs for many local communities that stand to be threatened by ecosystem management of public land resources. However, the extent of the economic consequences of ecosystem management remain unknown.

These issues are important in the cultural context in the U.S. and this is the principal reason why the federal ecosystem management initiative involves chiefly public lands, i.e., to stem fears of federal intrusion into private ownership rights. Rights of property owners and local loss of jobs resulting from federal ecosystem management programs are major concerns of the public that ecosystem management strategies must deal with positively (ESA 1996a). Varner (1994) envisions a steady progression, under sustainable development and ecosystem management, toward all land, regardless of ownership, being viewed as a public resource owned in common and held by individuals only in a stewardship capacity.

3.2. BARRIERS TO ECOSYSTEM MANAGEMENT

Other concerns and barriers to ecosystem management (Table 2) fall into five broad categories - scientific, informational, institutional, decision making, and ethics. In particular, the Keystone Center (1996) expressed concerns about ecosystem management lacking an accepted definition and a set of definitive practices. Critical importance was ascribed to the need to clarify characteristics sometimes ascribed to ecosystem management but that are not congruent with the forum's vision of community-based ecosystem management processes. Principal among the concerns were the issues of the threat of expanding government control over private land use decisions, diminished focus of communities and regions on NEPA and other national environmental laws, a giveaway of public lands to local economic interests, top down federal planning and the tendency for land manager bureaucrats to embrace the philosophy of ecosystem

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Table 2. Barriers and needs that agencies face in implementing ecosystem management.

- Understanding ecosystem structure and function and the role of biodiversity in sustaining ecosystems.
- Determining appropriate spatial scales and hierarchical units for establishing ecosystem management boundaries.
- Establishing indicators for evaluating the success of ecosystem management.
- Establishing and managing a base of knowledge and monitoring information.
- Gaining an understanding of biophysical and socioeconomic interrelationships in ecosystems.
- Achieving federal interagency coordination and cooperation.
- Communicating between federal agencies and the public and establishing trust.
- Forming partnerships with non-federal stakeholders for reconciling diverse management goals and collaborative decision making.
- Remaining flexible for applying adaptive management.
- Improving adherence to principles of environmental ethics and standards of professional practice among all categories of environmental professionals.

management and move away from traditional ways of managing public land resources. Statutory barriers to ecosystem management also exist in the U.S. (Keiter 1994). These need to be examined and revised if necessary to provide positive incentives for ecosystem management, particularly regarding stakeholder participation in decision making. Federal land management agencies are guided by legislation concerning resource management planning. These constructs, along with the National Environmental Policy Act, were developed before ecosystem management was conceptualized and may be administered in ways that preclude an ecosystem, landscape, or ecoregion view consistent with the goals of ecosystem management as a new paradigm. Such concerns and potential barriers to ecosystem management led the Keystone Center (1996) to recommend that implementing regulations for the involved federal statutes be reviewed and revised where appropriate to promote ecosystem management goals and partnerships for resource management initiatives on a landscape scale.

Apprehensions and obstacles to ecosystem management will continue as the discipline evolves. However, the most divisive issues are not scientific or technical: they are moral and philosophical (Lackey 1995). Science cannot resolve the moral issues involving ecosystem management. A proper role for science is to strive to reduce the

scientific uncertainty in much of ecosystem science and the technical aspects of ecosystem management. Resolution of both the moral issues and the scientific uncertainties must attempt to remain astride of the continued social trend in the U.S. and elsewhere toward placing ever greater weight on nonconsumptive societal benefits. Thus, the underlying reasons for the emergence of ecosystem management as a new paradigm for resource management and sustainable development is unlikely to disappear.

4. Ecosystem Management and Professional Ethics

Much is written about ecosystem management and environmental ethics (e.g., Cortner and Moote 1994, ESA 1996a, Francis 1993, Grumbine 1994, Lemons and Brown 1995, Wood 1994). Nothing will be added here to that important topic. Instead, the seldom considered issue of professional ethics in relation to ecosystem management will be addressed. This matter is important because while most ecologists and other environmental professionals profess to being environmentally ethical, relatively fewer in the U.S. view matters of professional ethics and standards of professional practice with similar importance.

It is true that professionals involved with matters affecting the environment generally recognize that the synthesis of facts and values is a professional responsibility. Beyond that, many ecologists and other natural scientists do not recognize a need for guidance on other matters of professional ethics and standards of practice. The Ecological Society of America (ESA), for example, has touched only slightly on this matter through its Code of Ethics (ESA 1996b). The point to be made here is that while the ESA Code of Ethics serves researchers and educators well, it is inadequate for consulting ecologists. This is especially true for ecological consultants involved with matters and affairs of applied ecology, environmental policy, and federal programmatic direction affecting public interests.

On the other hand, traditional environmental professionals such as the members of the National Association of Environmental Professionals (NAEP) that are involved principally in matters of regulatory compliance characteristically subscribe to a Code of Ethics and Standards of Professional Practice (Malone 1995, NAEP 1996). When the ESA (1996b) Code of Ethics is compared to the NAEP (1996) Code of Ethics and Standards of Professional Practice some important principles of professional ethics and standards are not found in the ESA (1996b) Code of Ethics (Table 3).

For example, the ESA's Code of Ethics does not specifically target the consulting profession even though significant numbers of ecologists are full-time or part-time consultants, often on matters important to ecosystem management and sustainable development. The dilemma posed here with respect to ecosystem management and professional ethics is illustrated by considering ecosystem management in the U.S. Department of Energy (DOE) which was the last federal land management agency to adopt ecosystem management.

An ecosystem management policy was adopted by the DOE in December 1994 (USDOE 1994). The policy's objectives were laudable, i.e., for DOE to manage its land and facilities as valuable national resources in accordance with the principles of ecosystem management and sustainable development. The policy sought to integrate the

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Table 3. Ethical principles that are fundamental to the National Association of Environmental Professionals (NAEP 1996) do not appear in Ecological Society of America's Code of Ethics (ESA 1996B).

- Professional consultants must conduct themselves in a manner consistent with the principles of environmental ethics.
- Environmental professionals must recognize that total environmental (i.e., ecosystem) management involves consideration of all environmental factors including technical, economic, ecological, and sociopolitical and their relationship.
- Environmental professionals must incorporate the best principles of design and environmental planning (e.g., ecosystem management) when recommending measures to reduce environmental harm and enhance environmental quality.
- They must provide their services in areas where they are qualified and turn to other experts where they are unqualified.
- The formation of interdisciplinary teams for resource management planning and for determining environmental impacts must be fostered.
- Communication with other professionals and respect for their contributions in developing and reviewing policies, plans, and projects must be pursued.

agency's mission with ecologic, economic, and social factors in a comprehensive plan for each DOE site that would guide land and facility use decisions. Comprehensive plans developed for each site were to consider the site's larger regional context and be developed with stakeholder participation.

The policy was first used for the Nevada Test Site (NTS) in the context of a site-wide environmental impact statement (EIS) that included a framework for a Resource Management Plan (RMP) (USDOE 1996). The RMP, the first ever for the DOE, is to be developed and implemented subsequent to the EIS, released to the public which occurred in October 1996. Ecosystem management is to be the foundation for the RMP, and the DOE approach in this case is consistent with the federal ecosystem management initiative.

Stakeholders and interested parties were pleased with the DOE initiative at NTS because it involves a regional planning strategy that will integrate stakeholder and community concerns and goals consistent with the pursuit of healthy ecosystems and sustainable development. Notable is the fact that the RMP framework document (USDOE 1996) reflects credible professional work that was led by an environmental professional on DOE's staff who is a member of the NAEP and thus subject to the association's Code of Ethics and Standards of Practice.

Despite the DOE's decision to implement ecosystem management at the NTS, it failed to include a large and costly long-term project meant to construct and operate an environmentally significant geologic repository for high-level nuclear waste, the Yucca Mountain Project (Malone 1995). Although a portion of the project site is located on the test site, DOE arbitrarily decided to exempt the project from the NTS EIS, resource management planning, and compliance with the DOE's Land and Facility Use Policy (USDOE 1994). Instead, project decisions fail to involve stakeholder collaboration, are inconsistent with adjacent public lands management, and do not address long-term environmental impacts associated with a repository at Yucca Mountain (Malone 1995).

The situation with respect to the Yucca Mountain Project is important because at present time there is no empirical basis for predicting what might occur at Yucca Mountain over the long term. Geologic disposal of high-level nuclear waste raises unique issues that have never before been faced. For example, the repository must isolate nuclear waste from the environment accessible to man for a minimum of 10,000 years. Malone (1995) presented a plausible scenario under global climate change whereby accelerated erosion and adverse geohydrologic changes could compromise the integrity of a repository and its waste packages at Yucca Mountain to prematurely release radioactive material to the environment.

Research based on the scientific premises of ecosystem management and coupled with long-term environmental pathway modeling could be conducted to shed light on the early-release scenario. However, the DOE Yucca Mountain Project has, on the basis of no data or objective evidence, used subjective judgement to rule out the scenario and the need for its study. The principal basis for the DOE's refusal to address the issue is the recommendation of the ecologist leading the Yucca Mountain environmental and ecological program. The leader is a community ecologist whose staff does not include ecosystem scientists. Without any empirical basis, and on subjective judgement alone, the program leader has concluded that nothing like the early-release scenario could occur.

The DOE accepts the leading ecologist's advice, which is convenient for the repository project. In this case, ignorance is expedient because ecosystem studies of long-term environmental potential of the Yucca Mountain site conflict with the fast-tract schedule for the project. This is despite the fact that ecosystem-level studies will be pursued at the Nevada Test Site under a resource management plan (USDOE 1996) from which the Yucca Mountain Project has excluded itself.

While the ecology program leader is a member of the Ecological Society of America, the society fails to endorse high principles of professional ethics and standards of practice comparable to those of the NAEP (Table 3). The NAEP (1996) Code of Ethics and Standards of Practice includes the concept of the integrated, interdisciplinary ecosystem approach to environmental protection, i.e., ecosystem management. By comparison, the DOE Yucca Mountain Project emphasizes only plant community ecology, reclamation of disturbed areas, and the population biology of one legally protected species. There is no professional way for critics of the ecology program to influence the program with respect to enforcing professional ethics and standards of practice (Malone 1995).

It can be seen from this case that there can be a role for ecosystem management and professional ethics to play in important environmental issues. Professional associations like the Ecological Society of America and the National Association for

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Environmental Professionals have a major role to play in matters of professional ethics and in providing guidance on the necessity for integrated studies and resource management programs. The ecological society's present ethical codes are insufficient for helping avoid difficult issues like the DOE Yucca Mountain Project present.

5. Summation

Traditionally, resource management practices have sought to achieve changes in ecosystems without concurrently achieving lasting social changes. Many management plans and programs have failed because both kinds of changes were not sought concurrently. A fundamental challenge to ecosystem management is to accomplish lasting management of resources consistent with maintaining economic progress and realizing responsible resource stewardship. In this respect, the importance of integrating human and biophysical dimensions is paramount, and disciplines such as economics, sociology, political science, and the study of institutional arrangements are as important to ecosystem management as are the natural sciences.

Sustaining renewable natural resources requires a land resource ethic that downplays traditional commodity-oriented, command-and-control management. Achieving this change requires using sociology, economics, ecology, political science, and studies of institutional arrangements in an interdisciplinary manner to reach goals and objectives that have been socially defined. Collaboration of this sort involves the public, policy makers, and government working cooperatively.

The concept of achieving sustainability through interdisciplinary ecosystem management involves adopting an ethic that integrates patterns of human thought and action with ecological reality and prospects for the future. Indeed, some believe that a new paradigm and ethic are emerging (Cortner and Moote 1994, Grumbine 1994, Wood 1994). Traditional resource management guided by a paradigm characterized by maintaining commodity production has been discredited and a new ideal is emerging based on biophysical and human dimensions, institutional coordination, and collaborative decision making. The principles of ecosystem management thus seem form the philosophical underpinning of a new ethic, one designed to safeguard ecological integrity, ecosystem sustainability, and biodiversity for future generations (ESA 1996, Lemons and Brown 1995, Westra and Lemons 1995).

As the new paradigm develops, scientists need to be involved throughout the policy making process of ecosystem management, but in a clearly defined, interactive role where the values and priorities of the public are implemented, not those of scientists. Ecosystem management clearly is an applied science, something that ecologists long have viewed with detachment. This is unfortunate because developing a useful and feasible approach to ecosystem management calls for a participatory, consultative approach involving ecological research. At the present time, the traditional disciplines of natural resource management and human dimensions are more attuned to this situation than is academic ecological science. However, there are refreshing signs that ecosystem scientists are recognizing their essential role in the U.S. effort toward achieving sustainable development through ecosystem management.

6. References

Allen, T.F. and T.W. Hoekstra. 1992. *Toward a Unified Ecology*. Columbia University Press, New York, NY.

Arrow, K., B. Bolin, R. Costanza, P. Dasguputa, C. Folke, C.S. Holling, B.O. Jansson, S. Levin, K.G. Maler, C. Perrings, and D. Pimentel. 1995. Economic Growth, Carrying Capacity, and the Environment. *Science* 268: 520-521.

Cortner, H.J. and M.A. Moote. 1994. Trends and Issues in Land and Water Resources Management: Setting the Agenda for Change. *Environmental Management* 18(2): 167-173.

(CRS) Congressional Research Service. 1994. Ecosystem Management: Federal Agency Activities. 94-339 ENR, April 19. CRS, Washington, DC.

Darling, F.F. and R.F. Dasmann. 1969. The Ecosystem View of Human Society. *Impact of Science on Society* 19: 109-121.

(ESA) Ecological Society of America. 1996a. The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecological Applications* 6(3): 665-691.

(ESA) Ecological Society of America. 1996b. Code of Ethics. ESA, Washington, DC.

Fitzsimmons, A.K. 1996. Sound Policy or Smoke and Mirrors: Does Ecosystem Management Make Sense? *Water Resources Bulletin* 32(2): 217-227.

Francis, G. 1993. Ecosystem Management. *Natural Resources Journal* 33(Spring): 315-345.

Gore, A. 1993. Reinventing Environmental Management: Accompanying Report of the National Performance Review. ISBN 0-16-042000-8. U.S. Government Printing Office, Washington, DC.

Grumbine, R.E. 1994. What is Ecosystem Management? *Conservation Biology* 8(1): 27-38.

Gunderson, L.H., C.S. Hollings, and S.S. Light. 1995. *Barriers and Bridges to the Renewal of Ecosystems*. Columbia University Press, New York.

(IEMTF) Interagency Ecosystem Management Task Force. 1995. The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies. White House Office of Environmental Policy, Washington, DC.

(IETC) International Environmental Technology Centre. 1996. Environmental Risk Assessment for Sustainable Cities. Technical Publication Series [3]. UNEP, Osaka/Shiga.

Keiter, R.B. 1994. Beyond the Boundary Line: Constructing a Law of Ecosystem Management. *University of Colorado Law Review* 65(2): 293-333.

Kennedy, J.J., B.L. Fox, and T.D. Olsen. 1995. Changing Social Values and Images of Public Rangeland Management. *Rangelands* 17(4): 127-132.

Keystone Center. 1996. Keystone National Policy Dialogue on Ecosystem Management: Implementing Community-Based Approaches. The Keystone Center, Keystone, CO.

Knight, R.L. and S.F. Bates (eds.). 1995. *A New Century for Natural Resources Management*. Island Press, Washington, DC.

Lackey, R.T. 1995. Ecosystem Management: Implications for Fisheries Management. *Renewable Resources Journal* 13(4): 11-13.

EIS001887

Lemons, J. 1995. Sustainable Development and Environmental Protection: A Perspective on Current Trends and Future Options for Universities. *Environmental Management* 19(2): 157-165.

Lemons, J. and D. Brown (eds.). 1995. *Sustainable Development: Science, Ethics, and Public Policy*. Kluwer Academic Publishers, Boston, MA.

Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. *Science* 260: 17-36.

Malone, C.R. 1995. Ecology, Ethics, and Professional Practice: The Yucca Mountain, Nevada, Project as a Case Study. *The Environmental Professional* 17(3): 271-284.

(NAEP) National Association of Environmental Professionals. 1996. Code of Ethics and Standards of Practice for Environmental Professionals. NAEP, Washington, DC.

Naveh, Z. and A. Lieberman. 1993. *Landscape Ecology: Theory and Application* (Second Edition). Springer-Verlag, New York, NY.

(NSTC) National Science and Technology Council. 1995. Building a Scientific Basis to Ensure the Vitality and Productivity of U.S. Ecosystems. White House, Washington, DC.

(OEP) Office of Environmental Policy. 1996. Memorandum of Understanding to Foster the Ecosystem Approach. OEP, White House, Washington, DC.

Pahl-Wostl, C. 1995. *The Dynamic Nature of Ecosystems: Chaos and Order Entwined*. John Wiley, Chichester, England.

Power, T.M. 1996. *Lost Landscapes and Failed Economies*. Island Press, Washington DC.

Sheifer, I.C. 1996. Integrating the Human Dimension in Ecoregion/Ecosystem Studies - A View from the Ecosystem Management National Assessment Effort. *Bulletin of the Ecological Society of America* 77(3): 177-180.

Slocombe, D.S. 1993. Ecosystem Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development. *Environmental Management* 17(3): 289-303.

Stanley, T.R., Jr. 1995. Ecosystem Management and the Arrogance of Humanism. *Conservation Biology* 9(2): 255-262.

(USBLM) US Bureau of Land Management. 1994. Ecosystem Management in the BLM: From Concept to Commitment. BLM/SC/GI-94/005+1736. January. USBLM, Washington, DC.

(USDOE) US Department of Energy. 1994. DOE Order 4320.1B, Land and Facility Use Management. USDOE, Washington, DC.

(USDOE) US Department of Energy. 1995. Department of Energy: Stewards of a National Resource. DOE/FM-0002. USDOE, Washington, DC.

(USDOE) US Department of Energy. 1996. Final Environmental Impact Statement for the Nevada Test Site and Off-site locations in the State of Nevada: Volume 2. Framework for the Resource Management Plan. DOE/EIS 0243. USDOE, Las Vegas, NV.

(USFS) US Forest Service. 1992. Taking an Ecological Approach to Management. WO-WSA-3. USFS, Washington, DC.

4662

(USFS) US Forest Service. 1994. An Ecological Basis for Ecosystem Management. GTR RM-246. USFS Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

(USFWS) US Fish and Wildlife Service. 1995. An Ecosystem Approach to Fish and Wildlife Conservation: Concept Document. February. USFWS, Washington, DC.

(USGAO) US General Accounting Office. 1994. Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach. GAO/RCED-94-111. USGAO, Washington, DC.

(USNBS) US National Biological Service. 1994. National Biological Service: The NBS Ecosystem Initiative Program. 950110, April 19. NBS, Washington, DC.

US Senate. 1994. Ecosystem Management: Status and Potential. Senate Print 103-98, December. U.S. Government Printing Office, Washington, DC.

van den Bergh, J.C. and J. van der Straaten (eds.). 1994. *Toward Sustainable Development*. Island Press, Washington, DC.

Varner, G.E. 1994. Environmental Law and the Eclipse of Private Property. In *Ethics and Environmental Policy: Theory Meets Practice*, F. Ferre and P. Hartel, eds. The University of Georgia Press, Athens, GA.

Westra, L. and J. Lemons (eds.). 1995. *Perspectives on Ecological Integrity*. Kluwer Academic Publishers, Boston, MA.

Wood, C.A. 1994. Ecosystem Management: Achieving the New Land Ethic. *Renewable Resources Journal* (Spring): 6-12.

Yaffee, S.L. 1994. *The Wisdom of the Spotted Owl: Policy Lessons for a New Century*. Island Press, Washington, DC.

Yaffee, S.L., A. Phillips, I. Frentz, P. Hardy, S. Maleki, and B. Thorpe. 1996. *Ecosystem Management in the United States*. Island Press, Washington, DC.

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Ecological Sustainability and Integrity: Concepts and Approaches

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ATTACHMENT M

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THE POTENTIAL FOR ECOLOGICAL RESTORATION AT YUCCA MOUNTAIN, NEVADA

Charles R. Malone
Nuclear Waste Project Office

Abstract. Federal policy for siting and developing a geologic repository for high-level nuclear waste at Yucca Mountain, Nevada, includes taking "reasonable and necessary" steps to restore the site to its predisturbed ecological condition. However, the state of the art for restoration of disturbed arid lands and the nature of the Yucca Mountain ecosystem are not encouraging with respect to the feasibility of achieving ecological restoration at the site without taking heroic steps. There is a need for establishing practical goals and economical restoration techniques for the site, a task that will be complicated by the presence of an endangered species, the desert tortoise (*Gopherus agassizii*). The Yucca Mountain Project should be viewed as an opportunity to influence both the direction of restoration ecology and future federal policies toward restoring disturbed lands.

INTRODUCTION

The U.S. has embarked on a unique project that could have important consequences for national policy with respect to ecological restoration involving major federal actions that have adverse environmental impacts. At the Yucca Mountain site in southern Nevada, the U.S. Department of Energy (DOE) is conducting studies to determine the suitability of the location for a geologic repository for disposing of high-level nuclear waste. In accordance with the Nuclear Waste Policy Act (NWPA) of 1982, as amended in 1987, the DOE must take "reasonable and necessary" steps to reclaim the site. The DOE's proposed environmental program plan for carrying out this and other environmental requirements (U.S. DOE, 1988a) equates "reclamation" with the accepted definition of "ecological restoration" (Bonnicksen, 1988; Jordan *et al.*, 1988; Allen, 1989). Thus, the DOE's goal of reclaiming the site upon completion of the Yucca Mountain Project is to return the ecosystem to a condition similar to the predisturbed state. The DOE Yucca Mountain Project thus constitutes one of the few instances where federal policy clearly has adopted the goal of ecological restoration.

The Yucca Mountain site is located adjacent to, and partly on, the DOE Nevada Test Site. The site is remote, has not been used heavily, and is considered by the DOE to be in a stable ecological condition (U.S. DOE, 1986). Because of the arid environment, no socially acceptable land use at Yucca Mountain can be envisioned as a goal for reclamation, other than returning the site to its predisturbed condition. The concept of taking reasonable and necessary steps to achieve restoration occurs in both the Nuclear Waste Policy Act, as amended, and the DOE's proposed environmental and reclamation plans (U.S. DOE, 1988a and 1989). This concept is significant to the science and practice of restoration ecology, because it constitutes an opportunity for demonstrating the practicability of restoring an ecosystem.

This article addresses the potential for successful ecological restoration at the Yucca Mountain site and draws upon the following:

- Regional and site-specific information on ecological and related environmental conditions at Yucca Mountain (U.S. DOE, 1986);
- The DOE's proposed environmental program for the site (U.S. DOE, 1988a and 1989; Parker *et al.*, 1990) and critiques of the plan (Malone, 1990a; Winsor and Malone, 1990);
- Information on practices for restoring arid ecosystems; and
- Studies conducted by the state of Nevada for the Yucca Mountain Project.

The last of these categories of information results from independent review of the DOE nuclear waste repository program by the state of Nevada, a function authorized and funded by the Nuclear Waste Policy Act, as amended. Activities are carried out with the assistance of contractors like Environmental Science Associates, Inc., Resource Concepts,

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Inc., and A.E. Karl. Much of this article is summarized from reports prepared by the contractors, which describe study methods, present analytical results, and in some cases, contain original field data. Copies of the reports, including maps, figures, and complete results of the studies, are available from the Nevada Nuclear Waste Project Office. They address the following topics:

- Remote sensing to determine the extent of existing disturbance of the Yucca Mountain site as a result of the DOE preliminary siting activities (ESA, 1989);
- Preliminary soil and biological surveys (RCI, 1989a; Karl, 1989; ESA, 1990); and
- A review of alternatives and costs for reclaiming and restoring the site (ESA, 1989; RCI, 1989b).

SITE AND PROJECT DESCRIPTIONS

Emphasis in the state of Nevada environmental program is on a 20 square kilometer study area at Yucca Mountain, where the potential for disturbance from repository siting and the need for ecological restoration are the greatest. Detailed environmental information on existing conditions at the site is not available, although an extensive information base exists for portions of the adjacent Nevada Test Site (U.S. DOE, 1986; US/IBP, 1978; Wallace *et al.*, 1980). The extent to which this information applies to Yucca Mountain must be evaluated, because the Yucca Mountain site runs north-to-south across the Great Basin-Mojave Desert ecotone, a type of ecosystem not studied on the Nevada Test Site. Yucca Mountain differs from the test site, also, because the closed basins, alluvial flats, playas, and predominately calcareous soils typifying the test site are absent at Yucca Mountain.

Three dominant landforms occur in the Yucca Mountain study area (Table 1). Mountainous volcanic uplands occupy the western 20 per cent of the site, and piedmont slopes comprised of alluvial fill occupy the 45 per cent of the site to the east. Between the uplands and piedmont slopes are mesas and sideslopes comprised of remnants of steep ridges and alluvial fans (ESA, 1989; RCI, 1989a and 1989b). Elevation ranges from 1,062 meters in the valley to the east to 1,458 meters on the ridge of Yucca Mountain. Annual precipitation varies according to elevation and averages about 16 to 19 centimeters (Karl, 1989; RCI, 1989a and 1989b; ESA, 1990). Regionally, 60-65 per cent of the precipitation falls between mid-September and late March; 10-15 per cent from late March to early June; and 25 per cent from early June to early September. The area has hot summers (daily high average temperature in July is 35 °C) and mild winters (daily low average temperature in December is -2 °C). Extremes vary from between -10 and -28 °C in January to between 42 and 49 °C in July.

Evaluation and planning for ecological restoration must rely on comprehensive, site-specific environmental information.

Table 1. Dominant Landforms of the Yucca Mountain Study Area: Extent of Occurrence and Amount of Existing Disturbed Area.

Landform Category	Area Covered (square kilometers)	Area Disturbed (hectares)
Mountainous Volcanic Uplands	4	10
Mesas and Side Slopes	7	74
Piedmont Slope	9	171
TOTALS	20	255

Because the DOE has not undertaken such studies, the state of Nevada initiated soil and plant surveys in 1989 (RCI, 1989a; ESA, 1990). Results of the first year's investigations are summarized in Table 2. Major soil units, described and mapped in 1989, were found to consist of soft to loose loamy sands with a 100 per cent gravel surface on the alluvial fans, dense gravels and cobbles on the slopes, and bedrock and boulders on the ridges. All the soils have poor water holding capacity, due to coarse textures and low silt, clay, and organic matter content. Attempts to characterize the vegetation were frustrated by drought conditions that prevented seeds of herbaceous species from germinating. However, the survey was able to cover the study area in sufficient detail to indicate that vegetation at the site is complex and reflects a diverse environment. Detailed maps made with the aid of color stereo aerial photos taken in June, 1988, assisted identification of soil units, vegetation associations, and landforms.

With respect to the fauna of Yucca Mountain, the state of Nevada environmental program has concentrated only on the desert tortoise (*Gopherus agassizii*). As an endangered species (U.S. DOI, 1989), the desert tortoise and its habitat must be important considerations for ecological restoration at the Yucca Mountain site. In the fall of 1989, a survey was conducted throughout the study area to estimate abundance and distribution of desert tortoise. A strip transect method was used for estimating distribution, habitat associations, and relative abundance of the species (Karl, 1989). Data on tortoises and their signs (carcasses, scat, burrows, and evidence of nests) were used to estimate tortoise abundance. The survey found that more signs of tortoises occurred on alluvial fans dominated by creosote bush than in other types of habitats (Table 3). It is reasonable to conclude that the best habitat for the tortoise is located in the eastern portion of the

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Table 2. Environmental Characteristics of the Yucca Mountain Study Area.

Climax Vegetation Series	Dominant Plants	Percent of Site Occupied	Landform	General Soil Characteristics	Elevation (m)	Area Disturbed (ha)
Creosote Bush	*Larrea/Menodora/Ambrosia* (creosote bush/mendora/bursage)	35	Piedmont Slope	Moderately deep to indurate duripan; sandy loam	1095-1290	152
Great Basin Mixed Scrub	*Ephedra/Eriogonum* (ephedra/buckwheat)	20	Mountainous Volcanic Uplands	Shallow to bedrock; gravelly and stony	1253-1395	26
Transition Mixed Scrub	*Ambrosia/Ephedra/Kameria* (bursage/ephedra/ratany)	15	Mesas and Side Slopes	Shallow to bedrock; recent alluvium	1062-1290	21
Blackbrush/ Creosote	*Coleogyne/Larrea* (blackbrush/creosote bush)	15	Mesas and Side Slopes	Shallow to duripan; recent alluvium	1143-1260	23
Blackbrush	*Coleogyne/Ambrosia/Menodora* (blackbrush/bursage/menodora)	<5	Mesas and Side Slopes	Shallow to duripan; gravelly sandy loam	1080-1305	31
Sagebrush	*Artemisia/Eriogonum* (sagebrush/buckwheat)	<5	Mesas and Side Slopes	Shallow to bedrock; cobbly sand	1350-1450	1
Joshua Tree	*Yucca/Coleogyne* (Joshua tree/blackbrush)	<5	Mountainous Volcanic Uplands	Shallow to bedrock; gravelly and stony	1440-1458	1
High Wash	*Salazaria* (bladdersage)	<5	Mesas and Side Slopes	Moderately deep to hardpan; sandy loam	1260	0

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Table 3. Occurrence of Desert Tortoise in the Yucca Mountain Study Area.

Climax Vegetation Series (# of transects)	Habitat Conditions	Number and Kind of Sign	Mean Density (no./sq. km)
Creosote Bush (7)	fair	12 burrows 3 scat 1 remains	8
Great Basin Mixed Scrub (7)	poor	6 burrows 6 scat 1 remains	7
Transition Mixed Scrub (3)	poor to fair	3 burrows 2 scat	7
Blackbrush/Creosote (5)	fair	15 burrow 2 scat 1 eggshell	1
Blackbrush (1)	poor to fair	1 burrow	1
Sagebrush (2)	poor to very poor	2 scat	2
Joshua Tree (2)	fair to poor	1 burrow 1 scat	2
High Wash		not sampled	

study area, dominated by large alluvial fans, inset fans, and gentle ridge remnants. This corresponds to the area covered by the DOE for complying with the Endangered Species Act (U.S. DOE, 1989b). However, the state of Nevada survey also found tortoise signs in the uplands and along ridge remnants not surveyed by the DOE. These results confirm that the limited surveys conducted by the DOE corresponded to the tortoise's preferred habitat, but that some of the less favorable habitats at the Yucca Mountain site cannot be ignored, because animals do occur there.

The DOE repository siting program involves activities that include vegetation and topsoil removal, surface compaction, and alteration of the terrain (Table 4). Preliminary siting activities consisting largely of geologic and hydrologic field studies like drilling, trenching, and seismic surveys have been performed by the DOE at Yucca Mountain for over a decade. Additional proposed repository siting activities are similar to those already conducted, but additionally will include extensive underground mining and construction of surface support facilities such as buildings, utilities, muck piles, and effluent ponds (U.S. DOE, 1988b). Anticipated disturbances from such activities are generalized in Table 4 under "Bladed Use Areas."

The DOE has no accurate inventory of the extent and location of areas already disturbed, and no reclamation has occurred. To provide the state of Nevada with an understanding of the present condition of the site, a study was performed using remote sensing techniques to locate existing disturbed areas (ESA, 1989). Disturbance features were categorized according to climax vegetation, and ground truth data were used to identify the kind of activity that had caused disturbances. Results of the study are reflected in Tables 1, 2, and 4, showing that 255 hectares of disturbed area already exists at Yucca Mountain, and at least another 176 hectares is anticipated during site characterization.

POTENTIAL FOR ECOLOGICAL RESTORATION

Ecological restoration of arid lands is highly problematic (Wallace *et al.*, 1980; Jordan *et al.*, 1988; Allen, 1988), and for this reason successful restoration of the Yucca Mountain ecosystem is not assured. The presence of the desert tortoise will complicate matters, depending on the extent to which efforts are made to restore the species' habitat. Studies by both the state of Nevada and the DOE at Yucca Mountain have focused only on occurrence of animals and not on distribution, cover, and forage. Thus, what follows here with respect to restoration potential does not include consideration

Table 4. Existing and Proposed Disturbances from Repository Siting Activities at Yucca Mountain

Activity Type	Existing (# - ha)	Proposed (# - ha)
Drilling and coring	62 - 36	365 - 50
Trenching, test pits, and plots	59 - 5	116 - 6
Seismic surveys	16 - 6	unknown - 28
Monitoring stations	6 - 1	unknown
Bladed use areas	41 - 40	unknown - 42
Access roads, trails, and corridors	313 - 166	unknown - 50
Erosion control	5 - 1	unknown
TOTAL AREA	255	176

Kind of activity, numbers (#), and amount of disturbed area in hectares (ha).

of the desert tortoise, an issue that requires considerable research into the animal's ecology.

In many respects, managed ecological restoration is comparable to early secondary succession. Therefore, it is important to understand the processes and species involved in natural revegetation of disturbed areas. In deserts, natural revegetation is slow, and may require decades or centuries, primarily because precipitation is severely limited (Romney *et al.*, 1980; Wallace *et al.*, 1980; Lathrop, 1983; Vaseck *et al.*, 1975). Recovery speed also depends on factors like the degree of soil compaction, and in cases of severe disturbance, recovery may take as long as 1,000 to 2,000 years (Webb and Wilshire, 1980; Webb *et al.*, 1983). Information exists with respect to some species common to the Great Basin and the Mojave Desert that reestablish themselves naturally and are potentially suited to restoration at Yucca Mountain. The most promising of these are listed in Table 5, while another 43 require significant additional study (RCI, 1989b).

Revegetation Practices

Management practices for reestablishing vegetation on arid lands involve providing plants or seeds, water, and sometimes nutrients at the proper time. At Yucca Mountain, the most limiting and critical factor is availability of soil water for plant development. Revegetation efforts without supplemental irrigation in regions with less than 25 to 30 centimeters of precipitation annually risk failure (DeRemer and Bach, 1978; Thornburg and Fuchs, 1978). In the Mojave Desert south of Yucca Mountain, irrigation typically is considered essential for seeding or transplanting vegetation (Kay and Graves, 1983). On the Nevada Test Site near Yucca Mountain, it was found that irrigation of transplants is needed during the first year, unless winter precipitation wets the soil to a depth of about 100 centimeters (Romney *et al.*, 1981). Instead of irrigation at Yucca Mountain, the DOE proposes using water harvesting and spreading by recontouring and reshaping the surface to collect and direct water to newly-established plants (U.S. DOE, 1988a). It remains to be seen whether this technique will be effective in place of irrigation.

In addition to measures for supplementing moisture, management options also include fertilizing, mulching, and fencing. Plant species currently recommended for deserts are adapted to conditions of low fertility, and the addition of nutrients may encourage only undesirable species that compete for water with preferred vegetation (Kay and Graves, 1983). The potential advantages of fertilizing should be determined on a site-specific basis, but such information for the Yucca Mountain site has yet to be developed. Mulching also is a useful practice, but has not been evaluated on sites like Yucca Mountain. Fencing, on the other hand, has been found essential for preventing grazers, such as lagomorphs and rodents, from otherwise destroying new plants. Grazing has been shown to be an especially acute problem near Yucca Mountain (Hunter *et al.*, 1980a and 1980b). Both mulching and fencing are among the practices to be evaluated during the DOE reclamation program for the Yucca Mountain site (U.S. DOE, 1988a and 1989).

Decisions on the use of containerized vegetation for transplanting will be influenced by the availability of plant material. Species like those listed in Table 5 are necessary for ecological restoration at the Yucca Mountain site, but in many cases are unavailable commercially in containers. Because seeds are not always available, it is advisable that in good years seeds be collected as close as possible to the site of interest and stored until needed (Kay and Young, 1988). This is especially important for the Yucca Mountain site, because it is likely that the plant species occurring there are adapted to an atypical environment for which it may be difficult to find suitable analogs. Commercial availability of containerized plants also may be complicated by the site's atypical environmental setting.

Studies involving the western Mojave desert concluded that managed, artificial revegetation neither hastened consistently nor improved ecological recovery of disturbed sites (Kay and Graves, 1983; Kay, 1988). Similar results were obtained from an unpublished study for the U.S. Soil Conservation Service near Caliente, Nevada, east of Yucca Mountain (RCI, 1989b). Of plantings made in 1987, the

Table 5. Plant Species Considered to be Suited for Ecological Restoration at Yucca Mountain (From RCI, 1989b).

Scientific and Common Names	Known to Naturally Reestablish	Has Been Seeded or Transplanted	Recommended But Not Tested
Acampotopapus Schockleyi (Shockley goldenhead)	X		X
Ambrosia dumosa (bursage)	X	X	X
Atriplex canescens (fourwing saltbush)	X	X	X
Atriplex confertifolia (shadscale)	X		X
Bromus rubens (red brome)	X		X
Ceratoides lanata (winterfat)	X	X	X
Chrysothamnus nauseosus (rubber rabbitbrush)	X	X	X
Ephedra nevadensis (Nevada ephedra)	X	X	X
Hymenoclea salsola (cheesebush)	X	X	X
Larrea tridentata (creosote bush)	X	X	X
Ledidum fremontii (desert alyssum)	X		X
Lycium andersonii (Anderson desert thorn)	X		X
Oryzopsis hymenoides (Indian ricegrass)	X	X	X
Stipa speciosa (desert needlegrass)	X		X

results of only a few were considered to be fair or good one year later, and after two years, almost none of the vegetation survived. Transplanting vegetation grown in containers and irrigating during the first growing season is the most viable option for revegetating arid sites like Yucca Mountain (Romney *et al.*, 1981). The DOE's preference for water harvesting and spreading over irrigation at Yucca Mountain may limit the chances of successful ecological restoration.

Estimated Costs

Restoration costs are influenced greatly by the features of a site. For the state of Nevada's estimate of costs for the Yucca Mountain site, the types of landforms, vegetation, soils, and disturbed areas were used to establish categories, reflecting the level of effort anticipated to be involved with site restoration. The resulting classifications were matched with prescribed reclamation and restoration practices (*e.g.*, soil scari-

Table 6. Amount of Existing Disturbed Area at the Yucca Mountain Site and Estimated Costs (1988 Dollars) of Ecological Restoration Classified by Cause of Disturbance and Landscape Category.

Disturbance Type and Landscape Category	Hectares	Cost/Hectare ($)	Total Cost ($)
Graded disturbances			
Restrictive	30	101,300	3,039,000
Nonrestrictive	150	78,300	11,745,000
Nongraded disturbances			
Restrictive	8	76,900	615,000
Nonrestrictive	42	74,000	3,108,000
Improved roads	25	115,800	2,895,000
TOTALS	255	–	21,402,000

fication, contouring, seeding, fertilizing, mulching, and irrigating) used in the Mojave Desert and the Great Basin (Kay and Graves, 1983; Kay, 1988; RCI, 1989b). This information served as the basis for cost estimates for the Yucca Mountain site (ESA, 1989; RCI, 1989b). The categories adopted for the disturbed areas were "graded" and "nongraded," to indicate where topsoil had been removed, thus making revegetation more difficult and costly. For landscape features, the categories used were "restrictive" and "nonrestrictive," to represent two levels of difficulty based on terrain features, with the former reflecting the greater degree of effort needed for restoration. Involved in restoring the Yucca Mountain site would be: (1)reshaping disturbed land to approximate original contour, (2)providing a substrate suitable for plant growth, (3)revegetating with previously-existing species in an effort to approximate the original plant communities, and (4)providing supplemental nutrients and moisture to enhance plant establishment.

Results of the cost estimates for restoring existing disturbed land at Yucca Mountain are summarized in Table 6. The estimated costs ranged from $74,000 to $115,800 per hectare, and the total estimated cost was about $21,400,000. Comparative information on the costs for restoration of arid ecosystems is sparse, but field experiments on restoration in Wyoming reported a cost of $8500 per hectare (Jordan *et al.*, 1988). The approximate order of magnitude difference for the Yucca Mountain site is due to the rugged terrain, harsh climate, remoteness of the site, complexity of plant composition, lack of readily available containerized nursery stock and seeds for species adapted to the site, and the need for irrigation for at least one year following attempts to reestablish vegetation (RCI, 1989b). Per unit area costs for restoring future disturbed areas at Yucca Mountain should be comparable to those given in Table 6. However, because of the large uncertainty with respect to the amount of additional land to be disturbed at Yucca Mountain, no attempt was made to estimate total reclamation costs that ultimately could result from DOE site characterization.

DISCUSSION AND CONCLUSIONS

Although the DOE Yucca Mountain Project can be viewed as an opportunity to demonstrate the efficacy of restoration ecology and to further the application and acceptance of restoration in federal environmental policy, such a perspective holds uncertain promise, because restoring desert ecosystems is problematic. Discussions like those presented in Allen (1988) emphasize that the convergence of theory and practice has not been achieved yet with respect to restoration of disturbed arid lands. Concepts and theories remain to be proven, and effective methods and techniques have to be developed (Wallace *et al.*, 1980; Jordan *et al.*, 1988). At Yucca Mountain, costs also may prove to be a concern, because of the rugged terrain.

While it would be encouraging to believe that the mandate to restore the Yucca Mountain site is evidence of a restoration ethic in Congress, that interpretation is questionable. Often a restoration ethic is associated with the belief that preexisting climax vegetation at a site can be returned successfully following ecosystem disturbance, and that unless this can be achieved, a site should not be altered (Bradshaw and Chadwick, 1980). It is questionable whether the policymakers involved in the NWPA and the DOE nuclear waste program

really comprehended the implications of requiring ecological restoration at Yucca Mountain. Little is known about restoration of transition desert ecosystems, and practice has been limited largely to stabilization for purposes of erosion control and aesthetics. Even these efforts typically fail. Thus, if successful ecological restoration were a criterion for siting a nuclear waste repository, it seems unlikely that the Yucca Mountain site would have been singled out from the range of alternative sites available when the Nuclear Waste Policy Act was amended in 1987. Because of limitations to restoration imposed by ecologic and economic factors, there can be no argument that Yucca Mountain is among the least likely of sites to hold any reasonable degree of potential for successful restoration.

Despite the present discouraging prognosis for successful ecological restoration at Yucca Mountain, the work of Wallace *et al.* (1980) can be viewed as a starting point for establishing management practices applicable to the site. They concluded that a better understanding is needed of the following: (1)water harvesting and irrigation, (2)fertilization and addition of organic soil amendments, (3)preserving fertile islands as sources of propagules for species critical for revegetation, and (4)using pioneer species and vigorous shrubs species adapted to the site.

Allen (1988) has emphasized ecological landscape approaches that enhance successional processes as a feasible approach for restoration of disturbed arid lands. Clearly, for the Yucca Mountain site, a creative approach to restoration planning will be needed. As the DOE continues to plan its environmental program, it should identify critical information needs and implement a pilot ecosystem restoration study aimed at developing methods and guidelines that are effective and practical. Among the critical issues that remain to be addressed and resolved is the extent to which the desert tortoise and its habitat will be considered in restoration planning. Important matters such as inclusion or exclusion of exotic species like red brome (*Bromus rubens*) also have to be considered for the Yucca Mountain restoration program.

An undecided fundamental issue for the Yucca Mountain site is whether ecological restoration will be modeled on structural/functional characteristics. The goals by which the success of restoration at the site can be judged remain to be established, as there are no criteria, guidelines, or endpoints for the program. There is, for example, indecision and controversy over such matters as selecting baseline environmental conditions. The DOE proposes using the disturbed, post-site characterization condition for its ecological baseline, and plans to characterize fully the Yucca Mountain ecosystem only after the impacts of siting studies have occurred (U.S. DOE, 1988a; Parker *et al.*, 1990). The state of Nevada, on the other hand, holds that the undisturbed, pre-site characterization environment should constitute the baseline (Malone, 1990a; Winsor and Malone, 1990).

The DOE ecological restoration program also should include a monitoring plan with schedules for obtaining information about the success of restoration efforts and contingency plans for implementing, if monitoring shows restoration efforts to be unsuccessful. A study for the state of Nevada (RCI, 1989b) recommended that one group conduct all monitoring activities and that a committee meet with the group to establish standards and methodologies for determining results of the alternative restoration practices investigated. The study also recommended that a clearinghouse be designated to maintain information about restoration practices. These ideas are not included in the DOE's draft environmental program plans for the Yucca Mountain Project (U.S. DOE, 1988a and 1989; Parker *et al.*, 1990).

Not addressed here are the DOE plans for repository construction, operation, closure, and abandonment, which are in the conceptual stage only. It is believed that during development of the repository, an additional 400 to 500 hectares of land will be disturbed (U.S. DOE, 1986). Especially noteworthy is that entombed nuclear waste at Yucca Mountain is expected to cause an increase of as much as 3 °C at the surface of the repository (U.S. DOE, 1988b; Blejwas, 1990). The elevated temperature is expected to last up to 1,000 years, and could effect ecosystem recovery drastically. The heat also could induce uplifting and fracturing of the repository overburden that, along with inhibited revegetation of the disturbed area, would contribute to accelerated erosion. Impacts of this nature not only would affect future ecosystems at Yucca Mountain, but also could alter the site's long-term physical integrity and ability to contain nuclear waste safely. These concerns are among many that remain to be addressed by the DOE and are indicative of the complexity and uncertainty that characterize the effort to dispose of high-level nuclear waste in a geological repository at Yucca Mountain safely (Lemons *et al.*, 1989; Lemons and Brown, 1990; Malone, 1990a, 1990b, and 1990c).

Despite many unresolved issues, the DOE Yucca Mountain Project provides an unusual opportunity for extensive, well-funded, long-term research and study. If adequately conceived and executed, the ecosystem restoration program could test the premise put forth in Allen (1988) that an ecological basis exists for developing means for restoring disturbed arid lands. The project provides an opportunity for the discipline of restoration ecology to benefit from efforts to determine what is reasonable and necessary for returning a desert ecosystem to a predisturbed condition. An unusual opportunity also is at hand for demonstrating the efficacy of ecological restoration as an integral component of federal environmental policy. Although the Yucca Mountain site may not be an ideal ecological laboratory for these purposes, it is an opportunity that should not be missed. The DOE ecosystem restoration program deserves the attention of restoration researchers and practitioners alike.

REFERENCES

Allen, E.B., ed. 1988. *The Reconstruction of Disturbed Arid Lands: An Ecological Approach*. Westview Press, Inc., Boulder, CO.

Blejwas, T.E. 1990. Influence of Thermally-Induced Effects on Repository Design. Report No. NMTHIM5PA24/3, 20-90. Sandia National Laboratory, Albuquerque, NM.

Bonnicksen, T.M. 1988. Restoration Ecology: Philosophy, Goals, and Ethics. *The Environmental Professional* 10: 25-35.

Bradshaw, A.D. and M.J. Chadwick. 1980. *The Restoration of Land*. University of California Press, Berkeley.

DeRemer, D., and D. Bach. 1978. Irrigation of Disturbed Lands. In *Reclamation and Use of Disturbed Land in the Southwest*, J.L. Thames, ed. University of Arizona Press, Tucson, pp. 224-237.

(ESA) Environmental Science Associates, Inc. 1989. Interim Impact Assistance Report: Past DOE Disturbance Inventory and Estimated General Reclamation Costs, Yucca Mt., Nevada. San Francisco, CA.

(ESA) Environmental Science Associates, Inc. 1990. 1989 Vegetation Studies at Yucca Mountain, Nye County, Nevada. San Francisco, CA.

Hunter, R.B., E.M. Romney, and A. Wallace. 1980a. Rodent-Denuded Areas of the Northern Mojave Desert. *Great Basin Naturalist Memoirs* 4: 208-211.

Hunter, R.B., A. Wallace, and E.M. Romney. 1980b. Fencing Enhances Shrub Survival and Growth for Mojave Desert Revegetation. *Great Basin Naturalist Memoirs* 4: 212-215.

Jordan, W.R., R.L. Peters, and E.B. Allen. 1988. Ecological Restoration as a Strategy for Conserving Biological Diversity. *Environmental Management* 12: 55-72.

Karl, A.E. 1989. Yucca Mountain Project: Investigations of Desert Tortoise Abundance and Distribution on the Focused Baseline Study Area, Fall 1989 Field Studies. San Francisco, CA.

Kay, B.L. 1988. Artificial and Natural Revegetation of the Second Los Angeles Aqueduct. Mojave Revegetation Note 24. Agronomy and Range Science Department, University of California, Davis.

Kay, B.L., and W.L. Graves. 1983. Revegetation and Stabilization Techniques for Disturbed Desert Vegetation. In *Environmental Effects of Off-Road Vehicles, Impacts, and Management in Arid Regions*, R.H. Webb and H.G. Wilshire, eds. Springer-Verlag, New York, pp.324-240.

Kay, B.L., and J.A. Young. 1988. Long-Term Storage of Desert Shrub Seed. Mojave Revegetation Note 23. Agronomy and Range Science Department, University of California, Davis.

Lathrop, E.W. 1983. Recovery of Perennial Vegetation in Military Maneuver Areas. In *Environmental Effects of Off-Road Vehicles, Impact, and Management in Arid Regions*, R.H. Webb and H.G. Wilshire, eds. Springer-Verlag, New York, pp. 152-166.

Lemons, J., and D.A. Brown. 1990. The Role of Science in the Decision to Site a High-Level Nuclear Waste Repository at Yucca Mountain, Nevada, USA. *The Environmentalist* 10(1): 3-24.

Lemons, J., C. Malone, and B. Piasecki. 1989. America's High-Level Nuclear Waste Repository: A Case Study of Environmental Science and Public Policy. *International Journal of Environmental Studies* 34: 25-42.

Malone, C.R. 1990a. Implications of Environmental Program Planning for Siting a Nuclear Waste Repository at Yucca Mountain, Nevada, USA. *Environmental Management* 14: 25-32.

Malone, C.R. 1990b. Performance Assessment and Long-Term Environmental Problems. *Project Appraisal* 5(3): 134-138.

Malone, C.R. 1990c. Geologic and Hydrologic Issues Related to Siting a Repository for High-Level Nuclear Waste at Yucca Mountain, Nevada, USA. *Journal of Environmental Management* 30: 381-396.

Parker, G.J., J.R. Krummel, K.E. LaGory, G.J. Marmer, and S.P. Goel. 1990. The Environmental Protection Program for Site Characterization at Yucca Mountain, Nevada. *The Environmental Professional* 12: 186-196.

(RCI) Resource Concepts, Inc. 1989a. Soil Survey of Yucca Mountain Study Area, Nye County, Nevada. Carson City, NV.

(RCI) Resource Concepts, Inc. 1989b. Review of Revegetation Practices Appropriate for Reclamation of the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada. Carson City, NV.

Romney, E.M., R.B. Hunter, and A. Wallace. 1981. Environmental Effects of Solar Thermal Power Systems—Experiments on Restoration of Disturbed Desert Land by Means of Revegetation. UCLA 12-1312 (UC/11,62). Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles.

Romney, E.M., A. Wallace, and R.B. Hunter. 1980. The Pulse Hypothesis in the Establishment of *Artemisia* Seedlings at Paiute Mesa. *Great Basin Naturalist Memoirs* 4: 28-30.

Thornburg, A.A., and S.H. Fuchs. 1978. Plant Materials and Requirements for Growth in Dry Regions. In *Reclamation and Use of Disturbed Land in the Southwest*, J.L. Thames, ed. University of Arizona Press, Tucson, pp.411-423.

(U.S. DOE) U.S. Department of Energy. 1986. Nuclear Waste Policy Act (Section 112) Environmental Assessment: Yucca Mountain Site, Nevada. DOE/RW-0073, Vols. 1-3. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988a. Draft Environmental Program Overview. DOE/RW-0207. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1988b. Site Characterization Plan: Yucca Mountain Site, Nevada. DOE/RW-0199. Washington, DC.

(U.S. DOE) U.S. Department of Energy. 1989. Draft Reclamation Program Plan for Site Characterization, Yucca Mountain Project. DOE/RW-0244. Washington, DC.

(U.S. DOI) U.S. Department of Interior. 1989. Endangered and Threatened Wildlife and Plants: Emergency Determination of Endangered Status for the Mojave Population of the Desert Tortoise. *Federal Register* 54 (149): 32326-32331.

(US/IBP) U.S. International Biological Program. 1978. *US/IBP Synthesis Series 9*. Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA.

Vasek, F.C., H.B. Johnson, and D.H. Eslinger. 1975. Effects of Pipeline Construction on Creosote Bush Scrub Vegetation of the Mojave Desert. *Madrono* 23: 1-13.

Wallace, A., E.M. Romney, and R.B. Hunter. 1980. The Challenge of a Desert: Revegetation of Disturbed Desert Lands. *Great Basin Naturalist Memoirs* 4: 216-225.

Webb, R.H., and H.G. Wilshire. 1980. Recovery of Soils and Vegetation in a Mojave Desert Ghost Town, Nevada, U.S.A. *Journal of Arid Environments* 3: 291-303.

Webb, R.H., H.G. Wilshire, and M.A. Henry. 1983. Natural Recovery of Vegetation Following Human Disturbance. In *Environmental Effects of Off-Road Vehicles, Impacts, and Management in Arid Regions*, R.H. Webb and H.G. Wilshire, eds. Springer-Verlag, New York, pp. 279-314.

Winsor, M.F., and C.R. Malone. 1990. State of Nevada Perspective on Environmental Program Planning for the Yucca Mountain Project. *The Environmental Professional* 12: 196-207.

ATTACHMENT N

Roundtable

High-level nuclear waste disposal and long-term ecological studies at Yucca Mountain

Yucca Mountain, in southern Nevada, is a volcanic ridge (elevation 1494 meters) that sits astride a little-known transition area at the juncture of the Mojave and Great Basin deserts (Figure 1). Ecologically dominant plants are desert shrubs, grasses, and forbs that are adapted to arid conditions. A unique program is under way at Yucca Mountain that has significant ecological and environmental implications.

The 175-square-kilometer site (Figure 2), managed by the US Department of Energy (DOE), is being considered for permanent disposal of the nation's commercially generated and defense related high-level nuclear waste. Studies to determine the suitability of the location for a deep geologic repository for permanent emplacement of the waste are to begin this year and will require 7 to 12 years to complete. If the location proves acceptable, repository development (i.e., construction, operation, closure, and site restoration) is expected to proceed for another 30 to 40 years. Concurrent with repository development, and for an indefinite period afterward, ecological and environmental monitoring is to be conducted to provide for successful restoration of the site's ecosystem and to confirm that the entombed nuclear waste remains isolated.

The proposed site-characterization studies and monitoring activities are intended to provide assurances that high-level nuclear waste and associated hazardous chemicals can be isolated from the biosphere for at least 10,000 years. A technological and physical performance-assessment methodology is being developed, in conjunction with environmental and safety assessments, to demonstrate that a combined engineered and natural geologic disposal system at Yucca Mountain will provide long-term protection to the environment and human health from radioactive and other hazardous materials. Specifically, performance assessment is to include projections of future geologic events that could affect repository performance; of evolving climatic factors and the availability of surface- and groundwater; of hydrologic factors that control availability of water, transport of radionuclides to the environment, and ecosystem development; of ecological factors that influence the environment; and of pathways by which radionuclides might reach humans. Such an ambitious effort has never before been attempted.

The complex issues of intergenerational environmental consequences make the success of the Yucca Mountain program especially important. However, we question whether aspects of the scientific underpinning of the program are sound and whether it will afford adequate assurances of protecting the environment and human health. In this article, we discuss environmental objectives for the Yucca Mountain project and the policy that has resulted in the current environmental program. We conclude with a critique of the program's shortcomings and provide a rationale for redirecting it to accommodate baseline and long-term ecological studies that would enhance assessment of repository performance and minimize potential adverse effects. Further, we argue that a restructured and comprehensive environmental

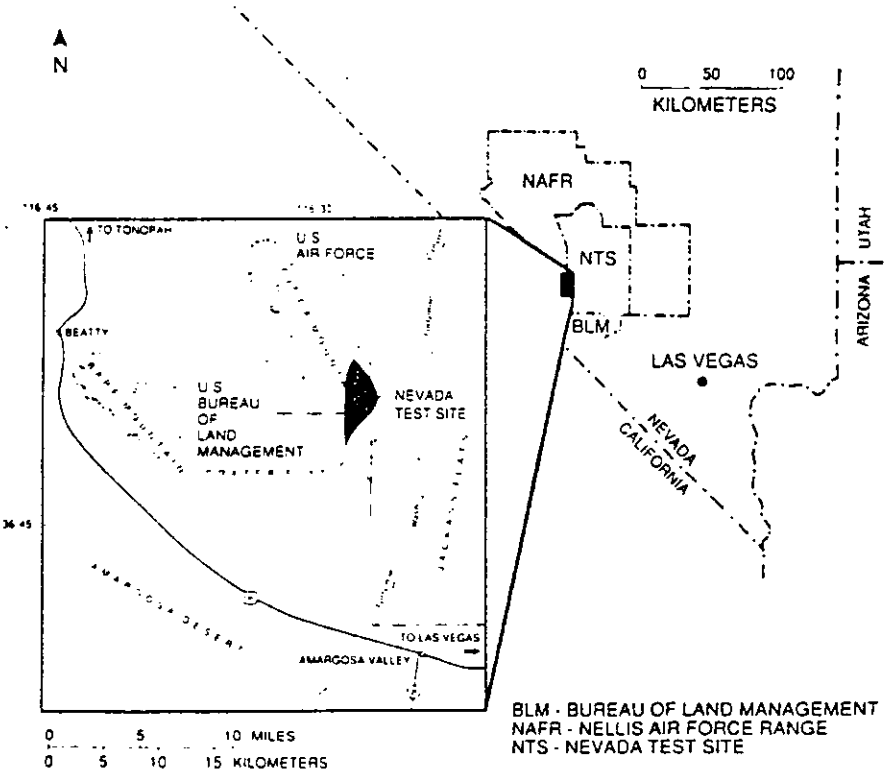

Figure 1. Location of the proposed high-level nuclear waste repository at Yucca Mountain, Nevada.

by John Lemons and Charles Malone

Figure 2. Yucca Mountain.

program would increase opportunities for basic long-term ecological research on desert ecosystem structure and function. A considerable need exists for such research.

Our current involvement in the Yucca Mountain project complements our previous work in interdisciplinary environmental research at Yucca Mountain (e.g., Brown and Lemons 1991, Lemons and Brown 1990, Lemons and Malone 1989, Lemons et al. 1989, 1990, Malone 1990a,b, Winsor and Malone 1990). Our work has been performed in our respective capacities as an independent university professor and as an environmental scientist for the Nevada Agency for Nuclear Projects, the state agency authorized by the Nuclear Waste Policy Act (NWPA), as amended, to review DOE's nuclear waste repository environmental program at Yucca Mountain.

The policy of geologic disposal

With passage of NWPA in early 1983, it became national policy to permanently dispose of high-level nuclear waste in deep geologic repositories (Carter 1987). The concept of geologic disposal relies on the characteristics of a natural environmental system to isolate radioactive materials and hazardous chemicals from the biosphere for a sufficient length of time to protect the environment and human health. NWPA establishes this time-length as 10,000 years, based on the anticipated durability of engineered canisters to retain waste materials for 300–1000 years before corrosion results in release of waste into the repository cavern. Safe sequestering of the waste for the balance of the isolation period depends on the integrity of the natural geologic setting in which a repository is constructed.

A procedure for selecting suitable sites for two repositories was set forth by NWPA. The act also designated DOE as the agency responsible for the geologic repository program (Parker et al. 1990). After DOE failed to identify sites for characterization studies under provisions of NWPA, the act was amended by the Nuclear Waste Policy Amendments Act (NWPAA) in late 1987 to simplify the task of repository site selection (Cooper 1989, Lemons et al. 1989). NWPAA mandated that only one repository be constructed, so only one site needed to be investigated for suitability. A year earlier, DOE (1986) had judged the Yucca Mountain site as the most likely of three sites under active consideration to be acceptable for a repository. Accordingly, NWPAA terminated the search for alternative repository sites and focused the efforts of DOE solely on the Yucca Mountain site, where preliminary siting activities had been carried out since the 1970s.

Repository siting investigations involve typical construction and mining activities such as exploratory drilling, geologic trenching, seismic studies, tunneling, and building the associated access and support structures (Malone 1990a, Parker et al. 1990). Preliminary work at the Yucca Mountain site has resulted in disturbance of vegetation and soils on approximately 260 hectares of land. An additional 210 hectares is expected to be disturbed as a result of further siting activities scheduled to begin this year. Although the full extent of disturbance that would result from repository development over the course of several decades has not been firmly established, there may be an additional 500–1000 hectares of land disturbed, principally as a result of rail and highway access and surface facilities needed for repository construction and waste processing and packaging.

The repository program does not include adequate planning for baseline or long-term ecological studies which are now considered necessary for environmental assessment (DOE 1989, National Research Council 1990, Winsor and Malone 1990). The program should be restructured to assess cumulative effects and include long-term ecological studies to determine the projected effects of repository performance on the environment and projected effects of environmental perturbations on repository performance.

There are several reasons for gathering baseline information and conducting long-term ecological studies at Yucca Mountain. First, the desert ecology of Yucca Mountain is fragile and has not been studied adequately (Beatley 1980, Collins et al. 1981, Winsor and Malone 1990). Second, there is no accepted method for evaluating repository performance (Bonton 1989, Lieberman and Lee 1986). An acceptable method would likely require adequate consideration of ecological baseline conditions at the repository site and long-term ecological studies to assess repository performance (Malone 1990b). The c

rent DOE plans do not include gathering of site-specific baseline data before undertaking additional characterization activities or plans for long-term ecological studies (Parker et al. 1990). Third, a number of countries are considering disposal of high-level nuclear waste, but none are as advanced in implementing a program as is the United States. Information on baseline conditions and long-term ecological studies are of potential interest to others involved in nuclear-waste siting issues (Garcia 1989, McCombie et al. 1989, van Dorp et al. 1989). Fourth, because the Yucca Mountain repository site will be protected from human intrusions (other than those due to the repository), it can serve as an ecological study area for long-term research. Knowledge from ecosystem studies conducted at the site could make a significant contribution to understanding of desert ecology.

Requirements for short-term environmental information

The Yucca Mountain project is different from traditional technological programs with respect to environmental regulation and attendant information needs. For example, the repository siting program is exempt from some major requirements of the National Environmental Policy Act (NEPA) for environmental documentation and review. Instead of requiring preparation of an environmental impact statement (EIS) for repository siting, NWPA required only a preliminary environmental assessment (EA). To speed the process, NWPA prohibited acquisition of any new data for the EA, thus requiring DOE to rely on incomplete information, much of which was of a regional generic nature as opposed to being site-specific.

The exemption from traditional NEPA review was meant to be compensated for by a subsequent detailed, site-specific investigation program. Thus the preliminary EA (DOE 1986) for the Yucca Mountain site did not contain complete information on biota at the site, contained no information on soils or effects on soils, contained no information on air quality and meteorological conditions at the site, and did not address water resources, including potential effects on ground water quality (Winsor and Malone 1990). Without adequate site-specific information, the EA concluded there would be no significant environmental impacts from repository siting activities (DOE 1986). It was on the basis of this document that the decision was made to select Yucca Mountain, as opposed to another site, as the sole location to be considered for a repository.

Consequently, DOE accepted the preliminary EA as evidence that repository siting activities would not result in significant environmental impacts (DOE 1988, Parker et al. 1990). DOE sought to comply with further requirements of NWPA, as amended, regarding the need to minimize effects expected from the siting program, mitigate any effects that did occur, and return the site to its previous condition if it proved unsuitable for a repository. It was reasoned by DOE decision-makers that because the preliminary EA found that no significant effects were expected from repository siting, it was unnecessary to conduct many detailed ecological studies and environmental analyses of pre-site characterization conditions at Yucca Mountain. However, to comply with the stipulations about impact mitigation and site restoration, it was necessary for DOE at least to plan for a limited program that would address the specific locations to be directly disturbed by proposed siting activities.

The DOE environmental program plan for the Yucca Mountain project follows directly from the requirements of NWPA, as amended, rather than constituting an approach based on the principles of integrated environmental management (DOE 1988, Winsor and Malone 1990). The plan consists principally of ecological surveys of areas to be disturbed, follow-up surveys after an activity is completed, and reclamation protocols for restoring the area to its prior ecological condition. A minor aspect of the program plan focuses on field activities that might be necessary for complying with limited environmental statutes and regulations that might apply outside of NWPA and NEPA.

The plan is not comprehensive either with respect to all important components of the environment or the entirety of the 175-square-kilometer Yucca Mountain site. As a consequence, the program does little to compensate for the absence of a comprehensive description of baseline environmental conditions. Furthermore, site-characterization activities could alter the fundamental nature of the ecosystem without those characteristics ever having been described in terms of ecological integrity, biological diversity, or ecosystem structure and function (Malone 1990b).

Need for long-term ecological research

Additional regulatory requirements relevant to an assessment of needs and prospects for long-term ecological research stem from NWPA, as amended, and other regulatory standards (Brown and Lemons 1991). The US Environmental Protection Agency has promulgated containment standards (40 CFR 191) for protecting human health and the environment from excessive releases of radionuclides from a high-level nuclear waste repository. These include standards that limit projected releases of radioactivity from the repository to the interface of the geosphere with the biosphere for 10,000 years after disposal. There are no standards that require consideration of the movement and consequences of radionuclides that enter the biosphere. However, NWPA, as amended, calls for preparation of an EIS pursuant to NEPA that addresses the consequences of developing a repository at Yucca Mountain.

Although planning for the EIS will not begin until at least 1997, it can be presumed that long-term effects that might be caused to the environment and to human health due to releases of radionuclides and persistent hazardous chemicals will be addressed in the context of protecting future generations, as required by NEPA. To accommodate such analyses, it is imperative that a long-term ecological perspective be taken. This work should be done on the basis of a sound description of existing environmental conditions at Yucca Mountain. However, by postponing the planning of such studies for an additional 5–10 years, the baseline conditions for ecological analyses will be those of the environment after site

characterization rather than of the original environment. This is a significant consequence of exempting the siting program from preparing a traditional EIS in accordance with NEPA, and it is unfortunate given the fragile nature of the Yucca Mountain site and what little we know about it.

Most ecological studies in the vicinity have been conducted at the Nevada Test Site (Collins et al. 1981). Conclusions from these studies focus on the importance of air and soil temperatures in the distribution of flora, soil fungi in micronutrient cycling, shrubs in soil-forming processes, and activity of Hymenoptera, which is associated with soil temperatures and moisture, and the role of that group in the decomposition process. However, according to the studies, no definitive soil surveys have been conducted, knowledge of physiological characteristics of flora has been derived mostly from greenhouse and laboratory studies, most soil-mineral plant relationships are unknown, and most types of insects and their functional roles are poorly known. Few site-specific studies have focused on important ecological parameters, including those necessary for long-term studies (Franklin et al. 1990, Magnuson 1990, Swanson and Sparks 1990). Further, DOE has no plans to conduct research on many of these parameters.

Recently, the Nuclear Waste Technical Review Board (NWTRB 1990) concluded that site characterization activities are not as negligible as stated in the Yucca Mountain EA. Consequently, it recommended that DOE should provide data to support its findings of negligible effects or should expand the scale of its ecosystem studies so that site characterization effects can be evaluated more fully.

DOE has decided not to study the implications and potential consequences of radionuclide releases into the biosphere or the effects of environmental perturbations on the repository's geohydrological setting (DOE 1988, Malone 1990a). This decision is predicated, in part, on 40 CFR 191, which establishes regulatory standards for the movement of radioactive waste through the geosphere to but not including into the biosphere. Although DOE may have a regulatory basis for its decision to exclude studies of radionuclides in the biosphere, it should be acknowledged that the decision was made even though researchers believe long-lived radionuclides ultimately will escape and be dispersed in the biosphere, either from repository failure or from environmental perturbations that may alter the repository's geohydrological barriers (Egan et al. 1989, National Research Council 1990, Ross 1989).

For example, the nuclear waste stored in the repository is projected to generate sufficient heat to increase soil surface temperature by 2–6° C (Blejwas 1990, NWTRB 1990). The temperature increase is expected to occur while the repository is being filled and to last for a period of approximately 1000 years. This warming may result in 200–300 cm of induced uplifting above the repository. A projected result of uplifting is the fracturing of the repository's geologic overburden, which can create new routes for groundwater to infiltrate and for stored wastes to exit the repository. The rate of soil erosion would also likely accelerate and further damage the environment or induce changes in the site's landscape and geohydrological characteristics. Such changes in the repository setting might increase gaseous fluxes of ^{14}C, tritium, and other radionuclides into the biosphere at Yucca Mountain (NWTRB 1990).

Another environmental pertubation that can be expected to affect long-term repository performance is regional climate change due to buildup of greenhouse gases in Earth's atmosphere. Climate change could alter characteristics of the repository's geohydrologic setting and ecosystem successional states, thereby affecting radionuclide cycling in the biosphere.

Assessing the risks to humans from releases of radionuclide and hazardous chemicals is also complicated by Kirchner's (1990) critique of models used to calculate hazards after failure of a geologic repository. He shows that calculations of hazards to humans must include simultaneous consideration of isotopic composition of the waste, transport of radionuclides to humans, and cycling in the biosphere. They must also consider time-dependent changes of the poten for risk due to radioactive buil and decay processes after disrupt of the repository and the entry waste into the biosphere. Models t include ecosystem processes incre required isolation times by sev orders of magnitude compared w models that are based only on rac nuclide composition and radioto ity to humans.

The parameters identified by Kir ner cannot be included in per mance assessments of the Yu Mountain repository unless DOE cides to conduct long-term studies radionuclides released into the en ronment. In contrast to the US pla which exclude study of long-term fects of radionuclides that enter biosphere and of how physical con tions at the site may be altered repository performance, European pository plans rely on environmen modeling in an endeavor to und stand and quantify the fates and co sequences of radionuclides in the b sphere over periods of tens thousands to millions of years (Gar 1989, van Dorp et al. 1989).

DOE will have to assess the fa and effects of radionuclides in t biosphere and risks to future gener tions beyond the 10,000-year peri when it conducts the EIS required NEPA, as modified by NWPA, f repository construction. Howev the assessment is likely to be flaw by current DOE decisions to fore analysis of cumulative effects fro site characterization activities, by n having a reliable and definitive bas line, and by not performing compr hensive and integrated ecologic studies.

Conclusions

Provisions of NWPA/NWPAA ar DOE policies have defined the en ronmental program for the plann high-level nuclear waste repository Yucca Mountain. The provisions ar policies have resulted in plans to co lect limited environmental data f purposes of monitoring and mitiga ing effects of proposed characteriz tion activities and repository develo ment. Consequently, the progra consists of overviews of the enviro mental program, reports of plans f environmental monitoring and mi

gation, regulatory requirements, and field activities for acquisition of environmental information to support monitoring, mitigation, regulatory compliance, and site reclamation. Accordingly, DOE's environmental plans, with the exception of those pertaining to field activities, are procedural and do not provide for the gathering of baseline data before site characterization activities.

The absence of baseline data before site characterization activities reduces the chances of developing a comprehensive and integrated environmental program. Unmonitored effects would not be detected, and remediation of disturbed areas critical to the performance of the repository would not occur or would be compromised. The absence of appropriate baseline studies coupled with the lack of long-term ecological studies will limit understanding of interactions between the geohydrologic setting of the repository and the biosphere. In other words, it may not be possible to assess how the repository potentially affects the environment (e.g., soil temperature increases from stored radionuclides or the effects of the changing composition of radionuclides over time) or how environmental perturbations affect repository performance (e.g., uplifting or fracturing of the repository overburden due to heat release from stored radionuclides or regional climate change). Consequently, significant uncertainty will exist about the effects of repository performance on the biosphere and to future generations.

NWTRB (1990) has stated its belief that there is no scientific or technical reason why a satisfactory geologic repository cannot be built. However, it notes that success for the repository program depends on meeting public concerns about long-term safety of repository performance. The environmental program at Yucca Mountain should be restructured to permit assessment of characterization activities on the site's ecosystem and to provide a basis for understanding fates and pathways for radionuclides that might escape the repository's geohydrologic surrounding. Specifically, such a program might entail development of comprehensive and integrated ecological studies to obtain baseline information before site characterization activities, assess the effects of repository performance on the site's ecosystem and integrity of the repository's geohydrologic surroundings, assess the effects of environmental perturbations on repository performance, assess the distribution and transport of radionuclides in the biosphere, assess implications to the biosphere of the changing composition of radionuclides over time, and estimate risks from radionuclides to future generations both within and beyond a 10,000-year time frame.

There are two additional reasons for restructuring the environmental program at Yucca Mountain, a site that will be protected from most human intrusions other than those related to the repository. First, data from a comprehensive scientific research program would complement radioecological studies gathered from other nuclear facilities, such as Oak Ridge, Savannah River, the Idaho National Engineering Laboratory, Hanford, and Los Alamos. Second, the site could serve as a site for basic long-term ecological research pertaining to desert ecosystem structure and function. Recently, the importance of obtaining data from long-term ecosystem studies and expanding the network of scientists and research sites to provide comparative analyses has been documented (Franklin et al. 1990, Magnuson 1990, Swanson et al. 1990). Long-term studies are uncommon despite the obvious need and the evidence that short-term research results are misleading.

We believe we have demonstrated both a need and a potential for long-term ecological studies at Yucca Mountain, due to the anticipated 30–50 year longevity of the DOE repository program and requirements for continued environmental and ecological monitoring. Such studies depend on the willingness of DOE to develop an environmental program consistent with that need and potential.

References cited

Beatley, J. C. 1980. Fluctuations and stability in climax shrub and woodland vegetation of the Mojave, Great Basin, and transition deserts of southern Nevada. *Isr. J. Bot.* 28: 149–168.

Blejwas, T. E. 1990. Influence of thermally-induced effects on repository design. NMTH1M5P A24/3–19, 20–90. Sandia National Laboratories, Albuquerque, NM.

Brown, D. A., and J. Lemons. 1991. Scientific certainty and the laws that govern the location of a high-level nuclear waste repository. *Environ. Manage.* 15: 311–319.

Buxton, B. E. 1989. *Geostatistical, Sensitivity, and Uncertainty Methods for Ground-Water Flow and Radionuclide Transport Modeling.* Battelle Press, Columbus, OH.

Carter, L. C. 1987. *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste.* Resources for the Future, Washington, DC.

Collins, E., T. P. O'Farrell, and W. A. Rhoads. 1981. Annotated bibliography for biological overview for the Nevada Test Site, Nye County, Nevada. EGG 1183-2419. EG&G Energy Measurements, Santa Barbara Operations, Goleta, CA.

Cooper, B. S. 1989. Focus shifts from capitol to Nevada. *Applied Research and Public Policy* 4: 26–28.

Department of Energy (DOE). 1986. Environmental assessment, Yucca Mountain site, Nevada research and development area, Nevada. DOE/RW-0073. Office of Civilian Radioactive Waste Management, DOE, Washington, DC.

_____. 1988. Site characterization plan. DOE/RW-0199. Office of Civilian Radioactive Waste Management, DOE, Washington, DC.

_____. 1989. Report to Congress on reassessment of the civilian radioactive waste management program. DOE/RW-0247. Office of Civilian Radioactive Waste Management, DOE, Washington, DC.

Egan, D. J., R. L. Clark, F. L. Gaopin, and W. F. Holcomb. 1989. Repromulgation of US EPA's environmental standards for disposal of spent nuclear fuel and high-level and transuranic radioactive wastes. Pages 155–159 in R. Post, ed. *Waste Management '89: Proceedings of the Symposium on Waste Management.* vol. 1. University of Arizona, Tucson.

Franklin, J. F., C. S. Bledsoe, and J. T. Callahan. 1990. Contributions of the Long-Term Ecological Research Program. *BioScience* 40: 509–523.

Garcia, A. L. 1989. Repository programs in Europe. *Trans. Am. Nucl. Soc.* 58: 94–101.

Kirchner, G. 1990. A new hazard index for the determination of risk potentials of disposed radioactive wastes. *J. Environ. Radioact.* 11: 71–95.

Lemons, J., and D. A. Brown. 1990. The role of science in the decision to site a high-level nuclear waste repository at Yucca Mountain, Nevada. *Environmentalist* 10: 3–24.

Lemons, J., D. A. Brown, and G. E. Varner. 1990. Congress, consistency, and environmental law: nuclear waste at Yucca Mountain, Nevada. *Environmental Ethics* 12: 311–327.

Lemons, J., and C. R. Malone. 1989. Siting America's geologic repository for high-level nuclear waste: implications for environmental policy. *Environ. Manage.* 13: 435–441.

Lemons, J., C. Malone, and B. Piasecki. 1989. America's high-level nuclear waste repository: a case study of environmental science and public policy. *Int. J. Environ. Stud.* 34: 25–42.

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Lieberman, J. A., and W. W. L. Lee. 1986. Mathematical modeling of waste repository performance: a peer review. Pages 749–758 in H. C. Burkholder, ed. *High-Level Nuclear Waste Disposal*. Battelle Press, Columbus, OH.

Magnuson, J. J. 1990. Long-term ecological research and the invisible present. *BioScience* 40: 495–501.

Malone, C. R. 1990a. Performance assessment and long-term environmental problems. *Project Appraisal* 5: 134–138.

———. 1990b. Environmental planning for siting a high-level nuclear waste repository at Yucca Mountain, Nevada. *Environ. Manage.* 14: 25–32.

McCombie, C., T. Papp, and S. Coplan. 1989. The development and status of performance assessment in radioactive waste disposal. In *International Symposium on the Safety Assessment of Radioactive Repositories*. Paris, 9–13 October. Commission of European Communities, Organization of Economic Cooperation and Development/Nuclear Energy Agency, and International Atomic Energy Agency.

National Research Council Board on Radioactive Waste Management. 1990. *Rethinking High-Level Radioactive Waste Disposal*. National Academy Press, Washington, DC.

Nuclear Waste Technical Review Board (NWTRB). 1990. Second report to the U.S. Congress and the U.S. Secretary of Energy. US Government Printing Office, Washington, DC.

Parker, G. J., J. R. Krummel, K. E. LaGory, G. J. Marmer, and S. P. Goel. 1990. The environmental protection program for site characterization at Yucca Mountain, Nevada. *Environ. Prof.* 12: 185–195.

Ross, B. 1989. Scenarios for repository safety analysis. *Engineering Geology* 26: 285–299.

Swanson, F. J., and R. E. Sparks. 1990. Long-term ecological research and the invisible place. *BioScience* 40: 502–508.

van Dorp, F., H. Grogan, and C. McCombie. 1989. Disposal of radioactive waste. *Radioactive Physics and Chemistry* 34: 337–347.

Winsor, M. F., and C. R. Malone. 1990. State of Nevada perspective on environmental program planning for the Yucca Mountain project. *Environ. Prof.* 12: 196–207.

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ATTACHMENT O

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Environmental assessment

Performance assessment and long-term environmental problems

Charles R Malone

This paper discusses quantified scenario methods of performance assessment and the problems of what time horizon to take. These questions are raised in connection with the Yucca Mountain Project for disposal of nuclear waste. Currently the method being developed will model the behaviour of the engineered and natural components of the system over a 10,000-year period but will exclude the biosphere and environmental consequences. Now is an appropriate time for consideration to be given to repository performance assessment with a view to facilitating the development of a methodology that has potential for application to broader environmental issues.

Keywords: performance assessment; environmental impact assessment; time horizons

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THE CONCEPT OF performance assessment is being used in the USA to predict whether or not a geologic repository will safely isolate and contain high-level nuclear waste for at least 10,000 years. The method being developed will model the behavior of the engineered and natural components of the system as well as the below-ground movement of radionuclides, but it excludes the biosphere and environmental consequences. If the conceptual changes recommended in this review of the US program are made, performance assessment could provide a model for how society can evaluate future long-term technological threats to the environment.

The disposal of high-level nuclear waste is an example of a technology that has the potential for affecting the environment and health of future generations. It has been suggested that how such decisions are made may contribute to methodologies for evaluating the consequences of new technologies for thousands of years (National Board for Spent Nuclear Fuel, 1988).

Several countries are considering disposal of high-level radioactive waste but none are as far advanced in implementing a program as the USA where Yucca Mountain, Nevada, has been selected as a prospective site for constructing a deep geologic repository for permanent disposal of the waste. The US Department of Energy (US DOE) is responsible for the program and the Yucca Mountain site is being characterized, design of a repository is underway, and a methodology for assessing repository performance over a 10,000-year period is being developed (Hunter and Bingham, 1989).

This article reviews the performance assessment program for the Yucca Mountain Project with the

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purpose of introducing the concepts, methods, and implications for technology assessment to others. It is this aspect of the US high-level nuclear waste program that is most likely to contribute to how society can appraise future technologies that pose long-term environmental threats.

Readers interested in the history of high-level radioactive waste management in the USA are referred to Carter (1987; 1989) who has documented events leading to passage of the Nuclear Waste Policy Act of 1982 (NWPA) and its revision in 1987. Others discuss nuclear waste programs in Europe (Garcia, 1989; van Dorp *et al*, 1989; McCombie *et al*, 1989) although a comparative critique of the various approaches to performance assessment and other aspects remains to be done and is needed.

Performance assessment

In the traditional engineering sense performance assessment involves understanding and evaluating how a system will function or behave. Assessing the performance of engineered systems such as a space shuttle or a nuclear power plant, for example, is essential for managing the risks involved with complex technologies.

Performance assessment for a geologic disposal system for nuclear wastes is complicated by the coupling of engineered and natural components of the system. The engineered component consists of a canister required to contain the waste for 300 to 1000 years. The natural component of the system, the geologic and hydrologic setting of the repository, is meant to retain most of the radioactive waste for 10,000 years or longer.

Total system performance depends principally on the geologic, hydrologic, and geochemical characteristics of the environment functioning as the primary barrier to migration of the radioactive wastes from the repository to portions of the environment accessible to man. An accepted method for evaluating the long-term behavior of a geologic disposal system does not exist in the USA or elsewhere (Lieberman and Lee, 1986; Stepp and Williams, 1989; McCombie *et al*, 1989; van Dorp *et al*, 1989; Davis *et al*, 1990).

In the USA the Environmental Protection Agency (US EPA) issued a 10,000-year containment standard for protecting the environment from excessive releases of radionuclides from a geologic repository (US EPA, 1985; Egan *et al*, 1989). Probabilistic standards were set that limit certain radioactive releases to a chance of one in ten of occurring within 10,000 years and limit other kinds of releases to between one chance in ten and one chance in 1,000 of happening. For estimating the release rates of radionuclides from a repository, the standards require that certain credible future phenomena be considered with respect to how a geologic repository might respond over the long term.

The environmental standards are included in the US Nuclear Regulatory Commission (US NRC, 1983) regulations for licensing a geologic repository and consequently probabilistic performance assessment provides the framework for the Yucca Mountain Project (US DOE, 1988). The purpose and goals of the US performance assessment program are shown in Table 1.

Table 1. Purposes of performance assessment in the US Geologic Repository Program for disposing of high-level nuclear waste

- Identifies processes and phenomena that can influence the behavior of a repository system.
- Screens the likelihood of occurrence of scenarios for the future.
- Quantifies current and expected future behavior of the repository system.
- Estimates extent of uncertainties in predictions of long term behavior.
- Predicts releases of pollutants that could impact the environment and man.
- Quantifies system behavior over time to assist with evaluating regulatory compliance and demonstrating safety.
- Provides information feedback for project design and development.

Yucca Mountain project

To be successful, a performance assessment method must be able to analyze how a natural environmental setting like that at Yucca Mountain will behave over thousands of years. Climatic, geologic, and human factors can influence the ability of a geologic repository to safely contain radioactive waste (Chapman and McKinley, 1987; Roxburgh, 1987; Berlin and Stanton, 1989).

Climate is important because changes over a 10,000-year period in precipitation, erosion, and infiltration of water would affect performance of the natural barrier and influence the movement of radionuclides to the environment. Epeirogeny (deformation of the earth's crust), tectonics (folding and faulting), and volcanism also could drastically alter the geohydrologic regime, and catastrophic events like faulting and volcanism could even compromise the integrity of the engineered barrier.

Human factors that could influence repository performance during the 10,000-year containment period include drilling of wells and exploring for mineral resources. Societal and human-related processes and phenomena have not received much attention in the US repository program and generally are considered irrelevant except for intentional and unintentional

To be successful a performance assessment method must be able to analyze how a natural environmental setting like that at Yucca Mountain will behave over thousands of years

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intrusion associated with resource exploration.

Omitted from performance assessment for the Yucca Mountain Project are considerations of the biosphere and environmental consequences of radionuclides that escape a repository and the surrounding geosphere. Instead of directly confronting the uncertainties imposed by considering environmental factors, the program conceptually excludes them by limiting concerns to the movement of radioactive waste through the geosphere to but not across the boundary with the biosphere (US DOE, 1988; Hunter and Bingham, 1989). What happens to the waste after it reaches the biosphere is avoided because foodchains, ways of life, and population distribution are considered too difficult to address (US EPA, 1985; Ross, 1986; Davis *et al*, 1990).

During the long time period being addressed for the Yucca Mountain Project the environment is expected to change, and how this is likely to affect a repository at the site must be well understood. This aspect of repository performance assessment comprises the major difference between traditional assessment of the performance of engineered systems and that which includes the natural environment.

Scenarios representing future site conditions are being based largely on event tree methods coupled with probabilistic risk assessment of geologic phenomena (Hunter, 1988; Ross, 1989). Judgmental methods increasingly are being used where uncertainty is excessively great as typically is the case when dealing with events that may occur in the distant future (Bonano *et al*, 1989; Ross, 1989).

The goal of scenario analysis is to depict future events that might allow radionuclides to escape the repository and reach the biosphere. As noted, this approach does not address the fate and effect of radionuclides in the biosphere because the phenomena included are restricted largely to physical ones. Omitted are such factors as anthropogenic climate change, ecosystem development, demography, and land use.

Once plausible scenarios are constructed they are analyzed by computational modeling to predict radionuclide movement. The modeling process (Table 2) has to assume that the range of possible scenarios are completely and correctly specified, that probabilities of occurrence of alternatives are accurately estimated, and that radionuclide transport pathways through the geosphere are reliably understood. The last step, evaluation, must address and resolve the question of whether or not the uncertainty associated with the results is sufficiently small to meet regulatory requirements.

Table 2. Steps in modeling to develop a repository performance assessment method

- Review and evaluate data and information suitability.
- Develop conceptual models and alternative scenarios.
- Decide on performance criteria to be predicted.
- Develop computer codes and perform model calculations.
- Predict probabilities and consequences associated with scenarios for future states of the geologic disposal system.
- Evaluate results to determine if uncertainty is sufficiently small.

The state-of-the-art of predictive modeling is insufficient to accomplish this objective with the degree of assurance usually associated with regulatory compliance and there is much debate about how to resolve the uncertainties (Brandstetter and Buxton, 1989; Hunter and Mann, 1989; Ross, 1989; Bonano and Cranwell, 1988; Chapman and Come, 1989). Some believe that many of the natural phenomena involved in scenario analysis and performance assessment are so poorly understood that data are statistically meaningless and theoretical models unprovable (Bartlett, 1988; Ross, 1989; Bonano and Cranwell, 1988).

The problematic nature of these issues gave rise to the restructuring of the US DOE high-level nuclear waste program in late 1989 to de-emphasize the quantitative, probabilistic based approach to regulatory compliance in favor of using qualitative judgement (DOE, 1989; Duffy, 1989). A problem with this approach is that probabilities based on judgment have no statistical validity (Chapman and Come, 1989) and their use in regulatory compliance is questionable.

Uncertainty also exists with respect to the appropriate timespan that should be addressed concerning nuclear waste. Recently Kirchner (1990) has shown that assumptions about the hazards posed often do not consider the changing nature of the waste over sufficiently long time periods. Based on environmental simulation modeling that included isotopic composition of nuclear waste, cycling in the biosphere, probability of transport of nuclides to man, radiotoxicity to man, and changing risk potential Kirchner showed that nuclear waste involves risks over a period about two orders of magnitude greater than that on which the US program is based.

These factors were not addressed in developing the US environmental protection standards and the selected 10,000-year period was chosen, rather than a million years as recommended by Kirchner, because it was believed that the state-of-the-art for predicting events by performance assessment was insufficient beyond 10,000 years (US EPA, 1985; Davis *et al*, 1990).

Comments

Environmental variables pose difficulties for repository performance assessment due to the lack of sound theories and data for predicting the behavior of natural systems. In the US program for the Yucca Mountain site the problems are compounded by the exclusion of non-physical phenomena from the environmental factors considered. This limitation could be overcome with a comprehensive and integrated environmental approach to repository performance assessment, if the US DOE were to promptly initiate the environmental assessment required for the repository by the NWPA, the National Environmental Protection Act (NEPA), and the US NRC

The assessment of the Yucca Mountain site will be deficient if it does not attempt to resolve the issues regarding the biosphere and long-term environmental risks posed by nuclear waste

repository licensing requirements.

The assessment, which must evaluate the environmental consequences of a repository at Yucca Mountain and consider near-term impacts as well as those to future generations, will be deficient if it does not attempt to resolve the issues raised by Kirchner (1990) regarding the biosphere and long-term environmental risks posed by nuclear waste. The US DOE has chosen to delay initiating the environmental assessment until late 1997 (US DOE, 1988 and 1989), well after site characterization and performance assessment are underway.

Although there is no insight as to how environmental assessment will be accomplished, no conceptual alternative exists for assessing long-term impacts to the environment other than sound, comprehensive environmental performance assessment. Pursuing such a course now instead of deferring it would eliminate the artificial distinction between the geosphere and the remainder of the environment that characterizes the Yucca Mountain Project, and contribute significantly to technology assessment methodology.

Clearly much remains to be done before performance assessment provides a means for evaluating technologies capable of affecting future generations. There is no accepted method for nuclear waste repositories and the US effort illustrates the relatively early development and state-of-the-art of the methodology. The decision to exclude the biosphere from performance assessment will result in even greater uncertainties than already characterize the existing methodology. This and the related shortcomings summarized in Table 3 reflect a perspective dominated more by compartmentalized concepts of engineering than by holistic environmental science.

Table 3. Shortcomings of the US performance assessment program for a geological repository at Yucca Mountain, Nevada

- Omits the biosphere as a component of the whole environment.
- Does not use environmental simulation.
- Ignores impacts to the environment and how they could feedback to affect repository performance.
- Avoids radiological consequence analysis for ecosystems and man.
- Time span assessed is too short.
- Attempts to rely on performance assessment as a means of evaluating quantitative regulatory standards while at the same time increasing emphasis on judgmental approaches as components of the methodology.

Conceptual limitations inherent in the approach to performance assessment taken for the Yucca Mountain Project may discourage some from viewing the concept as a means of addressing long-term environmental impacts of persistent pollutants like nuclear waste and other genotoxic materials that can cause human cancer, cellular injury, and fetal injury. The principle challenges that must be met with respect to application of performance assessment to environmental problems can be summarized as follows:

- Methods are needed for quantifying uncertainties associated with parameters characterizing natural systems.
- A rigorous objective approach is needed for developing complete scenarios.
- Means are needed for estimating probabilities of occurrence for phenomena and scenarios and for measuring associated uncertainty.
- Systematic approaches for judgmental methods must be developed that lend themselves to peer review and replication.
- Validated computational models are needed for quantitative and predictive analyses of complex natural processes and their interactions.
- Uncertainties need to be better understood and reduced with respect to the behavior of natural systems over long time periods.
- An accepted means is needed for demonstrating and evaluating a total performance assessment methodology, especially before performance assessment is used as a regulatory concept or tool.

Now is an appropriate time for consideration to be given to repository performance assessment with a view to facilitating the development of a methodology that has potential for application to broader environmental issues. Additionally, it may be that other forms of project appraisal such as environmental and technology assessments can contribute to the development of repository performance assessment. Judging from the limitations discussed herein to achieving an accepted method for the US Yucca Mountain Project such interaction has not occurred thus far.

References

J W Bartlett (1988), "HLW repository siting: getting from here to there with the issues", in R Post (editor), *Waste Management '88: Proceedings of the Symposium on Waste Management*, vol 2 (University of Arizona, Tucson) pages 423-25.

R E Berlin and C C Stanton (1989), *Radioactive Waste Management* (John Wiley and Sons, New York).

E J Bonano and R M Cranwell (1988), "Treatment of uncertainties in the performance assessment of geologic high-level radioactive waste repositories", *Mathematical Geology*, 20, pages 543-565.

E J Bonano, S C Hora, R L Keeney, and D von Winterfeldt (1989), "The use of expert judgements in performance assessment of high-level waste repositories" (Sandia National Laboratories, Albuquerque, NM) SAND89-0495C.

A Brandstetter and B E Buxton (1989), "The role of geostatistical, sensitivity, and uncertainty analysis in performance assessment", in B E Buxton (editor), *Geostatistical, Sensitivity and Uncertainty*

Methods for Ground-Water Flow and Radionuclide Transport Modeling (Battelle Press, Columbus, OH) pages 89-110.

L J Carter (1987), *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste* (Resources for the Future, Washington, DC).

L J Carter (1989), "Nuclear waste policy and politics", *Forum for Applied Research and Public Policy*, 4(3), pages 5-18.

N A Chapman and B Come (1989), "Long-term predictions: making proper use of geological evidence", *International Symposium on the Safety Assessment of Radioactive Waste Repositories* (CEC, OECD/NEA, and IAEA, Paris) 9-13 October.

N A Chapman and I G McKinley (1987), *The Geologic Disposal of Nuclear Waste* (John Wiley & Sons, Chichester, UK).

P A Davis, L L Price, K Wahi, M Y Goodrich, D Gallego, E J Bonano, and R Guzowski (1990), "Components of an overall performance assessment methodology" (US Nuclear Regulatory Commission, Washington, DC) NUREG/CR-5256.

L P Duffy (1989), "Briefing on the status of the DOE civilian high level waste program" (US Nuclear Regulatory Commission, Rockville, MD) transcript, 20 December.

D J Egan, R L Clark, F L Gaspin, and W F Holcomb (1989), "Repromulgation of US EPA's environmental standards for disposal of spent nuclear fuel and high-level and transuranic radioactive wastes", in R Post (editor), *Waste Management '89: Proceedings of the Symposium on Waste Management*, vol 1 (University of Arizona, Tucson) pages 155-159.

A L Garcia (1989), "Repository programs in Europe", *Transactions of the American Nuclear Society*, 58, pages 94-101.

R L Hunter (1988), "The importance of scenario development in meeting 40 CFR Part 191, in R Post (editor), *Waste Management '88: Proceedings of the Symposium on Waste Management*, vol 2 (University of Arizona, Tucson) pages 643-646.

R L Hunter and C J Mann (1989), "Techniques for determining probabilities of events and processes affecting the performance of geologic repositories: literature review" (US Nuclear Regulatory Commission, Washington, DC) NUREG/CR-3964.

T O Hunter and F W Bingham (1989), "Systems performance assessment for a Yucca Mountain repository", in R Post (editor), *Waste Management '89: Proceedings of the Symposium on Waste Management*, vol 1 (University of Arizona, Tucson) pages 545-549.

G Kirchner (1990), "A new hazard index for the determination of risk potentials of disposed radioactive wastes", *Journal of Environmental Radioactivity*, 11, pages 71-95.

J A Lieberman and W W Lee (1986), "Mathematical modeling of waste repository performance: a peer review", in H C Burkholder (editor), *High-Level Nuclear Waste Disposal* (Battelle Press, Columbus, OH) pages 749-758.

C McCombie, T Papp, and S Coplan (1989), "The development and status of performance assessment in radioactive waste disposal", *International Symposium on the Safety Assessment of Radioactive Waste Repositories* (CEC, OECD/NEA, and IAEA, Paris) 9-13 October.

National Board on Spent Radioactive Fuel (1988), "Ethical aspects of nuclear waste" (Statens Kernbransle Namnd, Stockholm) SKN Report 29.

B Ross (1986), "Disruption scenarios for a high-level waste repository at Yucca Mountain, Nevada", in R Post (editor), *Waste Management '86: Proceedings of the Symposium on Waste Management*, vol 2 (University of Arizona, Tucson) pages 403-409.

B Ross (1989), "Scenarios for repository safety analysis", *Engineering Geology*, 26, pages 285-299.

I S Roxburgh (1987), *Geology of High-Level Nuclear Waste Disposal* (Chapman and Hall, London).

J C Stepp and R F Williams (1989), "Need for performance-based approach to characterize and license the Yucca Mountain HLW repository", in *Proceedings of the Topical Meeting on Nuclear Waste Isolation in the Unsaturated Zone — Focus '89* (American Nuclear Society, Inc, La Grange Park, IL) pages 188-193.

US Department of Energy (1988), "Site characterization plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada" (US DOE, Washington, DC) DOE/RW-0199.

US Department of Energy (1989), "Report to Congress on reassessment of the Civilian Radioactive Waste Management Program" (US DOE, Washington, DC) DOE/RW-0247.

US Environmental Protection Agency (1985), "Environmental standards for the management and disposal of spent nuclear fuel, high-level and transuranic radioactive waste: 40 CFR 191", *Federal Register*, 50, pages 38066-38089.

US Nuclear Regulatory Commission (1983), "Disposal of high-level radioactive wastes in geologic repositories", *Federal Register*, 48, pages 28194-28229.

F van Dorp, H Grogan, and C McCombie (1989), "Disposal of radioactive waste", *Radiation Physics and Chemistry*, 34, pages 337-347.

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ENVIRONMENTAL PERFORMANCE ASSESSMENT: A CASE STUDY OF AN EMERGING METHODOLOGY

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ABSTRACT

The emerging methodology of environmental performance assessment offers a potential means by which the future consequences of new technologies can be evaluated. A pilot effort to create a nuclear waste repository at Yucca Mountain, Nevada, however, has yet to adequately address biological and societal components of the environment that will evolve at the site following closure and abandonment of a repository. The nonphysical components of environmental systems cannot be ignored in performance assessment studies and are likely to be no more recalcitrant to analysis than physical components such as the geologic and hydrologic characteristics of a site. If environmental performance assessment is to contribute to understanding the risks and uncertainties associated with technologies like nuclear waste disposal, the methodology must address all components of environmental systems in a comprehensive and integrated manner. A methodology that recognizes only physical factors stands little chance of predicting the future outcome of actions that will affect the environment for thousands of years.

The rapid development and complexity of modern technology assure that decisions made by society will increasingly risk affecting environmental systems far into the future. This raises questions about how to deal with the long-term consequences of actions that may threaten generations to come. Nuclear waste disposal is the first of these dangers to come under wide scrutiny. It has been suggested that the manner in which this problem is approached could serve as a model for dealing with other long-term consequences of technological change [1, 2]. High-level nuclear waste poses a threat to the environment for thousands of years; steps are being taken by the United States Department of Energy (DOE) to dispose of the waste in deep geologic repositories meant to be reasonably safe

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for at least 10,000 years. The concept of geologic disposal of nuclear waste pursued by the DOE is based on a dual-barrier approach to waste isolation that involves an engineered barrier and a natural environmental barrier. Long-term containment and isolation of radionuclides primarily is to be accomplished by the environmental barrier, subsequent to a 300- to 1000-year period during which the engineered barrier in the form of a cladding and canister combination may have corroded and released the waste into the repository environment [3, 4]. Ultimate containment and isolation of radionuclides from the biosphere is primarily to be attained by virtue of the natural setting of the repository. Thus, geologic isolation in the United States will rely ultimately on a site's natural environmental characteristics and features to confine radioactive waste to the vicinity of the repository and therby protect future environmental systems and generations.

The environmental uncertainties posed by disposing of nuclear waste in geologic repositories are recognized in probabilistic, risk-based regulatory requirements, compliance with which is to be demonstrated through the use of performance assessment [4-7]. "Performance assessment" means an analysis that identifies the processes and events that could affect a repository setting, models the associated uncertainties, and evaluates potential consequences to the environment. As the major available tool for making informed decisions regarding repository siting and licensing [8], performance assessment is an aspect of the nuclear waste disposal issue most likely to serve as a model for how long-term aspects of technological development may affect future environmental systems. The emerging methodology of environmental performance assessment, as applied to geologic disposal of nuclear waste, is reviewed here.

GEOLOGIC DISPOSAL AND PERFORMANCE ASSESSMENT IN THE UNITED STATES

The U.S. program for geologic disposal of high-level nuclear waste is set forth by the Nuclear Waste Polity Act of 1982 (NWPA) and the 1987 amendments to the act. As amended, the act requires that Yucca Mountain, located adjacent to the Nevada Test Site in southwestern Nevada, be evaluated as a suitable natural setting for a repository. Before authorization can be granted by the Nuclear Regulatory Commission (NRC) for constructing the repository and licensing it for operation, an environmental performance assessment must be carried out to demonstrate that the environment is likely to be protected from migrating radionuclides for at least 10,000 years [4]. A performance assessment methodology does not exist. The assessment program being developed by the NRC and the DOE is at an early stage and requires considerable evolution before it can be applied in other than simple bounding calculations of radionuclide releases to the accessible environment [8]. Because the regulations do not spell out how performance assessment is to be carried out, there is a need for

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agreement within the United States nuclear waste program on the methodology to be applied, especially regarding establishment of probabilities for risk assessment [9].

Much of the work relative to performance assessment for the Yucca Mountain Project has concentrated on constructing scenarios for future environmental systems [10-12]. The principal focus of scenario development for the Yucca Mountain environment has been on aspects of the physical environment such as geohydrology, geochemistry, and rock characteristics that are to comprise the primary barrier to radioactive waste migration. Once the components of the physical system are understood, plausible events will be postulated that could influence specific components of the system and lead ultimately to breaching of the repository and release of wastes to the biosphere [10]. Table 1 lists the physical components of the natural environment system believed to be important to the Yucca Mountain site.

The DOE and NRC performance assessment program for a geologic repository is based on the assumption that the most likely route for radionuclides released from a repository to take to the accessible environment is via ground water [3, 7, 13, 14]. Consequently, emphasis has been placed on environmental processes and scenarios that could lead to breaching the repository and releasing nuclear wastes to ground water. Other modes of repository breaching and mechanisms of transport of waste to the biosphere such as extrusive magmatic activity and denudation of the natural overburden also are considered but generally to a

Table 1. Physical Processes and Events Being Considered in Assessing the Environmental Performance of the Yucca Mountain Site for 10,000 Years

Geohydrology and ground-water hydraulics [3, 10, 11, 12]
Geochemistry [3, 12]
Tectonics and faulting [3, 10, 11, 12]
Volcanism [3, 10, 11]
Rock properties (e.g., thermodynamics and strength) [10, 11]
Site geometry and geology (stratigraphy) [3]
Occurrence of mineral and energy resources [3, 10, 11, 12]
Dissolution of rocks [12]
Formation of inorganic colloids [12]
Erosion and denudation of overburden [3, 10, 11]
Climatic change [12]
Surface hydrology and flooding [12]

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lesser extent than components of the environmental system that affect ground-water transport. This is evident from Table 1 which largely considers physical processes and events such as geohydrology, geochemistry, tectonics, rock dissolution, climatic change, and flooding that affect ground-water transport scenarios.

Table 2 lists the non-physical components of environmental systems that are being addressed for the Yucca Mountain site. The paucity of biological processes and events considered reflects the early stage of development of the environmental performance assessment concept. The only biological process considered has been microbial growth which has only recently been brought to the attention of researchers [12]. The hypothesis is that microbes naturally present in the host rock formation could render radionuclides more mobile and readily accessible to the environment. Some emphasis has been placed on human activities that might influence repository site performance, in particular on irrigation, intentional ground-water and climatic manipulation, and intrusion from resource exploration and mining [12]. War, sabotage, chemical waste disposal, and archeological exhumation have been discounted as potential influences on the future environmental performance of the Yucca Mountain site. For those societal factors considered, the emphasis has been on the likelihood of natural conditions and resources at the site being such that in the future an activity could occur. Thus, the likelihood of future society itself being such that an event might occur has not been addressed. For example, the possibility of human intrusion into a repository is based on the probability of extractible natural resources occurring at the site and not on the likelihood of the nature of a future society being such that resource exploration might or might not occur.

Scenarios under study for repository performance assessment are shown in Table 3. Hunter *et al.* describe the procedure as one of constructing event trees that depict the alternative courses that various processes could take [10]. The result is a hypothetical sequence of future events that might allow radionuclides to breach the natural barrier and escape from a repository. For both the engineered barrier and the natural barrier, the events, in combination with the rock types (e.g., welded tuff, alluvium, argillite) composing the natural barrier

Table 2. Non-Physical Processes and Events Being Considered in Assessing the Environmental Performance of the Yucca Mountain Site

Natural microbial activity [12]
Human intrusion in search of natural resources [3, 10, 11, 12]
Future irrigation [12]
Ground-water recharge or withdrawal [12]
Climate control [12]

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Table 3. Scenarios Being Considered for Environmental Performance Assessment of the Yucca Mountain Site

Hydrological alterations, increased underground water flow, and water-table rise [10, 11, 12]
Formation of new ground-water discharge points [12]
Tectonic disturbance, faulting, and rock fracturing [3, 10, 11]
Alteration of rock properties and geochemical changes [10, 11, 12]
Advance of a dissolution front [3, 12]
Extrusive magmatic activity [3, 10, 11, 12]
Erosion and overburden denudation [3, 10, 11]
Climatic control or change [3]
Migration of inorganic colloids [12]
Accelerated natural microbial activity [12]
Human intrusion by exploratory drilling [3, 10, 11, 12]

at the Nevada Test Site and Yucca Mountain led initially to 21,000 scenarios [10]. These next were narrowed to 4,000 scenarios, only 400 of which were considered sufficiently probable to pursue in the performance assessment program for the Yucca Mountain site [11]. Currently, eighty-four different scenario sequences (grouped in seventeen categories) are being analyzed by the DOE Yucca Mountain Project. The environmentally-based categories, listed in Table 3, are used as a basis for further analysis of disruptive event and process scenarios for Yucca Mountain [12], and include both physical and non-physical environmental factors influencing site performance. Table 3 also displays scenarios analyzed for the NRC in a demonstration of a hypothetical performance assessment methodology for a nuclear waste repository [14]. In the demonstration the objective was to show for a simple, idealized case that, in conformity with regulations and standards [4-6], performance assessment can be used to predict transport of radionuclides from a repository to the accessible environment. The constraints that ultimately will be posed by data limitations and uncertainties were recognized in the numerous assumptions made [14]. Nonetheless it was concluded that when perfected performance assessment methodology could serve to evaluate and demonstrate environmental performance of a repository site.

The scenarios shown in Table 3 assume that ground water poses the most likely route by which the environment and humans could be exposed to radioactive wastes in the future. For example, the environmental standards [4-6] assume that the principal risk to future individuals would be very small except

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for the possibility that individuals one day might use ground water from the vicinity of a repository. This risk also was recognized by the National Academy of Sciences [13], which concluded that for a site like Yucca Mountain water resources probably would be limited in the future as they are now and consequently any water available at the site would most likely be used by future generations. Despite these concerns, no attention in the environmental performance assessment program for the DOE Yucca Mountain Project is being given to the likelihood of future societal factors at Yucca Mountain being such that ground water there would be used. Instead, the focus is on that gound water itself and the likelihood of radionuclides reaching the biosphere via that route during the next 10,000 years. Scenarios of this sort depend more on information on environmental events and processes like those shown in Table 1 than those in Table 2. This is because it is accepted that food chains, ways of life, and population distributions over 10,000 years, unlike geologic and hydrologic factors, cannot be usefully predicted over such long periods of time [5, 12]. As a consequence no serious attempt is being made in the United States repository program to understand biologic and societal factors with respect to future environmental systems and the intergenerational consequences of nuclear waste disposal.

Once events, processes, and plausible future scenarios are well-defined, probabilistic and deterministic models must be developed to perform the complex computations that will be necessary for analyzing possible interactions among climates, geohydrologic regimes, tectonic disturbances, volcanism, geochemical alterations, and resource exploration. The analytical models for the Yucca Mountain site [15, 16] are in a rudimentary stage of development and are limited by existing knowledge of the geologic and hydrologic environment [8]. The work will try to incorporate alternative conceptual models and mathematical structures into the environmental performance assessment. Significant progress in developing definitive models to predict the behavior of the physical environment at Yucca Mountain will require much new information on how the geologic and hydrologic systems function and interact. This level of understanding will come only after five to seven years of planned field studies at the site are completed by DOE [17]. In the interim, the performance assessment program will continue developing plausible scenarios for the Yucca Mountain environmental system.

SOME METHODOLOGICAL LIMITATIONS AND UNCERTAINTY

Many difficulties stand in the way of understanding the complex environmental processes at Yucca Mountain. As noted, the focus to date has been on understanding the nature of the physical system. The DOE has developed detailed plans to characterize the geologic and hydrologic environment at the site [17]. The efficacy of the performance assessment program depends on

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the ability of science to "interrogate" the site's environment successfully enough to warrant probabilistic and/or deterministic predictions of events and processes in at least the next 10,000 years. Several reviews have been undertaken of the ability of existing study methods and techniques to provide the data and information needed for constructing models of the Yucca Mountain geology and hydrology. For example, Jones, *et al.* found that seismic reflection profiling and electromagnetic methods are of little use in determining the deep internal geologic structure due to the complexity of the site [18]. It also was concluded that seismic refraction techniques require further development to overcome existing limitations with respect to Yucca Mountain's geology. Other efforts have found an absence of commonly agreed upon techniques and theory for characterizing and modeling ground-water movement in unsaturated fractured rock media like that at Yucca Mountain [19-21]. These findings for both the geologic and geohydrologic environment at the Yucca Mountain site were endorsed by an oversight review of the DOE Project [22].

Difficulties also exist with respect to understanding subsurface geochemistry and the combined radionuclide-fluid-rock interactions. Only now are preliminary efforts being made to model geochemical phenomena with respect to radionuclide transport and repository performance assessment. Many difficulties have arisen [23]. For example, it has recently come to light that colloids in the subsurface environment play an important role in the migration of radionuclides [23, 24]. Failure to account for colloidal movement can lead to significant underestimates of the distances that radionuclides will migrate in ground-water systems. McCarthy and Zachara discuss instances where waste plutonium and americium have, over short periods of time, unexpectedly traveled in excess of thirty miles below ground due to colloidal mechanisms, when laboratory analyzes indicated that movement of only a few millimeters would be expected [24]. The occurrence and properties of below-ground colloids are poorly understood, so the insights necessary for predictive modeling of this mode of transport are not well developed. Relevant to the Yucca Mountain site are concerns that colloids may be important to mobilizing radionuclides in both the vadose and the saturated ground-water zones. It is further suspected that in combination with naturally occurring microbes, biocolloids could be formed [24], which would further complicate understanding ground-water transport of radionuclides from a geologic repository to the accessible environment. This possibility would significantly complicate performance assessment for Yucca Mountain and emphasizes the uncertainties that exist with respect to biological components of the environmental system.

The complexity of Yucca Mountain's physical setting and the absence of reliable data, techniques, and models for predicting future tectonics, seismicity, volcanism, and geohydraulics that will govern transport of radionuclides from a geologic repository to the biosphere limits existing scientific and technological capabilities and results in considerable uncertainty with respect to performance

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assessment for the Yucca Mountain Project [19, 25]. Because of the long half-lives of radionuclides involved and the need to accurately predict their fates in the environment for at least 10,000 years, best or conservative estimates will not suffice. In the face of large uncertainties in characterizing the geology and geohydrology of a site like Yucca Mountain and the uncertainties inherent in long-term prediction it is imperative to quantify the uncertainties in predicting repository performance in order to establish levels of confidence in assessing the performance of a site [19]. This limitation was recognized conceptually in the NWPA and the applicable environmental radiation standards [4-6], and must be dealt with in the course of environmental performance assessment for the Yucca Mountain site. Consequently, considerable attention is now being devoted to the task of characterizing and analyzing probabilities and environmental uncertainties [19, 26].

Table 4 lists the broad classes of uncertainty that apply to a geologic repository site like Yucca Mountain. At this stage most attention is being devoted to the uncertainty related to the geosciences where the need for validated probabilistic and conceptual models is clearly recognized as being critical [19]. Some attention has been turned to the future state of the non-geologic environment in terms of predictions, probabilities, and uncertainties associated with future climate. This is critical not only to future hydrologic regime at a repository site but also to the biological and societal components of the environmental system that may develop there, possibly enhancing radionuclide accessibility to the environment. Unfortunately no definitive methods exist for predicting climates over thousands of years and no study has addressed all the environmental processes and events necessary to predict future conditions at the resolution needed for evaluating repository sites and conducting performance assessments [26].

Limited effort has been devoted to date to predictions and uncertainties associated with non-physical components of environmental systems (as in Table 2). In the United States repository program, human intrusion is considered one of the most likely of the occurrences that might compromise repository integrity [26]. Consequently, this possibility has been addressed somewhat,

Table 4. Types and Sources of Uncertainty that Apply to Environmental Performance Assessment for a Geologic Repository Site (Based on Buxton [19])

Variation in the natural environmental setting and choice of parameters
Conceptual and probabilistic modeling (definitions and calculations)
Future evolution of the environmental system (physical, biological, and societal)
Measurement errors (systematic, random, bias, arbitrary)

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especially in the resource exploration scenario, which is particularly applicable to Yucca Mountain because the site is located in a region characterized by extractible mineral resources. Hunter and Mann concluded that objective estimates of the future mineral resource potential of an area cannot be made with known techniques [26].

Another human intrusion issue centers around the possibility of unintentional intrusion. Gillis reported on the findings of the DOE Human Interference Task Force [27], which evaluated modes of unintentional human intrusion into a nuclear waste repository. The study concluded that the probability of human intrusion could satisfactorially be reduced by using comprehensive communication systems at the repository site in the form of permanent markers. This conclusion was reached without the use of scenario, probability, or uncertainty analyses. Nonetheless, the results of the study have been used in the Yucca Mountain Project to largely dismiss the issue of human intrusion. Thus, this and other uncertainties associated with societal components of future environmental systems at Yucca Mountain are not being aggressively pursued.

Uncertainty also is introduced in environmental performance assessment of a repository site by errors associated with measuring environmental parameters. These can result from inaccurate instruments, inferences made from erroneous data, and from bias and arbitrariness introduced into assumptions made in data analysis and interpretation [19]. Crowe has recognized intentional bias built into the Yucca Mountain Project as a result of mounting pressure to "prove" the site in the face of increased funding and political realities [28]. This concern appears increasingly valid in light of the fact that Yucca Mountain represents the sole site being considered for a high-level nuclear waste repository in the United States. With no alternative to Yucca Mountain, the success of the DOE repository siting program rests on the correct assumption having been made that Yucca Mountain is an acceptable, licensable site.

As has been argued, at this stage in the environmental performance assessment program for the Yucca Mountain site, there seems to be little effort devoted to non-physical components of the environmental system in constructing future scenarios. Instead, there is a tacit assumption that biologic and societal factors cannot be usefully predicted [5, 12]. Rather than (say) trying to assess the likelihood of a future society taking some action at Yucca Mountain that will interfere with the performance of the natural environment as a barrier to radionuclide movement to the biosphere, the approach is to focus on the physical component of the environmental system that would be altered either by direct manipulation or as the indirect consequences of manipulation. Exploitation of the ground-water system as a water supply source is an example. As a result there is no attempt to construct and assess scenarios that embody plausible alternative courses of society and ecosystems that might develop at and affect the performance of the Yucca Mountain site in terms of nuclear waste isolation. Nowhere does there appear to have been a serious effort made to

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identify the sources of such uncertainty and consider how these uncertainties may be addressed or resolved by insights into future development of biological and societal components of environmental systems.

DISCUSSION AND CONCLUSIONS

The extent of information and analysis needed to carry out a 10,000-year environmental performance assessment is immense, on a scale never before attempted, and challenges the ability of science to comprehend the complexities and uncertainties involved. This is particularly true when the comprehensive physical, biological, and societal nature of environmental systems is considered. The importance of societal components of environmental systems to the integrity of a repository system was considered in part by the Swedish National Board for Spent Nuclear Fuel [1], which recognized that the nuclear waste issue may become a model for dealing with long-term consequences of other technologies. Their study found it essential to the success of the Swedish geologic repository program that means be sought for addressing risks and uncertainties from societal components of the environmental system. Similarly, the Canadian Nuclear Fuel Waste Management Program considers biosphere modeling essential for estimating the range and probabilities of environmental effects of geologic disposal of nuclear wastes [29].

In the performance assessment program for the Yucca Mountain site it is understandable that initial attention would be given to aspects of the physical environment such as those in Table 1. Not only are events and processes involving geologic and hydrologic factors easier to portray than those involving biological and societal ones, but the non-physical factors appear more likely to pose limits to the site's ability to perform as required and isolate nuclear wastes for at least 10,000 years. Soon, however, the more difficult task of identifying and understanding non-physical events, processes, and scenarios that could characterize future environmental systems at Yucca Mountain must be undertaken. The importance of this is underscored by postulated scenarios [5, 13], suggesting that the distant future use of ground water from the vicinity of a repository in an arid region like southwestern Nevada could result in substantial health risks to individuals. These preliminary analyses were based on limited information on ground-water travel time, radionuclide migration, the assumption that water will continue to be limited in the distant future, and the further assumption that, as is the case now in the Yucca Mountain region, ground water will be used by humans for potable water and irrigation. Thus, the generally arid nature of the Yucca Mountain site suggests that potentially contaminated ground water is likely to be used and that individual radioactive dose rate criteria may not be met [13].

Another example of the need to address future societal scenarios concerns inadvertent human intrusion. Efforts to date have focused only on means of

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marking a repository so that future generations would detect and avoid or manage its hazards [27]. In the same light it bears noting that lack of a means of assessing the potential of a future society to explore a given site for natural resources led only to the simplistic recommendation that a repository not be sited where any natural material occurs in greater abundance that the average for the Earth [26].

While uncertainties with respect to the physical environment may be dealt with separately in the initial stage of an environmental performance assessment for a repository, the large uncertainties posed by biological and societal factors cannot be set aside without further consideration. Within the various scenarios analyzed for Yucca Mountain must be what really will occur at the site during the next 10,000 years. Otherwise, the entire performance assessment exercise will be for naught, despite the sophistication of the analytical methodologies used. Incorrect scenario specification may result in a nuclear waste repository not performing as intended. It has been pointed out that incorrect specification of repository performance scenarios is likely to be the most significant source of error in trying to assess how the environmental system will behave [19].

There is some reason to believe that currently perceived limitations to dealing with the uncertainties posed by non-physical factors can be overcome. Recent applications of risk and uncertainty analyses to environmental assessment holds the promise of quantifying biological and societal factors [30, 31]. Adequate knowledge of the non-physical components of the environment seems to exist. The constraints that remain to successful application of risk and uncertainty analyses to them appear to be:

1. Adapting existing models to express output in terms of probabilities; and
2. Expressing data in terms that allow uncertainties to be quantified.

A category of recently developed computer programs referred to as "expert systems" also may help overcome some of the limitations of traditional assessments based on subjective judgement. For example, Lein has argued that expert systems encoded with the knowledge of biological and societal factors affecting the course of a future technology can provide solutions to specialized problems previously thought not to be amenable to more traditional risk and uncertainty analysis [32]. Prototype expert systems appear to suggest that artificial intelligence can be used to screen comprehensive alternative scenarios reflecting both physical and non-physical events and processes. If so, it is possible that tools may soon exist for evaluating and assessing the importance of cultural, societal, and other non-physical factors in environmental systems. Certain parameters that can be documented, characterized, compared over time, and used to predict trends have been identified [33, 34]. Conceptual means of formulating these issues are available [35], as are the rudiments of an information base [36]. New ways of addressing heretofore unmanagable issues within performance assessment models thus may be within reach. This suggests

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that uncertainties posed by biological and societal factors may be no greater and no more recalcitrant to resolution that those associated with the physical aspects of environmental systems. They simply are receiving less attention than geologic, hydrologic, and related factors in the United States repository program.

REFERENCES

1. National Board on Spent Nuclear Fuel, *Ethical Aspects of Nuclear Waste*, Report 29, Statens Kambransle Namdn, Stockholm, Sweden, 1988.
2. J. Lemons and C. Malone, Siting America's Geologic Repository for High-Level Nuclear Waste: Implications for Environmental Policy, *Environmental Management, 13*, pp. 435-441, 1989.
3. U. S. Department of Energy, *Mission Plan for the Civilian Radioactive Waste Management Program*, DOE/RW-0005, Washington, D.C., June 1985.
4. U. S. Nuclear Regulatory Commission, Disposal of High-Level Radioactive Wastes in Geologic Repositories, 10 CFR Part 60, *Federal Register, 48*, pp. 28194-28229, 1983.
5. U. S. Environmental Protection Agency, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR Part 191, *Federal Register, 50*, pp. 38066-38089, 1985 (remanded 17 July 1987, U. S. Court of Appeals, First Circuit).
6. D. Egan and R. Clark, Amended Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR Part 191: Working Draft I, U. S. Environmental Protection Agency, Washington, D.C., June 2, 1989.
7. U. S. Department of Energy, Nuclear Waste Policy Act of 1982: General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories, 10 CFR Part 960, *Federal Register, 49*, pp. 47714-47770, 1984.
8. J. A. Lieberman and W. W. L. Lee, Mathematical Modeling of Waste Repository Performance: A Peer Review, in *High-Level Nuclear Waste Disposal*, H. C. Burkholder (ed.), Battelle Press. Columbus, Ohio, pp. 749-758, 1986.
9. R. L. Hunter, R. M. Cranwell, and C. J. Mann, Determining Probabilities of Geologic Events and Processes, in *High-Level Nuclear Waste Disposal*, H. C. Burkholder (ed.), Battelle Press, Columbus, Ohio, pp. 637-646, 1986.
10. R. L. Hunter, G. E. Barr, and F. W. Bingham, *Preliminary Scenarios for Consequence Assessments of Radioactive-Waste Repositories at the Nevada Test Site*, SAND82-0426, Sandia National Laboratories, Albuquerque, New Mexico, 1982.
11. ———, *Scenarios for Consequence Assessments of Radioactive-Waste Repositories at Yucca Mountain, Nevada Test Site*, SAND82-1277, Sandia National Laboratories, Albuquerque, New Mexico, 1983.
12. B. Ross, *A First Survey of Disruption Scenarios for a High-Level-Waste Repository at Yucca Mountain, Nevada*, SAND85-7117, Sandia National Laboratories, Albuquerque, New Mexico, 1987.

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13. National Academy of Sciences, *A Study of the Isolation System for Geologic Disposal of Radioactive Wastes*, National Academy Press, Washington, D.C., 1983.
14. E. Bonano, P. Davis, L. Shipers, K. Brinster, W. Beyeler, C. Updegraff, E. Shepherd, L. Tilton, and K. Wahi, *Demonstration of a Performance Assessment Methodology for High-Level Radioactive Waste Disposal in Basalt Formations*, U. S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-4759, 1989.
15. M. Board, *Examination of the Use of Continuum versus Discontinuum Models for Design and Performance Assessment for the Yucca Mountain Site*, U. S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-5426, 1989.
16. A. Dudley, R. Peters, J. Gauthier, M. Wilson, M. Tierney, and E. Klavetter, *Total Systems Performance Assessment Code (TOSPAC) Volume 1: Physical and Mathematical Bases*, SAND85-0002, Sandia National Laboratories, Albuquerque, New Mexico, 1988.
17. U. S. Department of Energy, *Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada*, DOE/RW-0199, Washington, D.C., 1988.
18. G. Jones, M. Blackey, J. Rice, V. Murphy, E. Levine, P. Fisk, and R. Bromery, Survey of Geophysical Techniques for Site *Characterization in Basalt, Salt, and Tuff*, U. S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-4957, 1987.
19. B. E. Buxton, *Geostatistical, Sensitivity, and Uncertainty Methods for Ground-Water Flow and Radionuclide Transport Modeling*, Battelle Press, Columbus, Ohio, 1989.
20. National Academy of Sciences, *Ground-Water Models: Scientific and Regulatory Applications*, National Academy Press, Washington, D.C., 1989.
21. National Water Well Association, Vadose Zone Investigations at a Potential Nuclear Waste Repository Site, in *Proceedings of the NWWA Conference on Characterization and Monitoring of the Vadose (Unsaturated) Zone*, National Water Well Association, Dublin, Ohio, pp. 396-563, 1986.
22. Nevada Nuclear Waste Project Office, Geologic and Hydrologic Issues Related to Siting a Repository for High-Level Nuclear Waste at Yucca Mountain, Nevada, USA, *Journal of Environmental Management, 28*, in press, 1989.
23. M. D. Siegel and C. D. Leigh, *Progress in Development of a Methodology for Geochemical Sensitivity Analysis for Performance Assessment: Parametric Calculations, Preliminary Databases, and Computer Code Evaluation*, U. S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-5085, 1989.
24. J. F. McCarthy and J. M. Zachara, Subsurface Transport of Contaminants, *Environmental Science and Technology, 23*, pp. 496-502, 1989.
25. C. R. Malone, The Yucca Mountain Project: Storage Problems of High-Level Radioactive Wastes, *Environmental Science and Technology, 23*:12, pp. 1452-1453, 1989.

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26. R. L. Hunter and C. J. Mann, *Techniques for Determining Probabilities of Events and Processes Affecting the Performance of Geologic Repositories: Literature Review*, U. S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-3964, 1989.
27. D. Gillis, Preventing Human Intrusion into High-Level Nuclear Waste Repositories, *Underground Space, 9*, pp. 35-43, 1985.
28. B. M. Crowe, Volcanic Hazard Assessment for Disposal of High-Level Radioactive Waste, in *Studies in Geophysics: Active Tectonics*, National Academy Press, Washington, D.C., pp. 247-260, 1986.
29. J. M. Barnard, Biosphere Model for the Interim Assessment of the Canadian Concept for Nuclear Fuel Waste Disposal, in *High-Level Nuclear Waste Disposal*, H. C. Burkholder (ed.), Battelle Press, Columbus, Ohio, pp. 659-670, 1986.
30. L. W. Barnthouse and G. W. Suter, *User's Manual for Ecological Risk Assessment*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL-6241, 1986.
31. G. W. Suter, L. W. Barnthouse, and R. V. O'Neill, Treatment of Risk in Environmental Impact Assessment, *Environmental Management, 11*, pp. 295-303, 1987.
32. J. K. Lein, An Expert System Approach to Environmental Impact Assessment, *International Journal of Environmental Studies, 33*, pp. 13-27, 1989.
33. L. W. Milbrath, Culture and the Environment in the United States, *Environmental Management, 9*, pp. 161-172, 1985.
34. D. Alexander (ed.), Culture and the Environment, *Environmental Management, 9*, pp. 95-177, 1985.
35. A. Miller, Technological Thinking: Its Impact on Environmental Management, *Environmental Management, 9*, pp. 179-190, 1985.
36. R. DeYoung and S. Kaplan, On Averting the Tragedy of the Commons, *Environmental Management, 12*, pp. 273-283, 1988.

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ATTACHMENT Q

THE YUCCA MOUNTAIN PROJECT AS AN EXAMPLE OF UNREPLICATED ECOLOGICAL EFFECTS STUDIES

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Abstract

Sampling the same ecosystem over time to evaluate the impacts of human disturbance or changes resulting from prescribed management practices commits pseudoreplication. Frequentist analysis of studies lacking true replication is improper, gives rise to uncertainty, and raises questions regarding the precautionary principle. A review of the literature on unreplicated studies and an assessment of postmodern statistical approaches sheds some light on the dilemmas encountered without true replicates and controls. As a solution to such problems, attention is called to the Bayesian statistical approach increasingly being applied to investigations concerning single, large ecosystems. The postmodern development of Bayesian inference compliments the ongoing transition to ecosystem-based approaches to environmental impact assessment and management. Thus, ecosystem management and Bayesian statistics appear to compliment each other with respect to monitoring, understanding, and managing environmental impacts in single, large ecosystems. These issues are illustrated by the Yucca Mountain Project in Nevada where ecological effects studies are underway for developing a nuclear waste repository.

Introduction

In studies concerning either human induced ecological impacts or investigations to understand how natural resources respond to management, investigators traditionally prefer having suitable numbers of replicate treated and control sites. This is a requirement for long-used "optimal impact study design" (Green 1979, Hurlbert 1984, Stewart-Oaten et al. 1986). Without adequate replication, the result is a "suboptimal impact study design" in which natural variation (the stochastic factor) can be confused with human distrubances (Green 1979, Hurlbert 1984, Stewart-Oaten et al. 1992 Underwood 1994). Although the use of frequentist statistics is known to be uncertain and misleading for unreplicated ecological effects studies, alternatives have not been available (Hurlbert 1984, Smith et al. 1993, Stewart-Oaten et al. 1992, Underwood 1994). In this situation, controversies can arise because of questions about uncertainty, Type I and Type II errors, and the precautionary principle (Eberhardt and Thomas 1991, Hilborn and Ludwig 1993, Jassby and Powell 1990, Lemons et al. 1997).

To resolve problems resulting from the lack of replication, ecosystem and watershed levels of assessment and management increasingly are being encouraged and implemented (e.g., Malone 1998, Mongomery et al. 1995, Underwood 1994). This evolution is part of the change in postmodern ecological science and statistical paradigms that researchers such as Maurer (1998) and Underwood (1995) believe are needed for ecosystem management and environmental management.

The need for changes in statistical approaches to suboptimal unreplicated impact studies can be illustrated by examining an ongoing controversial study. At the Yucca Mountain site in southern Nevada, the U.S. Department of Energy (DOE) plans to dispose of the nation's high-level nuclear waste in a geological repository Initially in the Yucca Mountain case, there was only one ecosystem to study and no predisturbance baseline ecological information. This is the worse case for evaluating ecological effects (Green 1979) because it is unknown when, where, and to what extent impacts may have occurred before the study began. Five years after initiating the suboptimal impact studies, the DOE added a single far-field control site. However, neither the new "control" site nor the Yucca Mountain "treated" site were replicated. At both locations sampling over time was performed resulting once more in pseudoreplication but in two sites as opposed to one. Additionally, frequentist inference methods continue to be misapplied. The reproach bears restating simply because many investigators remain unaware of or fail to acknowledge that their field investigations face uncertainties that can affect subsequent decision making. Correctly understanding ecosystem conditions and responses to disturbance is essential to the effectiveness of decisionmaking regarding the postmodern approach to ecosystem management.

Objections to unreplicated studies still are made, but authors such as Hilborn and Ludwid (1993), Shrader-Frechette and McCoy (1994), Stewart-Oaten (1995), and Underwood (1995) realize that better approaches to teaching statistical inference to ecologists is needed because so few of us are more than "cookbook" students who lack sufficient training in probability, the need for replication and controls, and frequentist and Bayesian theorems. The absence of sufficient training in statistical procedures impedes ecologists particularly regarding studies in unreplicated ecosystems (Dennis 1996, Dixon and Ellison 1996, Stewart-Oaten 1995, Underwood 1994).

If ecosystem and watershed level approaches are coupled with suitable inference methods, it appears that many of the uncertainties arising from unreplicated impact study design could be resolved. This proposition is discussed below in the context of the Yucca Mountain ecological impact studies. Actual field

data from the ecological studies are not used because the DOE has chosen not to make such information available before an environmental impact statement for the project is finalized no earlier than 2001.

Pseudoreplication and Suboptimal Impact Study Designs

Environmental impact assessment became popular following passage of the National Environmental Policy Act (NEPA) and has led to wide-spread use of suboptimal impact study designs for interpreting the effects of human-induced disturbances in single ecosystems. Hurlbert (1984) was among the first to call attention to the dilemma of using traditional frequentist analyses for unreplicated ecological studies. His insights led Stewart-Oaten et al. (1986) to recommend a version of the "Before-After-Control-Impact" (BACI) study design using two ecosystems, one disturbed and one undisturbed, to be interpreted by traditional frequentist approaches. Because there was no true replication for either ecosystem, sampling through time before and after one site was perturbed still committed pseudoreplication. Similar difficulties trouble natural resources manager faced with evaluating the response of a single large ecosystem to prescribed management (Walters 1986, Walters and Holling 1990).

It was not long before other investigators (e.g., Eberhardt and Thomas 1991, Jassby and Powell 1990, Reckhow 1990, Walters and Holling 1990) became involved with the issues raised by false replication. As a result, some ecologists concluded that such studies are highly problematic and have no ready solution for coping with stochastic environmental variations (e.g., Dennis 1996, Hilborn and Ludwig 1993, Pitelka and Pitelka 1993, Smith et al. 1993, Stewart-Oaten 1995, Underwood 1994). In other words, if true replication is not possible, it remains erroneous to use classical frequentist statistics to derive conclusions (Stewart-Oaten et al. 1992, Underwood 1994 and 1995).

This explains why some pioneers in postmodern environmental impact assessment and natural resources management (e.g., Canter 1985, Reckhow 1990, Walters 1986, Westman 1985) have not accepted pseudoreplication and traditional frequentist approaches as a solution to interpreting suboptimal impact study designs. Among them are Walters and Holling (1990) and Shrader-Frechette and McCoy (1994) who question whether such problems are irresolvable with respect to classical state-of-the-art statistical analysis. Eberhardt and Thomas (1991) doubt whether such ecological effects studies should even be attempted. Smith et al. (1993) and Underwood (1994), on the other hand, believe that new statistical approaches can yet be developed, and this is where Maurer's (1998) views fit on the challenges presented to the need for new practices and philosophies regarding postmodern ecological

science and statistical paradigms.

As emphasis expands on conserving biodiversity through ecosystem management (Maurer 1998, Underwood 1995, Vogt et al. 1997), investigators must meet the challenges posed by understanding how entire ecosystems and landscapes respond to both natural and human-caused changes. In this regard, Holling and Meffe (1996) recognized the quandry of studying single, large ecosystems and argured for new approaches to understanding natural variation and its influence on discerning and managing ecosystem impacts. Gunderson et al. (1997) and Vogt and collaborators traced the development of the postmodern ecosystem management and natural resources protection and Montgomery (1995) and Montgomery et al. (1995) discuss its implementation in the western U.S. On these and other bases, an argument has been made (Malone 1998a, 1998b, 1998c, 1999) for adopting the ecosystem-based approach at Yucca Mountain that is being implemented in the surrounding region (DOE 1996, USAF 1997, TKC 1996, TNC, 1996).

Wiens and Parker (1995) have shown that where disturbed sites cannot be replicated, consideration of methodological limitations and hidden ecological assumption can be helpful. At issue are concerns regarding sampling for characterizing levels of environmental disturbance. Additional concerns arise from common assumptions that are seldom verified regarding spatial and temporial variation in biotic parameters and their interactions with human-caused disturbances. Wiens and Parker present several suboptimal designs that compensate for pseudoreplication by considering stochastic factors. However, each requires before-and-after comparisons, a condition not met when baseline information is lacking, such as at Yucca Mountain.

An approach to traditional BACI studies where the "Before" condition (pre-disturbance baseline ecological data) is missing was presented by Osenberg et al. (1994). Their "After-Impact" procedure alone assesses ecological effects on post-impact sites in comparison with control sites distant from the disturbed site. Osenberg and colleagues conclude that such study designs can be an effective approach to assessing ecological impacts . However, the authors note that if frequentist analysis is to be used, true replication of both the disturbed condition and the far-field sites is essential. Otherwise, Bayesian inference is needed to distinguish between the effects of the disturbance natural natural variability over time, the ultimate delimma with pseudoreplication.

Thus, the solution to unreplication ecosystem impact studies well may rest with the premise of Walters (1984) and Walters and Holling (1990) involving more wide-spread use of Bayesian analysis to understand natural variation. A fresh look is being taken at Bayesian inference for interpreting trends over time in

single, non-replicated ecosystems (e.g., see Dixon and Ellison 1996 and other authors in a Special Section of Ecological Applications 6: 1034-1103, 1996). In a study of ecological effects in a single, unreplicated ecosystem, Crome et al. (1996) analyzed the same body of data both by the suboptimal experimental design/frequentist method and the Bayesian approach. The comparison demonstrated that traditional statistical methods are illogical and that Bayesian methods are strong and correct.

The goal is to develop a study design to replace classical frequentist statistics in unreplicated ecosystem-level studies. Presently, Bayesian approaches often are not used because many ecologists fail to understand the significant differences between them and traditional frequentists analysis where subjectivity is hidden. Bayesianists, on the other hand, know that in unique, one-of-a-kind ecosystems subjectivity is handled openly and transparently (Crome et al. 1996). The rapidly developing Bayesian approach is a general one adaptable as an integrated package for site-specific situations of ecological impact assessment. For non-replicated studies, Bayesian statistical inference provides an attractive alternative to frequentist inference because the latter rests on too many assumption that often cannot be satisfied (Eberhardt and Thomas 1991, Reckow 1990, Smith et al. 1993, Underwood 1994, Wiens and Parker 1995).

Ecological Effects Studies at Yucca Mountain

In 1979, the DOE began investigating Yucca Mountain in southern Nevada for the site's environmental suitability as a deep repository for disposing of the nation's high-level nuclear waste. Disturbance of 480 ha of habitat in the 190 km^2 site has resulted from construction of roads, drillpads, pads for tunneling, trenches, pipelines, and powerlines through 1997. Seventy-nine percent, or 370 ha, of the habitat ultimately lost had been destroyed prior to initiation of environmental impact studies in 1989. Since then, habitat on another 110 ha of land has been destroyed (Wade 1996). To assess ecological impacts, 24 pairs of 4 ha plots were established at the Yucca Mountain site in 1998 (Green et al. 1991). One of each pair of the ecological study plots was established adjacent to a disturbed area with the second plot sited 200-300 m from the disturbed area. It was subjectively assumed that the distant plot was not influenced by ecological disturbance (habitat destroyed by construction activities) and that if plots nearer to a disturbance were similar to the one 200-300 m distant, no impact has resulted from habitat destruction.

Using paired plots constitutes a "split-plot" study design (Steel and Torrie 1980). The DOE had assumed that the Yucca Mountain ecological effects study design was an acceptable variation of Green's (1979) "optimal impact study design,"

despite committing pseudoreplication, missing pre-disturbance ecological baseline data, and interpreted with classical analysis of variance, multiple regression, and correlation analysis (Green et al. 1991, Sokal and Rolf 1981, Stewart-Oaten et al. 1986). As discussed in the previous section, pseudoreplication is incompatible with frequentist analysis because there is no way to account for stochastic, natural variation, especially of the magnitude that occurs in arid mountains.

Yucca Mountain can experience a hundred-fold change in productivity from year to year due to pronounced variation in climate, elevation, topography, and substrate conditions (EGG 1991, Malone 1991). Where the range of natural variability is this large, Type II errors, i.e., not detecting impacts when in fact they exist, especially are difficult to elude (Osenberg et al. 1994, Underwood 1994, Wiens and Parker 1995). For this and other reasons, the strategy for the DOE's study was weak (Table 1) in that (1) during the first five years the treated and untreated plots were collocated, (2) effects that might have occurred before 1989 were disregarded, and (3) frequentist analyses was applied to data obtained through pseudoreplication.

Table 1. Weaknesses in the environmental study design and the statistical approach to the Yucca Mountain ecological impact investigations.

- Absence of true spatial replication commits pseudoreplication by using time-series samples as replicates.
- Treatment and control plots collocated during 1989-1994 and not demonstrated to be independent of habitat disturbances on the site.
- Absence of predisturbance ecological baseline information before commencing the investigation after 10 years of habitat destruction.
- Misapplies standard frequentist statistical analysis to non-replicated data.
- Degree of variability not quantitatively demonstrated between Yucca Mountain site and the far-field control site adopted in 1995.
- No spatial replication for the single disturbed (Yucca Mountain) site and the single far-field control site adopted in 1995.

- Time-series sampling in the disturbed (Yucca Mountain) site and the far-field control commits pseudoreplication.

- Use of the 1989-1994 information from the previously disturbed Yucca Mountain site as an unverified ecological baseline for comparing to the far-field control site.

After the initial five years, an effort was made to compensate for the absence of baseline data. Thus, in 1995, the DOE altered the initial study design by reducing the number of ecological study plots at the Yucca Mountain site from 48 to 12 and adding six plots to a single far-field control site located 22 km from Yucca Mountain. The plan now is to use the results obtained 1989 through 1994 as a baseline for discerning effects caused by the post-1994 site characterization activities (DOE 1996, TRW 1996, Wade 1996). The "baseline" information subsequently will be compared to the 12 plots remaining at Yucca Mountain and the six new plots in the far-field ecosystem.

The changes made by the DOE in the Yucca Mountain ecological study design result from the lack of baseline information prior to initiation of the impact study in 1989. Originally, 24 paired plots were sampled at Yucca Mountain from 1989 through 1994. In 1995, the study design was altered when sampling was discontinued in all but 12 of the initial 48 plots. At the same time, six new plots were established at the far-field location. Due to the initial absence of baseline information, the DOE has elected to use data from the 1989-1994 studies at Yucca Mountain as the baseline for comparing results of the revised study design. This strategy assumes that the habitat destruction at Yucca Mountain prior to 1989 (79% of the total during 1979-1997) had no effect on the 12 study plots retained at the site since the end of 1994. Thus, if an effect is subsequently detected, it will be supposed to have resulted from the the 21% of the site disturbance that has occurred since 1994.

There is no assurance that the 12 remaining plots at Yucca Mountain are a sufficient number to characterize the stochastic factor. The same is true for the six study plots established at the new control site. In redesigning the experiment, the DOE should have measured the variability in the disturbed site and the control site and asked how many replicates of each are needed in view of the observed variability among them (Table 2). The DOE apparently has no evidence to answer the question of whether or not the two different sites are sufficiently similar for one to be used for the disturbed situation and the other as a comparable control (DOE 1996, TRW 1996, Wade 1996). Demonstrating the alikeness of ecosystems visually judged similar always is open to doubt because separate ecosystems can always be shown to

be different if adequately sampled (Eberhardt and Thomas 1991, Smith et al. 1993, Stewart-Oaten et al. 1992).

Table 2. Statistical weaknesses in the two phases of the Yucca Mountain ecological effects studies.

PHASE ONE (1989-1994)

- Absence of spatial replication.
- Commits pseudoreplication by using repeated sampling as replication.
- Treatment and control plots collocated and not shown to be independent.

PHASE TWO (1995-1998)

- Similarity between treatment and control site not tested.
- Treatment and control site unreplicated.
- Commits pseudoreplication by using repeated sampling as replication.
- Absence of predisturbance ecological baseline information.
- Misapplied frequentist analysis to non-replicated data.

An ecological impact study design, such as that being pursued now for the Yucca Mountain Project, involving two independent sites where one is disturbed and the second one is not indeed is a credible version of the BACI model (Wiens and Parker 1995, Osenberg et al. 1994). However, treating time-series samples from each location as independent replicates by applying standard frequentist statistics remains erroneous (Smith et al. 1993, Stewart-Oaten et al. 1992, Underwood 1994). Thus, the DOE has returned full circle to the dilemma posed by lacking true replication. All that has been accomplished is having located an independent, undisturbed site to use as a lone control. Also problematic now is the adequacy of the new concept for obtaining baseline information. Interpreting such results correctly would require using Bayesian methods such as those discussed by Reckhow (1990) and Ellison (1996).

Conclusions

In the past, dilemmas of the Yucca Mountain sort arose because adequate analytical approaches did not exist for interpreting unreplicated ecosystem investigations. Traditional statistical approaches lack empiricism and are fraught with subjective judgement, particularly where there is an absence of baseline ecological information. Consequently, some researchers have suggested abandoning hypothesis testing in such cases and resorting to purely descriptive studies and subjective judgement. However, this action is too drastic in view of the recent advances being made in analyzing and interpreting unreplicated field studies. Some promising methods attemp to cope with single-ecosystem studies by identifying and substantiating inherent ecological assumptions associated with spatial and temporal variation. Other methods use after-only studies in comparison with far-field controls with but depend on adequate replication for determining the stochastic factor. The most promising solutions to the problems of pseudoreplication seem to rest with empirical Bayes methods and hierarchical models that are rapidly being developed.

In some respects, the challenges presented by postmodern ideas regarding biodiversity conservation through ecosystem management appear to be ahead of the capacity of ecological science to support. New approaches to old problems of natural complexity and uncertainty are needed more than ever for the new paradigm of managing natural resources. The ideal of sustaining both ecosystems and the human economies linked to them places a burden of precaution on decisions regarding ecosystems and landscapes. Past emphasis in ecology has been placed on traditional study designs, methods of data collection, and analysis of the results. Now, increased attention is needed regarding decisionmaking in the context of ecosystem management.

These problematic issues apply in the case of the Yucca Mountain ecological impact studies. However, time remains for the DOE to explore alternative approaches such as Bayesian inference to improve the validity of its environmental impact assessment. Clearly, nothing stands to be lost by the DOE from attempting to validate information from what otherwise may prove to be unproductive ecological data. Without doing so, interpreting the ecological effects investigations now underway will remain at risk with regards to complying with the National Environmental Policy Act for developing a nuclear waste repository in southern Nevada.

References

Canter, L.W. 1985. Impact prediction auditing. The Environmental Professional 7(3): 255-264.

Crome, F.H.J., M.R. Thomas, and L.A. Moore. 1966. A novel Bayesian approach to assessing impacts of rain forest logging. Ecological Applications 6(4): 1104-1123.

Dennis, B. 1996. Discussion: should ecologists become Bayesians? Ecological Applications 6(4): 1095-1103.

Dixon, P. and A.M. Ellison. 1996. Introduction: ecological applications of Bayesian inference. Ecological Applications 6(4): 1034-1035.

DOE (U.S. Department of Energy). 1995. Site environmental report for calendar year 1994. June. DOE, Las Vegas, NV.

DOE (U.S. Department of Energy) 1996a. Framework for the resource management plan. Volume 2 of Final environmental impact statement for the Nevada Test Site. DOE/EIS 0243. DOE, Las Vegas, NV.

EGG (EG&G Energy Measurements). 1991. Yucca Mountain biological resources monitoring program: annual report FY89 & FY90. EGG 10617-2084. January. EGG, Goleta, CA.

Eberhardt, L.L. and J.M. Thomas. 1991. Designing environmental field studies. Ecological Monographs 61(1): 53-73.

Green, R.H. 1979. Sampling Design and Statistical Methods for Environmental Biologists. John Wiley & Sons, New York, NY.

Green, R.A., M.K. Cox, T. Doerr, T.P. O'Farrell, W.K. Ostler, K. Rauthestrauch, and C. Willis. 1991. Assessing impacts on biological resources from site characterization activities of the Yucca Mountain Project. pp. 1456-1460, in High-Level Radioactive Waste Management. American Nuclear Society, La Grange Park, IL.

Gunderson, L.H., C.S. Holling, and S.S. Light (eds.) 1997. Barriers & Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York, NY.

Holling, C.S. and G.K. Meffe. 1996. Command and control and the pathology of natural resources management. Conservation Biology 10(2): 328-337.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54(2): 187-211.

Jassby, A.D. and T.M. Powell. 1990. Detecting changes in ecological time series. Ecology 71(6): 2044-2052.

Lemons, J., K. Shrader-Frechette, and C. Cranor. 1997. The precautionary principle: scientific uncertainty and Type I and Type II effors. Foundations of Science 2: 207-236.

Malone, C.R. 1991. The potential for ecological restoration at Yucca Mountain, Nevada. The Environmental Professional 13(3): 216-224.

Malone, C.R. 1995. Ecology, ethics, and professional environmental practice: the Yucca Mountain Project as a case study. The Environmental Professional 17(3): 271-284.

Malone, C.R. 1998a. The federal ecosystem management initiative in the United States. In, J. Lemons, L. Westra, and R. Goodlane (eds.) Ecological Sustainability and Integrity: Concepts and Approaches. Kluwer Academic Publishers, Boston, MA.

Malone, C.R. 1998b. Implications of resources management at the Nevada Test Site. Federal Facilities Environmental Journal 9(1): 51-62.

Malone, C.R. 1998c. The Southern Nevada Initiative: A case of federal ecosystem management in the U.S. Environments 26(2): 1-15.

Malone, C.R. 1999. Integrated weapons-site cleanup. Forum for Applied Research and Public Policy 14(2): in press.

Maurer, B.A. 1998. Ecological science and statistical paradigms: at the threshold. Science 279(5350): 502-503.

McBride, G.B., J.C. Lostis, and N.C. Adkins. 1993. What do significance tests really tell us about the environment? Environmental Management 17(4): 423-432.

Montgomery, D.R. 1995. Input- and output-oriented approaches to implementing ecosystem management. Environmental Management 19(2): 183-188.

Montgomery, D.R., G.E. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31(3): 369-386.

NWTRB (Nuclear Waste Technical Review Board). 1995. Report to the U.S. Congress and the Secretary of Energy: January to December 1993. NWTRB, Arlington, VA.

NWTRB (Nuclear Waste Technical Review Board). 1996. Report to the U.S. Congress and the Secretary of Energy: 1995 Findings and

Recommendations. NWTRB, Arlington, VA.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K. Abu-Saba, and A.R. Flegal. 1994. Detection of environmental impacts: variability, effect size, and power analysis. Ecological Applications 4(1): 16-30.

Pitelka, L.F. and F.A. Pitelka. 1993. Environmental decision making: multidimentional dilemmas. Ecological Applications 3(4): 566-568.

Reckhow, K.H. 1990. Bayesian inference in non-replicated ecological studies. Ecology 71(6): 2053-2059.

Shrader-Frechette, C. and E.D. McCoy. 1994. Ecology and environmental problem solving. The Environmental Professional 16(4): 342-348.

Smith, E.P., D.R. Orvos, and J. Cairns, Jr. 1993. Impact assessment using the Before-After-Control-Impact (BACI) model: concerns and comments. Canadian Journal of Fisheries and Aquaitic Sciences 50: 627-637.

Sokal, R.R. and F.J. Rolf. 1981. Biometry: The Principles and Practice of Statistics in Biological Research. W.H. Freeman and Co., New York, NY.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. Second edition. McGraw-Hill, New York, NY.

Stewart-Oaten, A. 1995. Rules and judgement in statistics: three examples. Ecology 76(6): 2001-2009.

Stewart-Oaten, A., W.M. Murdoch, and K.R. Parker. 1986. Environmental impact assessment: "pseudoreplication" in time? Ecology 67(4): 929-940.

Stewart-Oaten, A., J.R. Bence, and C.W. Osenberg. 1992. Assessing effects of unreplicated pertubations: no simple solutions. Ecology 73(4): 1396-1404.

TKC (The Keystone Center). 1996. Dialogue on a DoD biodiversity management strategy. Final Report, January 23. TKC, Keystone, CO.

TNC (The Nature Conservancy). 1996. Conserving biodiversity on military lands. TNC, Arlington, VA.

TRW (TRW Environmental Safety Systems, Inc.) 1996. The vegetation of Yucca Mountain: description and ecology. BOOOOOOOO-01717-5705-00030 REV 00. March 29. DOE, Las Vegas, NV.

Underwood, A.J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4(1): 3-15.

Underwood, A.J. 1995. Ecological research and (and research into) environmental management. Ecological Applications 5(1): 232-247.

USAF (U.S. Air Force). 1997. Integrated natural resources management plan: Nellis Air Force Base/Nellis Air Force Range. March 1997 Draft. Nellis Air Force Base, NV.

Vogt, K.A. and collaborators. 1997. Ecosystems: Balancing Science with Management. Springer-Verlag New York, Inc., New York, NY.

Wade, S.A. 1996. Yucca Mountain site characterization project environmental protection process. November 6. Presentation by the Yucca Mountain Project Office to the Mojave-Southern Great Basin Resource Advisory Council, Las Vegas, NV.

Walters, C.J. 1986. Adaptive Management of Renewable Resources. McMillian Publ. Co., New York, NY.

Walters, C.J. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71(6): 2060-2068.

Westman, W.E. 1985. Ecology, Impact Assessment, and Environmental Planning. John Wiley & Sons, Inc., New York, NY.

ATTACHMENT R

Appendix A

BASE CASE SCENARIO - HIGH LEVEL TRANSPORTATION

Emergency Response Vans

The number of emergency response vans may be affected by the routes chosen. It therefore would be premature to specify how many and at what intervals the response vans should be placed. Ideally, they should be located so as to have a maximum response time of one hour. The alternative to this would be to assign one response van to each Port of Entry.

Based upon a minimum of two (2) Port of entries design for inspection of nuclear shipments, two (2) emergency response vans with crews, would be required. An additional nine (9) emergency response personnel would be required to staff the Port of Entry and still maintain sufficient personnel for routine inspection should the response van be called out. The cost projection for an equipped emergency van was estimated to be $350,000. The cost for two (2) (one for each Port of Entry) would be approximately $700,000. Again, the two Ports of Entries would be a minimum. Replacement vehicles would be based upon State requirements of mileage.

Response to area's on railroad routes would require specialized equipment such as military type (Hummer, etc.) Vehicle or helicopter. Costs of these are not reported here within as this would most probably be the responsibility of another agency other than the highway patrol.

Safe Escorts

Safe escorts should be required should high-level shipments commence through Nevada. A minimum of 2 two-man units would be required per shipment. During the first year it is estimated that there will be seven (7) legal weight shipments per day. This would require 8, two-man teams to escort two shipments per day under ideal conditions. This equates to the following costs using new positions rather than existing positions.

Personnel Initial Cost

32 Troopers

Hire, Train, Equipment =	$ 94,000
Escort Vehicle - Commercial type =	$ 32,400
Total	$ 126,400
	x 32 troopers
	$4,044,800 Initial

Personnel Annual Costs

32 Troopers	$1,429,600
Benefits	$ 590,304
Total	$2,019,904

Training

Until such time that specific needs for training are determined which can not be done until routes and the commitment level is established, only a rough projection can be given regarding needed training.

Based upon a 40 hour course conducted in conjunction with the Fire Marshall' Office and given at the P.O.S.T. academy as a money-saving factor, the following is projected. The dorm at P.O.S.T. is reserved to house 22 NHP personnel. The need to train 274 troopers which do not line in Carson City (location of the dorm) would be required. With an estimated $2,000 per week overhead cost. Approximately 25 to 28 weeks of overhead would be required. Supervisors from the rank of Sergeant and above (approximately 64) would need an additional week of command/advanced training. As taken from the 1988 report from Dr. Mushkatel of State Costs, training would need to include Port of Entry and Escort Troopers 60 to 120 troopers).

The training for all troopers, the necessary Supervisors, Port of Entry personnel and Escort personnel would require the total P.O.S.T. overhead to fall between 25 weeks minimum to an approximate maximum of 28 weeks. The monetary amounts for overhead would be a minimum of $45,000.00 with an estimated maximum of $60,000. State per diem should be added to the above figure based upon $26.00 per day. Per diem costs figure to be at a low of $35,070.00 and an approximate high of $41,370.00. Per diem for supervisors is estimated at $4,550.00 bringing the totals to a low of $39,620.00 and a high of $45,920.00.

Loss of time from regular duties due to training requirements should be accounted for as follows:

						Training		Training Time
3 -	Majors -	$7,734.58 x 3=	$23,203.75	per month	or	11,601.88	/	80 hrs
5-	Captains-	$7,085.83 x 5=	$35,429.17	per month	or	17,714.58	/	80 hrs
15-	Lieutenants-	$6,498.92 x 15 =	$97,483.75	per month	or	48,741.88	/	80 hrs
44-	Sergeants-	$5,717.83 x 44 =	$251,584.67	per month	or	125,792.33	/	80 hrs
207-	Troopers	$5,260.17 x 207=	$1,496,555.83	per month	or	5,986,223.32	/	40 hrs

Estimates for port of Entry personnel and Escort personnel would range from a minimum of $468,646 to an estimate high of $973,292.

For ease of figuring, reimbursement for loss of regular duties, due to required training, would for one month's time be at a minimum of $3,158,674.00 and estimated maximum of $3,695,649.00.

ATTACHMENT A

Projected Construction Costs for Ports of Entry

To assist with determining construction costs with establishing a "Port of Entry", contact was made with Russ Hall of the Nevada Department of Transportation and David K. Nakao, P.E. of the State of California's Department of Transportation, Office of Permits and Truck Studies.

The state of California has currently developed a plan for the construction of a 4 bay facility on I-15 near the Nevada/California border with construction beginning in the year 2001.

Site location is important with respect to construction costs. Generally, straight and flat terrain is the most economical. Consideration is given to the terrain as approximately 75% of construction costs are attributed to paving and lighting. Approximately 1 mile of deceleration and acceleration lanes are required to enter and leave the site. Nevada, with raised speed limits, may be required to lengthen the deceleration/acceleration lanes.

The following information is supplied by California for construction costs of actual and projected sites:

1-15 @ Mountain Pass = $17,880,000
I-40 near Needles = 19,200,000
I-5 So. Of Redding = $12,840,000

Construction costs per monitoring station based upon the State of California's average cost for constructing Port of Entry's would be $16,560,000.00. The cost for two would be $33,120,000.00. This estimate is based upon providing:

Signs, lighted at night, on the roadway directing all trucks transporting high-level radioactive waste to exit.

Paved heavy-duty freeway two-lane ramps leading into and out of the weight-in-motion scales.

Computer-assisted weigh scales that allow individual axle weights and gross vehicle weights to be recorded and the vehicle to be classified while the truck continues to move.

Over-dimensional detectors.

A building that includes office space, reception area, restrooms, showers, locker room, Hazardous Material locker room for self-contained Haz Mat examining protective suits, break room, computer and electronic reader area,

A signal system that, when necessary, directs the trucks and drivers to an inspection area or into the facility.

An all weather vehicle inspection facility complete with high intensity lights, automatic bay doors, fire suppression equipment, Haz Mat detection and monitoring equipment, generator.

A high-level radioactive materials containment area for leaking of ruptured containers and a decontamination area for personnel.

A paved parking and vehicle impoundment area, equipped to transfer data to NHP stations, other state, local and federal law enforcement and public safety agencies and other haz mat responder teams.

Each monitoring station would be operated 24 hours a day, 7 days a week. This would require 15 commercial troopers, one sergeant and one lieutenant.

PERSONNEL ANNUAL COSTS:

60 Troopers	$2,680,500
Benefits	$1,106,820
4 Sergeants	$ 195,484

Benefits	$ 78,972
4 Lieutenants	$ 224,120
Benefits	$ 87,828
12 Clerical	$ 351,300
Benefits	$ 8,495
2 Dispatchers	$ 75,420
Benefits	$ 18,452
TOTAL PERSONNEL EXPENSES	$4,827,391
Overtime would be estimated at 5% of total personnel costs,	$ 241,370
TOTAL PERSONNEL COSTS INCLUDING OVERTIME	$5,068,761

OPERATING COSTS: ANNUAL

Vehicle operating costs 68 vehicles	$ 121,176
Utilities	$ 144,000
Supplies	$ 192,000
Maintenance	$ 96,000
Contracts	$ 72,000
Personnel driven operating costs	$ 675,451
TOTAL OPERATING COSTS	$1,300,627

EQUIPMENT:

Furniture	$ 240,000
High-level radioactive monitoring equipment and personal protective attire	$ 600,000
68 vehicles	$1,713.600
Computers	$ 166,900
68 new positions, equipment	$1,070,214

TOTAL EQUIPMENT COSTS $3,790,714

Sworn officers assigned this duty will, over and above the normal training cost, receive specialized training in the detection and containment of Radioactive Waste.

TRAINING:

68 sworn $2,093,203

Specialized training ..... $ 300,000

TOTAL TRAINING COSTS $2,393,203

TOTAL MONITORING STATION COSTS FIRST YEAR $43,280,120

SECOND YEAR COSTS would not include construction costs or new equipment costs or initial training costs associated with academy training and Radioactive specialized training.

TOTAL SECOND YEAR COSTS ..... $ 6,369,387

RAILROAD INSPECTION OF THE TRANSPORTATION OF HIGH-LEVEL RADIOACTIVE WASTE

These inspections of high-level radioactive waste transported via railway could be conducted by monitoring station personnel. Specialized training would be provided by the Federal Railroad Administration. Inspection areas are restricted to the following:

Tracks
Haz Mat
MP & E Inspector
Operating Procedures
Signal and train control

This Division has no information to base a cost statement.

To monitor the transportation of high-level radioactive waste, it would be recommended that as permit restriction, the commercial carriers of this cargo be required to have a Global Positioning System transmitter on the vehicle. This would allow for the continuous monitoring of the vehicle as it travels to it destination. Included here are the costs to the state of this program. For detailed information on equipment and quantity, see the attached memorandum, subject GPS.

TOTAL COST OF THE GPS MONITORING SYSTEM ..... $ 195,984

FIRST YEAR COSTS $66,683,826

SECOND YEAR COSTS ..... $ 7,024,188

Question: Could less expensive mobile units be constructed for Ports of Entry?

We currently deploy mobile inspection stations statewide on a random basis for the purposes of conducting safety inspections and weighing activities. These are designed for short term use for the following reasons:

1. Inadequate lighting at the facilities, as well as around the inspection station.
2. There are no facilities or running water at these sites.
3. There is no emergency decontamination facilities to handle exposure to hazardous materials.
4. There is no shelter to conduct inspection activities during inclement weather.
5. The inbound and outbound access ramps are not designed for continuous operation.
6. The current sites are not large enough to handle high volume traffic 24 hours per day, 7 days per week
7. The current sites are not large enough to place more than two or three vehicles out of service at any given time.
8. There are no buildings to operations. We currently use a converted recreational vehicle that could not handle the rigors of continuous 24-hour use and cannot hold more that about five (5) people.

ATTACHMENT S

Appendix B

The following chart was published in the newsletter NHTSA, published by the U.S. Department of Transportation, National Highway Traffic Safety Administration. (DOT808 952)

Involvement in Fatal and Injury Crashes and involvement rates for large trucks, 1998-1998

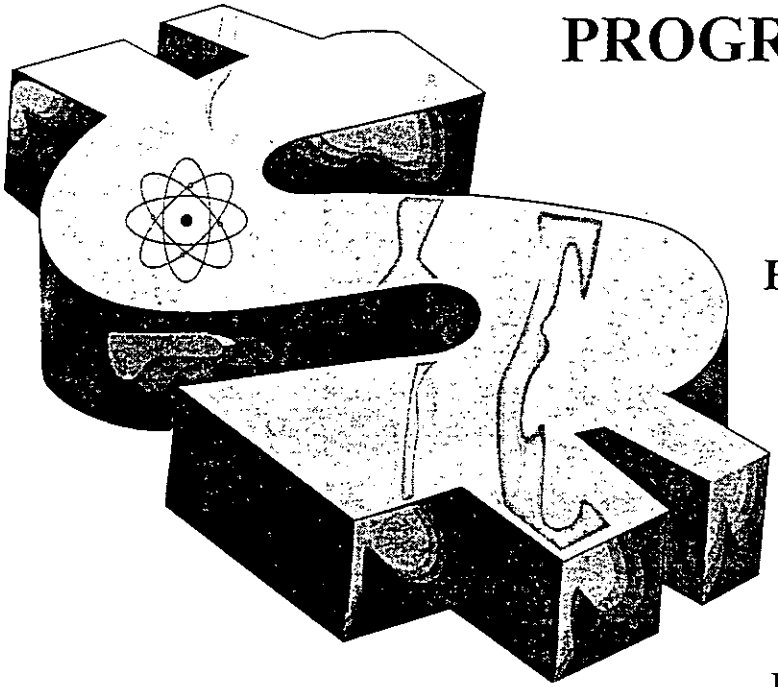
Year	Number of large trucks involved in fatal crashes	Number of large trucks registered	Vehicle involvement rate*	Vehicle miles traveled (millions)	Vehicle involvement rate **
1988	5,241	6,136,884	85.4	137,985	3.8
1989	4,984	6,226,482	80.0	142,749	3.5
1990	4,776	6,195,876	77.1	146,242	3.3
1991	4,347	6,172,146	70.4	149,543	2.9
1992	4,035	6,045,205	66.7	153,384	2.6
1993	4,328	6,088,155	71.1	159,888	2.7
1994	4,644	6,587,885	70.5	170,216	2.7
1995	4,472	6,719,421	66.6	178,156	2.5
1996	4,755	7,012,615	67.8	182,971	2.6
1997	4,917	7,083,326	69.4	191,345	2.6
1998	4,935	----------	----------	----------	----------
Year	Number of large trucks involved in injury crashes	Number of large trucks registered	Vehicle involvement Rate*	Vehicle miles traveled (millions)	Vehicle involvement rate**
1988	96,000	6,136,884	1,562	137,985	69
1989	110,000	6,226,482	1,770	142,749	77
1990	107,000	6,195,876	1,730	146,242	73
1991	78,000	6,172,146	1,264	149,543	52
1992	95,000	6,045,205	1,567	153,384	62
1993	97,000	6,088,155	1,585	159,888	60
1994	96,000	6,587,885	1,452	170,216	56
1995	84,000	6,719,421	1,244	178,156	47
1996	94,000	7,012,615	1,339	182,971	51
1997	96,000	7,083,326	1,349	191,345	50
1998	89,000	----------	----------	----------	----------

* Rate per 100,000 registered vehicles.
** Rate per 100 million vehicles miles traveled.
---------- = not available
Source: Vehicle miles traveled and registered vehicles - Federal Highway Administration.

ATTACHMENT T

EIS001887

AN INDEPENDENT COST ASSESSMENT OF THE NATION'S HIGH-LEVEL NUCLEAR WASTE PROGRAM



February
1998

By

PLANNING INFORMATION CORPORATION
THOMPSON PROFESSIONAL GROUP
DECISION RESEARCH INSTITUTE

Review of Findings By
KPMG Peat Marwick

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Preface

In 1996, the U.S. Department of Energy (DOE) announced plans to prepare, by late 1998, a "Viability Assessment" as a tool for managing and making decision about the federal high-level radioactive waste program, in particular the proposed Yucca Mountain nuclear waste repository. One component of the Viability Assessment was to be an assessment of the total cost of the federal program, something that has been and continues to be plagued by great uncertainty due to the changing and evolving nature of the program since 1983.

In order to effectively evaluate the accuracy and appropriateness of the Viability Assessment's findings, the State of Nevada commissioned an independent study of likely costs associated with accepting spent fuel and high-level radioactive wastes at generator sites, transporting the material to Nevada, and ultimately disposing of it in a repository. The report which follows grew out of this effort. However, as the project progressed, it became apparent that the data and findings have applicability and importance far beyond the narrow confines of DOE's Viability Assessment.

To undertake this project, it was necessary to make determinations about what the reference waste management system would consist of and how it will operate. Toward that end, the waste management system prescribed in pending congressional legislation was used as the report's guiding framework. Consequently, the assumptions in this independent cost assessment report reflect the legislation's provisions regarding schedules and time frames, DOE responsibility for at-reactor storage pending shipment, waste acceptance activities, transportation planning and emergency preparedness, shipping assumptions and intermodal transportation, centralized interim storage, repository disposal, and other related aspects of the system.

To assure that the report's contents and finds would be as accurate and objective as possible, a team of independent consultants was employed to gather information, analyze the data, and develop the ultimate cost conclusions. The accounting firm of KPMG Peat Marwick was commissioned to provide expert peer review for the effort.

The result of this extraordinary independent undertaking is a comprehensive and timely evaluation of the real costs to the nation of the federal high-level nuclear waste program - not just the Yucca Mountain repository component - and the potential taxpayer liability the country will incur as that program moves forward.

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April 23, 1998

Mr. Robert R. Loux
Executive Director
Nevada Agency for Nuclear Projects
1802 N. Carson Street, Suite 252
Carson City, Nevada 89701

Re: Peer Review of "An Independent Cost Assessment of the Nation's High-Level Nuclear Waste Program", February 1998

Dear Mr. Loux:

Pursuant to your request, KPMG Peat Marwick LLP ("KPMG") has completed its review of "An Independent Cost Assessment of the Nation's High Level Nuclear Waste Program", February 1998 ("Study"), prepared by Planning Information Corporation, Thompson Professional Group and Decision Research Institute, and hereby submits this summary letter describing work performed and conclusions reached.

KPMG was retained to provide the agreed upon procedures of "Peer Review" of the Study, pursuant to the engagement letter dated June 4, 1997. Of the limited tasks set forth below, the calculations tested were found to be accurate, the Study's assumptions appear to be supportable, and KPMG's peer review is complete.

The agreed upon procedures which constitute the peer review include the following:

a. Review the reasonableness of Study assumptions
b. Review the cost categories and cost components for completeness
c. Review the supporting documentation
d. Test selected mathematical calculations for accuracy
e. Review the Study for internal consistency
f. Review the Study for overall consistency

KPMG Peat Marwick LLP

To complete the above described agreed upon procedures, KPMG performed certain tasks including the following:

1. Detailed review of Study
2. Site visits and interviews with authors of various Study components including: Planning Information Corporation, Thompson Professional Group and Decision Research Institute
3. Verify calculations/assumptions in narrative and charts to underlying data
4. Verify assumptions/citations in narrative to source documents (i.e. DOE Reports)
5. Review literature and supporting materials outside the body of the Study

The procedures performed do not constitute an audit, examination or review in accordance with standards established by the American Institute of Certified Public Accountants and therefore, we do not make any representations regarding the sufficiency of the procedures performed for your informational needs. The term "review" has a defined meaning in U.S. accounting and auditing literature; however, the term "review" as used in this letter is intended to refer to obtaining and analyzing information, and does not encompass the term or scope of engagement defined in the accounting and auditing literature.

Should you have any questions or comments regarding KPMG's completion of these services, please call me at (213) 955-8994.

Sincerely,

KPMG Peat Marwick LLP

Joseph S. D'Antoni
Principal

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1. EXECUTIVE SUMMARY

This report presents the findings of a new, comprehensive and independent assessment of the Total System Life Cycle Costs (TSLCC) for the nation's high-level nuclear waste (HLNW) program and the proposed repository at Yucca Mountain, Nevada. This study finds that the costs will be $53.9 billion in constant 1996 dollars.

The study bases its cost evaluation on current plans by the U.S. Department of Energy, recent federal court decisions, and pending federal legislation that has the support of a majority of members in Congress. The costs include expenditures to date and estimated costs for the study, licensing, development, and operations necessary to implement the federal program.

The HLNW is produced or stored at 80 locations including commercial nuclear power stations, nuclear weapons facilities and temporary storage sites. Moving these wastes to Yucca Mountain requires an unprecedented national waste transportation program. Since the majority of the HLNW is produced or stored east of the Mississippi River, rail and highway transportation will affect residents in 43 states and more than 500 communities. This report fully takes account of the national scope of the federal government's HLNW program.

The assessment for future activities, events, and behaviors depends upon the quality of the data and the assumptions made about future conditions. This 1998 Independent Report provides details of how this new study was conducted, including the important assumptions, data sources, calculations, and considerations that have significant effects on the total cost estimate. The total cost reported here is a conservative estimate that includes a contingency margin for ordinary complications but *does not include* estimates for uncertainties that could add significant additional costs to this first-of-a-kind, century-long, and historically-troubled effort. These uncertainties—which range from the cost of extended at-reactor storage, to accidents in cross-country transportation, to the technologies of emplacement, retrieval or closure—are summarized in Table 2 and described in the body of this report.

The goal of the HLNW program is to permanently dispose of these wastes in a facility that provides geological safety for humans and the environment as long as necessary, a period of 10,000 years or more. Faced with these requirements, no country in the world has developed a HLNW disposal facility. The stringent technical requirements, the lack of any precedent in scientific, engineering, and management experience, and the need to obtain public support make any program very costly. From the very beginning of the current program during the Carter administration, up to the present day, concerns about costs have been expressed in Congress, by the nuclear power industry, and by officials of the Reagan, Bush, and Clinton administrations. In authorizing the program, Congress reserved to itself the right to annually appropriate funds for the program and it imposed requirements on the program administrators to estimate costs and revenues.

Background to a Total System Life Cycle Cost Estimate

The Nuclear Waste Policy Act (NWPA) requires the U.S. Department of Energy (DOE) to "estimate, on an annual basis, . . . the costs required to construct and operate the repositories to be needed . . . and to carry out any other activities under this Act" (Section 310 (a) (10)) and to "evaluate whether collection of the fee [authorized in the Act] will provide sufficient revenues to offset the costs . . ." (Section 302 (a) (4). The requirements are generally referred to as the analysis of "total system life cycle costs" (TSLCC) and the Fee Adequacy Assessment. During the 15 years that the Nuclear Waste Policy Act has been in effect, DOE has prepared three reports to meet these requirements. The 1986 report estimated TSLCC for a program using a single repository in tuff (at Yucca Mountain) at $30.0 billion; the 1990 estimate was $33.5 billion; and the 1995 estimate was $34.0 billion (in constant 1996 dollars).*

Focus on Yucca Mountain

In the Nuclear Waste Policy Act of 1982, Congress outlined a program for studying three sites simultaneously as potential locations for the nation's first HLNW repository and then developing a second repository. This would have allowed the government to choose the best of the three sites for the first repository and to achieve geographical equity by eventually developing both a western and an eastern site. Both these goals were abandoned as program requirements when the Nuclear Waste Policy Act Amendments of 1987 directed the DOE to study only the potential repository site at Yucca Mountain, Nevada. The amendments also prohibited location of an interim storage facility in Nevada. This shift in policy responded to widespread public opposition to the original program and saved the costs of site characterization studies at Hanford, Washington and Deaf Smith County, Texas. DOE estimated the savings at $7.4 billion (in constant 1996 dollars).

Progress at Yucca Mountain has been slow and difficult. Meeting U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency licensing and permitting requirements even within time lines that were extended several times appeared impossible. Therefore, DOE suggested, and Congress authorized, a preliminary judgment about the suitability of this site in the form of a "viability assessment," which is due for release by the end of September, 1998. It now appears that this viability assessment will not include a TSLCC estimate. A presentation of the viability assessment cost estimate made to the 94th meeting of the Advisory Committee on Nuclear Waste on September 25, 1997 stated that this estimate will address only the "mined geologic disposal system" and will exclude "historical costs, licensing, waste acceptance, storage, national transportation, and other costs." The preliminary estimate for this portion of the repository work was $14.8 billion. This figure does not represent a comparable base for reference with past DOE estimates of a TSLCC or the 1998 independent assessment described in this report.

Also, it should be noted, the legislation now in Congress would remove the existing prohibition and establish an interim storage facility adjacent to Yucca Mountain on the assumption that prompt removal of wastes from civilian reactors is needed and that Yucca Mountain will eventually serve as a disposal site.

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* DOE estimates have been adjusted for changes in the inventory requiring permanent disposal, as well as changes in the value of the dollar.

The Independent Cost Assessment by Major Category

The work done for this estimate of the TSLCC for the nation's high-level nuclear waste program can be summarized in seven categories, as shown in Table 1, below.

Table 1. Overview of Total System Life Cycle Cost by Major Cost Categories

Major Cost Categories	Cost (bil FY'96$)	
Expenditures Through Fiscal Year 1996		6.1
Estimated Future Costs		47.8
1. Onsite Storage	4.3	
2. Cross-Country Transportation	6.0	
3. Nevada Transportation	3.2	
4. Centralized Interim Storage Facility	9.2	
5. Geological Repository	23.0	
6. Other Development and Evaluation Costs	0.4	
7. Other Program Costs	1.7	
Total		$53.9

Each of these categories requires a brief summary description.

1. **Onsite Storage**: These are costs incurred at the nuclear power reactors for onsite storage due to an estimated delay in pickup of spent nuclear fuel of 5 years assuming that DOE pickup begins in 2003 instead of the contractual date of 1998.

2. **Cross-Country Transportation**: This includes costs of equipment and services for highway and rail transport of all HLNW from civilian, nuclear weapons, and temporary storage facilities to Yucca Mountain.

3. **Nevada Transportation**: This includes costs to receive and transport HLNW in heavy rail casks within the State of Nevada including the development and operation of an intermodal transfer facility at Caliente, heavy-haul operations to the centralized storage facility at Area 25 near Yucca Mountain, and the construction and operation of a government-owned railroad between Caliente and Yucca Mountain.

4. **Centralized Storage Facility**: This includes the costs of site development, facility construction, and operations. It also includes the cost of metal and concrete storage systems for spent fuel arriving by legal-weight truck and by rail, and for rail shipments using dual-purpose canisters or single-purpose canisters to transport spent fuel.

5. **The Geologic Repository**: This includes the costs of design, licensing, constructing, equipping, operating, and closing the repository.

6. **Other Development and Evaluation Costs**: This includes fees paid to the U.S. Nuclear Regulatory Commission and the costs of the Nuclear Waste Technical Review Board.

7. **Other Program Costs**: This includes payments equal to taxes and benefits as provided for under the Nuclear Waste Policy Act.

All estimates in Table 1, above, include contingency, project management, and program management costs, as well as the direct costs for personnel, equipment, materials, and sub-contractor expenses.

Summary of Assumptions for the Independent TSLCC Assessment

Where possible, this TSLCC cost assessment is similar to the 1995 DOE TSLCC report. The most notable differences are in the waste management assumptions, which reflect recent court decisions and pending Congressional legislation. This cost assessment study takes into account the similar legislative proposals of Senate Bill 104 and House Bill 1270, both of which have been passed and now await actions by a conference committee in the current Congress, and the recent court decision on DOE's contractual obligations to nuclear power utilities (Northern States Power, et al., versus USDOE, November 14, 1997).

Uncertainties

Cost estimates for complex projects and programs traditionally include a contingency factor to allow for a range of conditions and performance within the planning parameters. This was done in the case of the 1995 DOE TSLCC estimate and in the 1998 independent TSLCC study reported here. These contingency allowances assume that the waste disposal program proceeds as expected with no major surprises or complications, and are included in the Table 1 figures, above.

In fact, as the history of the selection and site characterization process shows, many things could go wrong and produce additional costs or reduced revenues. More importantly, there are many major components to the waste program that have no precedent, and adverse conditions or events could create large potential costs. Some areas of uncertainty that could add significant costs to the program, but which are not included as in this TSLCC assessment are listed in Table 2, below. The disqualification of Yucca Mountain as a suitable site, which could occur because of adverse site conditions, or for regulatory, political, or technological reasons, would be the most dramatic, unaccounted for outcome.

Costs and Revenues

The estimates of revenues from civilian nuclear power plants are based upon projected electric generation of existing stations, which are expected to operate in gradually reduced numbers until the year 2033, when all currently operating reactors will have completed their license terms. There is some uncertainty about operating projections since several plants already have shut down early. Early shutdowns reduce revenues on a one-to-one basis for each kilowatt of power not produced, but the reduced amount of spent fuel reduces costs only at the margin of a program that must be developed in any case. The effects of early shutdowns in reducing nuclear waste fund revenues are likely to be substantially greater than their effects in reducing program costs.

Through fiscal year 1996, the program spent $6.1 billion, 11.4 percent of the total estimated program costs. This means that expenditures to date—the "sunk costs"—are just over one-tenth of the total estimated program costs.

Table 2. Uncertainties in the Federal Government's HLNW Program

Uncertainty	Commentary
1. Inventory of HLNW	Nuclear power stations may produce less spent fuel due to early shutdowns, thus producing less revenue. Weapons complex wastes may be greater than currently estimated.
2. Pickup of Spent Fuel	Pickup start dates or schedules may be delayed adding costs to the program. Courts could allocate costs to the disadvantage of the Nuclear Waste Fund. Defense waste disposal could be delayed to accommodate commercial spent fuel.
3. Onsite storage	Onsite storage of spent fuel could result in a different mix of dry-cask and pool storage with costs in operations, repackaging, and ability to operate reactors.
4. Canisters and Casks	Problems with the construction, performance, and maintenance of canisters and casks could introduce additional direct costs and significant indirect costs through program delays.
5. Cross-Country Transportation	Transportation capacity, performance, and public or community responses could adversely affect the cross-country transportation costs. Accidents (or sabotage incidents) involving waste shipments could add direct costs for response and cleanup, and cause delays in the shipment schedule.
6. Regulatory and Oversight	Licensing and permitting may delay the program. The site characterization program itself may encounter technical, budgetary, management, or personnel performance delays.
7. Construction	Delays for numerous reasons are possible at the intermodal transfer facility, and in heavy-haul and rail construction, or due to unexpected conditions at the repository, adjustment of the design to meet revised HLNW demand, management and contractor performance, and Congressional funding.
8. Operations	Discovery of adverse conditions not predicted during site characterization, natural events such as earthquakes, complications with the performance of advanced technologies (e.g., robotics), personnel, contractor organizations, or program managers could introduce additional costs.
9. Retrieval	A retrieval option for wastes already emplaced is required. If conditions at the site or with the wastes required retrieval the costs could be very significant.
10. Closure	Estimate of the TSLCC is based upon closure of the repository and termination of the costs. If the planned techniques for closure do not prove to be adequate, ongoing costs could extend indefinitely.

The costs of managing and disposing of the nation's high-level radioactive wastes have been a central concern since the late 1970s when the original terms of the Congressional program were first negotiated. The primary purpose of resulting legislation, The Nuclear Waste Policy Act of 1982, was to dispose of spent fuel from nuclear power plants and establish the Nuclear Waste Fund as the means to pay for the federal program (Section 111 (b)(4); Section 302 (a)(3)). The principle was to have the beneficiaries of nuclear power pay the costs of spent fuel disposal. The Secretary of Energy is required to annually evaluate and see whether the existing fee "will provide sufficient revenues to offset the costs" of the program (Section 302 (a)(4). If the fee is not adequate, the Secretary is directed to propose an adjusted fee and immediately inform Congress.

Costs for federal government use of the high-level nuclear waste repository to dispose of wastes from the nation's nuclear weapons complex, for example, are funded by taxpayers through Congressional appropriations. The expected use of the nation's proposed repository at Yucca mountain is about 80 percent for civilian spent nuclear fuel and about 20 percent for the nation's nuclear weapons wastes.

Congress, on its part, has the authority to modify the program, as it did in selecting Yucca Mountain, Nevada as the only site to be studied as a potential repository. This action prohibited further study of other sites (NWPA Amendments Act of 1987) and thereby cut costs for the program. Reductions in annual Congressional appropriations for the program, which are typically less than the administration's budget requests, can delay progress and impose increased costs in the long run.

The most recent estimate by the U.S. Department of Energy is that the Nuclear Waste Fund (current balance and future revenues) will produce $28.1 billion in constant 1996 dollars, about half (52 percent) of the $53.9 billion dollar projected cost for implementing the nation's HLNW program, leaving the general taxpayer with a liability of $25.8 billion.

Implications

The cost-revenue condition of the nation's HLNW program and the potential for costly uncertainties are causes for concern. The key implications are that the probable costs of managing the nation's HLNW and the liability for the general taxpayer are substantially greater than have been estimated. The Nuclear Waste Fund under its current fee structure will not meet its share (approximately 80 percent) of the costs of permanent disposal of the nation's high-level nuclear wastes.

2. THE RESULTS, UNCERTAINTIES AND IMPLICATIONS OF THE INDEPENDENT COST ASSESSMENT

Introduction

Escalating costs in the U.S. Department of Energy's (DOE) High-Level Radioactive Waste Management Program have been a matter of concern since the early days of the program. Initial estimates of the costs for characterizing three potential repository sites under the original Nuclear Waste Policy Act of 1982 were in the neighborhood of $80 million per site. The currently estimated cost of characterizing just one site - Nevada's Yucca Mountain - exceeds $5 billion.

Recognizing the importance of cost as a factor in determining the feasibility of continuing with the program, DOE initially included an assessment of program costs as one of the four components to its Yucca Mountain "Viability Assessment" (VA) that is being prepared for submission to the President and Congress in September, 1998. The VA was initially conceived by DOE in 1996 as part of a revised Program Plan for the Yucca Mountain project. The VA is intended to provide a basis for an assessment, by Congress and the Administration, of the overall feasibility of moving ahead with the federal high-level waste program. As proposed by DOE, the VA will have four components: (1) a preliminary Total System Performance Assessment (TSPA), (2) a conceptual design for the proposed repository and support facilities, (3) a plan for obtaining a license to construct and operate the repository from the Nuclear Regulatory Commission, (4) and an assessment of program costs. In 1997, DOE revised its concept of the VA to include only an assessment of the current and future costs associated with constructing and operating a repository - not the total costs for the program. DOE subsequently announced plans to issue a Total System Life Cycle Cost report in mid-September, 1998, but this will not be part of the VA.

Together with the ability of the site to isolate highly radioactive wastes from the environment for tens of thousands of years, the overall cost of the effort is a major determinant of the program's scope, direction, and impacts to states and communities. It is also a crucial ingredient for determining whether the program can, in fact, be implemented. The State of Nevada embarked on an independent system-wide cost assessment when it became known that the cost estimates in the VA would not be reflective of the total costs involved with implementing the federal high-level waste program. This independent cost assessment effort has two interrelated objectives: (1) to serve as the basis for critically and substantively evaluating DOE's conclusions about project costs as they are presented in the VA and in any associated TSLCC assessment and (2) to provide an objective and complete picture of the costs of the federal high-level waste program and the implications for impact assessment and for national high-level nuclear waste policy. Given the history of cost overruns and schedule delays not only for the Yucca Mountain program but also for a variety of other DOE programs nationwide,* a credible assessment of total system life cycle costs for the high-level waste program is indispensable for determining whether or not the federal program is, in fact, viable.

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* See USGAO: "Department of Energy: Opportunity to Improve Management of Major System Acquisitions" (GAO/RCED-97-17), November 1996.

Since 1987, contractors for the State of Nevada's Yucca Mountain socioeconomic impact assessment studies have been collecting data on program costs as major factors that will drive project impacts in Nevada. At the same time, Nevada technical contractors have been closely monitoring DOE's site characterization activities and the design processes for the repository and related facilities. These efforts have generated significant amounts of information directly relevant to the issue of total system costs. In order to effectively and adequately evaluate the cost projection component of the DOE's VA, independent contractors have been engaged to compile available information on current and projected inventory requiring disposal, the costs of continued on-site (at reactor) storage, the costs of cross-country transportation, the costs of heavy haul and rail transportation in Nevada, the costs of centralized storage, and the costs of repository evaluation, licensing, construction, operations, and closure. Independent contractors also estimated contingency, and project and program management costs.

All of this information was then rolled up into a total system life cycle cost for the DOE program, as that program is defined by DOE's revised Program Plan, the requirements of currently-proposed legislation (e.g. S.104/H.R. 1270), the rulings of the U.S. Circuit Court of Appeals for the District of Columbia in litigation brought by utility companies (Northern States Power Company et al. v DOE), and recent DOE policy shifts. A prominent national accounting firm, KMPG Peat Marwick, was engaged to ensure that the independent cost analysis used reasonable and accurate assumptions, costing procedures, and cost factors.

This independent assessment draws on source data assembled by DOE and NRC, previous TSLCC and fee adequacy assessments by DOE, U.S. General Accounting Office (GAO) reports dealing with costs of DOE's high-level radioactive waste program (especially the 1990 report that reviewed DOE's findings with regard to Waste Fund adequacy),* and related assessments by special interest groups to support particular positions**.

2.1 TOTAL SYSTEM COST RESULTS

This section reviews the results of the independent cost analysis. Unless otherwise noted, cost estimates include contingency and project and program management as well as direct costs. Following sections address the uncertainties that suffuse the high-level nuclear waste program and their potential cost effects, and the key implications that flow from the findings of the assessment. Chapter 3 of this report discusses the basis for the cost analysis in greater detail—the assumptions regarding the inventory requiring permanent disposal, the strategy for waste management and the schedule for its implementation, the cost categories themselves and the cost analysis procedures.

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* "Nuclear Waste: Changes Needed in DOE User-Fee Assessments to Avoid Funding Shortfall," U.S. GAO, June 1990 (GAO/RCED-90-65).

** For example, the Nuclear Energy Institute's 1997 assessment of the costs of extended at-reactor dry storage and the 1997 Public Citizen analysis of on-site storage costs.

Total and Projected System Costs

The independent cost assessment for the DOE/OCRWM program estimates total system costs at $53.9 billion (FY'96$), about 54.1 percent greater than DOE's estimate in September 1995 (see Figure 1). Projected expenditures after FY 1996 are estimated at $47.8 billion, about 66.8 percent greater than the DOE 9/95 estimate for this period. Of the total system cost, about 88.6 percent is projected expenditure and only 11.4 percent is "sunk costs" through FY 1996 (see Figure 2).

As mentioned, future expenditures are estimated at $47.8 billion, of which 9.0 percent is the cost of onsite storage due to delay in DOE pickup, about 12. 5 percent is cross-country transportation, about 6.8 percent is Nevada transportation, about 19.2 percent is centralized storage, about 48.0 percent is the cost of the repository, and about 4.5 percent is other program components (see Figures 3 and 4). About $38.5 billion (80.7 percent) is costs attributable to the disposal of commercial spent nuclear fuel, for which the Nuclear Waste Policy Act anticipates full recovery from the Nuclear Waste Fund.

Figure 1. Total Cost is Estimated at $53.9 Billion (FY'96$)

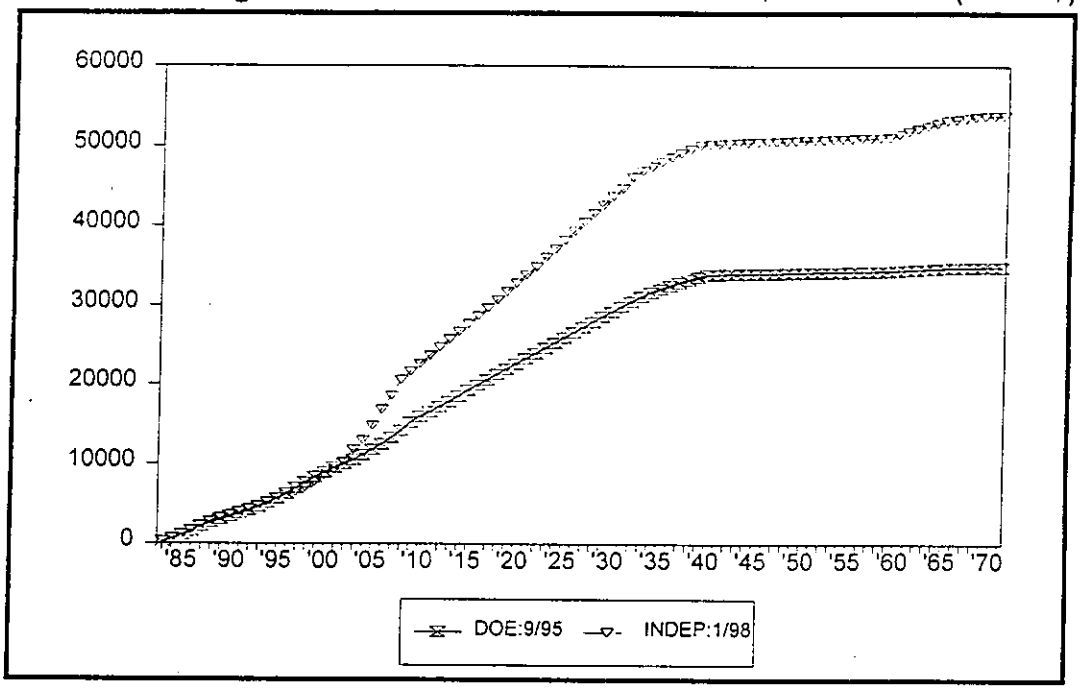

Figure 2. About 11 Percent of the Total Has Been Spent

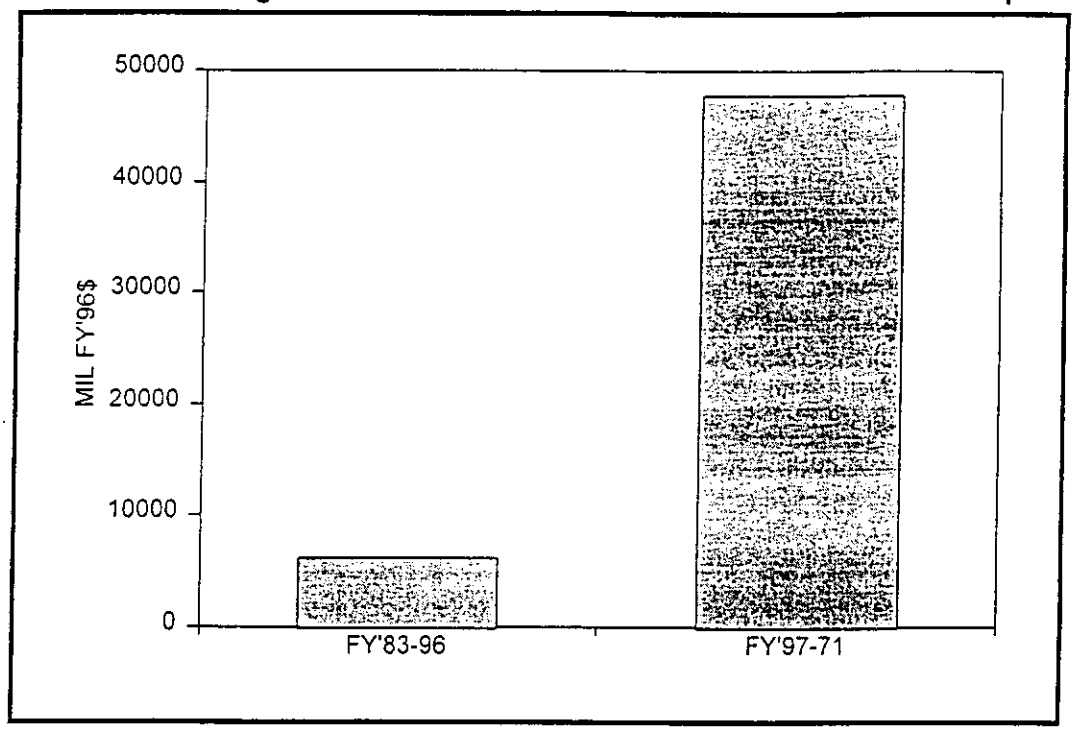

Figure 3. Future Costs for Major Components

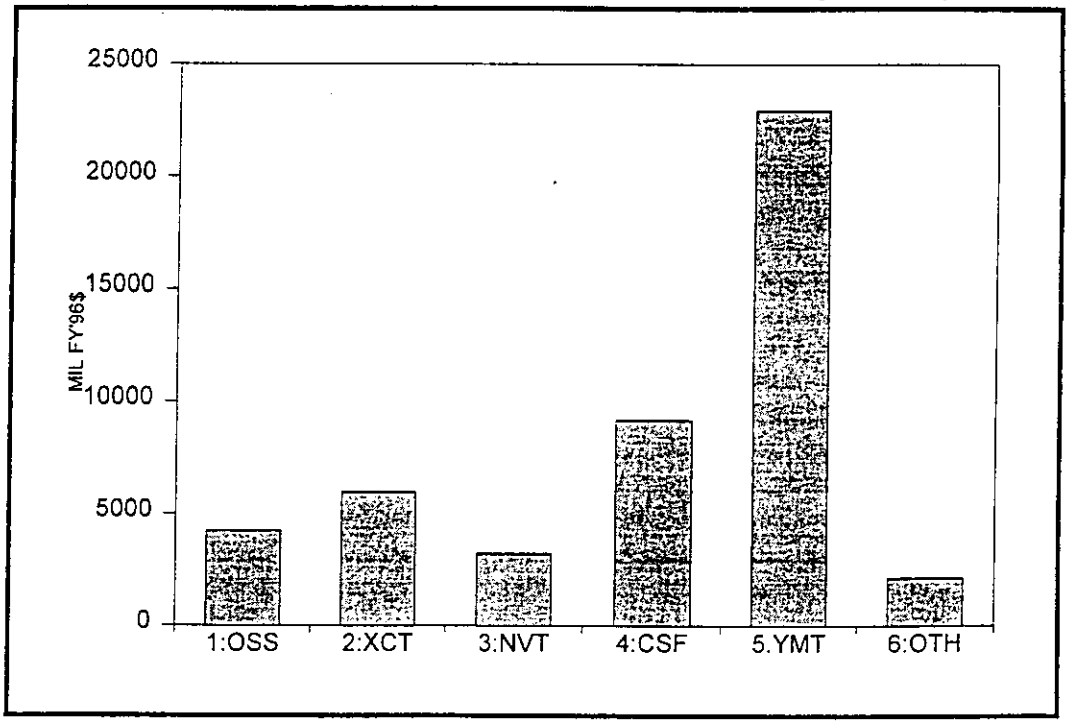

Figure 4. Sunk and Future Program Costs (FY'97 - FY'71; MIL '96$)

		Total	%FY'83+	%FY'97+	%categ
GRAND TOTAL: FY 1983FY 2071		53905.4	100.0%	NA	NA
EXPENDITURE THROUGH FY 1996		6128.0	11.4%	NA	NA
FUTURE COSTS: FY 1997 FY 2071		47777.4	88.6%	100.0%	NA
1.0	ONSITE STORAGE COSTS	4278.9	7.9%	9.0%	100.0%
1.1	Commercial SNF in Que	3886.1	7.2%	8.1%	90.8%
1.2	DOE SNF & SNF not in Que	392.8	0.7%	0.8%	9.2%
1.3	DOE High-Level Waste	NA	0.0%	0.0%	0.0%
2.0	X-COUNTRY TRANSPORTATION	5968.2	11.1%	12.5%	100.0%
2.1	Commercial SNF in Que	4269.3	7.9%	8.9%	71.5%
2.2	DOE & Other SNF not in Que	590.1	1.1%	1.2%	9.9%
2.3	DOE High-Level Wastes	505.1	0.9%	1.1%	8.5%
2.4	Technical Assist Trng: 180(c)	603.7	1.1%	1.3%	10.1%
3.0	NEVADA TRANSPORTATION	3244.7	6.0%	6.8%	100.0%
3.1	Intermodal Transfer Facility	92.3	0.2%	0.2%	2.8%
3.2	Heavy-Haul to CSF	437.2	0.8%	0.9%	13.5%
3.3	Rail Spur to CSF/YMP	2715.1	5.0%	5.7%	83.7%
4.0	CENTRALIZED STORAGE FACILITY	9179.3	17.0%	19.2%	100.0%
4.1	Misc Upfront Costs	65.2	0.1%	0.1%	0.7%
4.2	Construction	429.7	0.8%	0.9%	4.7%
4.3	Major Equipment	8469.2	15.7%	17.7%	92.3%
4.4	Operations	215.2	0.4%	0.5%	2.3%
5.0	REPOSITORY	22955.1	42.6%	48.0%	100.0%
5.1	Site Characterization	2553.8	4.7%	5.3%	11.1%
5.2	Design & License Application	1079.2	2.0%	2.3%	4.7%
5.3	Surface Facilities	6142.5	11.4%	12.9%	26.8%
5.4	Underground Facilities	7158.2	13.3%	15.0%	31.2%
5.5	Waste Containers	6021.4	11.2%	12.6%	26.2%
6.0	OTHER DEVEL & EVAL COSTS	433.6	0.8%	0.9%	100.0%
6.1	NRC Fees	400.0	0.7%	0.8%	92.3%
6.2	NWTRB	33.6	0.1%	0.1%	7.7%
6.3	Nuclear Waste Negotiator	0.0	0.0%	0.0%	0.0%
7.0	OTHER PROGRAM COSTS	1717.8	3.2%	3.6%	100.0%
7.1	PETT Payments	1233.0	2.3%	2.6%	71.8%
7.2	Benefits	484.8	0.9%	1.0%	28.2%

Extended Onsite Storage

As implied in the November 14, 1997 decision of the District of Columbia Circuit Court in Northern States Power et al versus USDOE, this assessment assumes that the federal government and the Nuclear Waste Fund (not individual utility ratebases) have an obligation to pay for the costs of onsite storage of SNF which would have been removed from commercial reactor sites had DOE pickup begun in 1998 (as anticipated in the NWPA) and proceeded at rates specified in proposed legislation. These include costs for onsite dry storage, for operation of spent fuel pools as interim storage facilities after reactor shutdown, and for limited upgrades at spent fuel pools needed to load casks for cross-country transportation.

This assessment assumes that DOE pickup of commercial SNF will be delayed from 1998 to 2003, during which time centralized storage, intermodal transfer and other needed facilities might be designed, licensed and constructed. The projected cost (FY'97+) to the nuclear waste program for onsite storage associated with a five-year delay is $4.3 billion, of which $3.9 billion is for onsite storage of SNF at commercial reactor sites, and $0.4 billion is for onsite storage of SNF located elsewhere. Of the $3.9 billion, about $0.6 billion (14.8 percent) is for dry storage, and about $3.3 billion (84.2 percent) is for the operation of pools as interim storage facilities after reactor shutdown. Since this assessment bases transportation choices on the current loading capabilities of spent fuel pools, the estimated cost for upgrading pool dimensions or lifting apparatus is only $37 million (1.0 percent).

Cross-Country Transportation

For legal-weight truck shipments, cross-country transportation includes the cost of shipment from origin sites to Yucca Mountain or Nevada Test Site (NTS) Area 25. These include the shipment costs, the shipment escort and inspection costs, the cost of the high-capacity cask and special truck trailer, and the operations, maintenance, replacement and decommissioning costs of this equipment.

For rail shipment, cross-country transportation is the cost of shipment in dedicated trains to Caliente (NV), where such shipments would be transferred to heavy-haul trucks or continue along a 365-mile government-owned and operated rail spur. Equipment purchases include cask and buffer cars; shipment costs are based on the loaded cask and the ballast in the buffer cars. Some rail shipment sites which lack or no longer have a rail spur require heavy-haul to a nearby railhead.

The total cost of cross-country transportation is estimated at $6.0 billion, of which $4.3 billion is for transport of SNF from commercial reactor sites, $0.6 billion is for SNF transport from other sites, $0.5 billion is for HLW transport from four sites in the DOE complex, and $0.6 billion is for emergency management training for affected states, counties and Tribes. Of the $4.3 billion, about $3.1 billion (71.9 percent) is for rail and truck carrier costs for 24,400 cask shipments over 56 million miles, about $1.0 billion (22.7 percent) is for purchasing, maintaining and decommissioning transportation casks and equipment, and $0.2 billion (5.4 percent) is for shipment escort and inspection.

Nevada Transportation

In this assessment, Nevada transportation is included to enable transportation (cross-country and in Nevada) by rail as well as by legal-weight truck. Intermodal transfer and heavy-haul are included

(consistent with directives in proposed legislation) to enable *early* cross-country shipment by rail as well as by legal-weight truck. Nevada transportation costs are estimated at $3.2 billion, of which $0.5 billion (16.3 percent) is for the intermodal transfer facility at and heavy-haul from Caliente, while $2.7 billion (83.7 percent) is for the construction and operation of a 365-mile government-owned and operated rail spur from Caliente to Yucca Mountain.

Consistent with DOE's 1991 conceptual plan, the direct construction cost for the Caliente-Yucca Mountain rail route is estimated at $1.2 billion (FY'96$). Contingency and project and program management costs increase this figure to $1.9 billion. Upfront design and right-of-way costs, the construction of ancillary facilities, the purchase and maintenance/replacement of major equipment, and operations costs account for the remainder of the $2.7 billion estimate for the rail spur.

The Central Storage Facility at NTS Area 25

Under the assumptions of this assessment, the centralized storage facility receives and stores SNF until it is emplaced in the nearby geologic repository at Yucca Mountain. About two-thirds of the SNF arrives at the centralized storage facility in dual-purpose rail canisters. Under normal circumstances, these canisters need not be opened at the central storage facility; they are removed from transportation casks and placed in concrete bunkers or vaults for onsite storage. This assessment assumes that, at 16 rail shipment sites, utilities choose to purchase dual-purpose canisters as an onsite storage cost in order to limit the operation of spent fuel pools as interim storage facilities after reactor shutdown. At 31 other rail shipment sites, utilities choose to use storage-only canisters for dry storage; the cost of dual-purpose canisters for transportation and central storage of SNF from these sites is included as a central storage cost.

About one-third of the SNF arrives at the centralized storage facility uncanistered in high-capacity casks for legal-weight truck transport. Under the assumptions of this assessment, this SNF is removed from the transportation cask and held in a reinforced concrete fuel transfer facility until a sufficient number of PWR or BWR assemblies have accumulated to fill a metal cask for onsite storage.

The total cost for centralized storage is estimated at $9.2 billion, of which $2.4 billion (26.3 percent) is the direct cost of purchasing, replacing and decommissioning metal casks for storage of SNF arriving by legal-weight truck, about $2.7 billion is the direct cost for dual-purpose canisters for rail shipment of SNF which has been stored onsite in pools or storage-only canisters, and about $0.4 billion (4.4. percent) is the direct cost of concrete storage for all SNF arriving by rail or heavy-haul. Other direct costs include upfront and construction costs (about $0.3 billion, 3.4 percent) and operations (about $0.14 billion, 1.5 percent). Contingency and project/program management costs account for the remaining non-direct portion of centralized storage costs.

The Repository

Under the assumptions of this assessment, the geologic repository would dispose of the nation's entire current and projected inventory in 11,000 waste containers for SNF and 19,234 canisters* for HLW, emplaced in 94 miles of drifts bored in parallel rows at a single emplacement level through the fractured

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* Purchased by the DOE Office of Environmental Restoration and Waste Management as containers for onsite storage (and transportation, emplacement) of HLW; costs not included in estimates for the DOE/OCRWM program.

tuff beneath Yucca Mountain. Major challenges include the design of the emplacement drifts and the movement and emplacement of waste packages within and among them, the monitoring and possible retrieval of flawed or damaged packages, and the backfill and decommissioning of the facility* late in the 21st century.

The projected cost of the Yucca Mountain repository is estimated at $23.0 billion, of which the completion of site characterization is $2.6 billion (11.1 percent). Licensing and design (upfront and ongoing during construction and operations) is $1.1. billion (4.7 percent). The cost of surface facilities at the repository (their construction, equipping and operation throughout emplacement, care-taking and decommissioning) is estimated at $6.1 billion (26.8 percent of projected repository costs). Underground facilities are estimated to cost $7.2 billion (31.2 percent). The direct cost of waste emplacement containers for SNF is estimated at $6.0 billion (26.2 percent), of which $3.9 billion is the direct purchase cost at an estimated $350,000 per container.

2.2 UNCERTAINTIES IN THE DOE/OCRWM PROGRAM

The projected costs described above include estimated contingency costs to address the potential for ordinary complications in scheduling, regulatory compliance, design, construction, procurement or hiring. However, any large, long-term, first and only-of-its-kind project is subject to uncertainty over and above standard contingency factors. This section reviews some of the uncertainties in the DOE/OCRWM program, and suggests how they could affect program costs and/or the implementation of the waste management strategy implicit in current directions and proposed legislation.

The Inventory Requiring Permanent Disposal

A Reagan administration decision in 1985 required collocated geologic disposal for high-level defense wastes as well as SNF from commercial and DOE reactors. However, the disposition of GTCC** and other wastes (e.g., decommissioned nuclear weapons) remains uncertain. Also, the estimates of high-level wastes are not finalized and are increasing; DOE's estimates in December 1996 are 45 percent greater in volume and 39 percent greater in canisters than its estimates 15 months earlier in September 1995. Additional waste streams could increase costs for cross-country and Nevada transportation, complicate the design and emplacement strategy for the repository, and increase repository construction and operations costs.

The NWF Obligation Due to Delay in DOE Pickup of SNF

In its November 14, 1997 decision in Northern States Power et al versus USDOE, the US Court of Appeals for the District of Columbia Circuit concluded that the federal government has an obligation

* Some studies suggest that the repository might be "ventilated" that is—not closed or decommissioned, but continued in caretaker operation into the 22nd century and beyond.

** Greater-than-class-c low-level wastes, much of which is expected to be generated in the decommissioning of nuclear reactors.

under its standard contract* with utilities to remediate costs attributable to delays in pickup and/or reductions in pickup rates. However, it declined to specify a remedy until delays actually begin, and it did not determine whether the costs of delay should be drawn from the Nuclear Waste Fund or from the general fund.

In the absence of a court-approved formula, this assessment allocated the costs of delay based on an estimate of the projected inventory at each site (assuming pickup beginning in 2003 and proceeding at rates specified in proposed legisilation) compared to the inventory had pickup begun in 1998. The uncertainties are a) the Court could specify a remedy more advantageous to utilities and less advantageous to DOE and the NWF or general taxpayer, and b) DOE could fail to begin pickup in 2003 and/or fail to proceed at S-104 rates. These contingencies could increase onsite storage costs and/or the portion of onsite storage costs allocated to the NWF or general taxpayer. If not anticipated and very effectively managed, delays in pickup (start date or rates) could result in unused capacity in cross-country and Nevada transportation, and in additional costs of systems developed but not fully used. Delays in the SNF pickup start date and rate could result in delay in pickup of high-level defense wastes, which the DOE Office of Environmental Restoration and Waste Management must vitrify and store while awaiting shipment to a geologic repository for permanent disposal.

Dry Storage for Discharges in Excess of Pool Capacity

The assessment assumes that dry storage can be developed at any site at which it may be required. However, at some sites physical limitations or community concerns could complicate the licensing and development of dry storage facilities. The consequence could be a more costly solution to dry storage and/or a utility decision to shutdown before license term, thus depriving the NWF of currently anticipated revenues.

Defective Canisters and/or Transportation Casks

This assessment assumes no defective storage canisters or transportation casks. If canisters are found to be defective, they would need to be repaired or replaced—increasing costs for onsite storage, transportation or centralized storage, depending on the point at which the defect is discovered. Defective transportation casks may or may not require repair or replacement, since transportation choices and schedules could result in an excess cask inventory in some shipment years. The major cost consequences, however, depend on the management of defects by utilities and/or DOE as they occur. Ineffective management could have major cost consequences.

Canister and Cask Standardization

Our estimates assume all SNF will be shipped in a standard LWT cask and one of two rail casks, each matched with a standard canister for storage and/or transportation. If the container delivery "system" (DOE, NRC, vendors, fabricators) fails to deliver an adequate quantity of standard casks and canisters, as required by shipment schedules, system efficiency would go down and costs would go up. Under a privatized transportation system, such as DOE is now proposing, market-driven decisions could result in

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* Paragraph B of NWPA Section 302(a)(5) says that "in return for payment of fees," DOE will dispose of commercial spent nuclear fuel, beginning not later than January 31, 1998.

use of a variety of unstandardized casks, perhaps with reduced cask purchase costs, but with increased costs for handling, repackaging and storage at the centralized facility.

Shipment Costs for Cross-Country Transportation

Transportation carrier costs for 30,400 cask shipments and 65 million cask shipment miles on the nation's Class A railroads and interstate highways are not yet negotiated. Rail carriers and USDOE disagree on the need for and cost of shipping SNF in dedicated trains. Given speed, route and operating restrictions for shipments of SNF and HLW—and the implications of these restrictions for other rail or highway freight traffic—shipment costs per ton-mile or per ton-originated may be higher than assumed in this assessment.

Concerns in Transportation Corridor Communities

The willingness of corridor communities to accept a shipment campaign of this type and magnitude—the ability of our political system to produce and maintain acceptance when such a large portion of affected communities see themselves as corridors for dangerous materials originating elsewhere and benefitting others—has not been demonstrated. Resistance could come from state-local-tribal governments along corridors or from grassroots activism. Some believe that concerns with early shipments will rapidly diminish after the initial shipments along various routes; others anticipate the concerns could build as the campaign proceeds.

It is conceivable that concerns among corridor communities, as expressed through participatory state and local politics, could shutdown or greatly complicate parts of the nationwide campaign for cross-country shipment of high-level wastes. DOE could build a central storage facility and/or repository, and be able to ship only parts of the projected inventory to these Nevada facilities.

Accidents in Cross-Country Transportation

Our assessment assumes no accidents in a cross-country shipment campaign involving 16,920 legal-weight truck shipments and 37.6 million cask shipment miles on often-congested public highways, plus 4,500 dedicated train shipments over 9.1 million miles of heavily-used rail corridors. Accidents in cross-country transportation are likely. Such accidents could require substantial emergency response, as well as evacuation, road closure or other measures resulting in losses for corridor businesses. The associated costs are not included in this assessment. Nor are the costs of potential radiation releases, should such occur, which would be paid under guidelines established by the Price-Anderson Act of 1957, as amended in 1988. The major costs of accidents in cross-country transportation, however, are likely to be subsequent to the accident itself, in the management and operation of the shipment campaign.

NRC Review for Shipment Staging or Switching Locations

Our assessment assumes that NRC review and/or licensing is not required for staging or switching locations required in the cross-country shipment campaign—e.g., major rail yards in Chicago, St. Louis, Kansas City. Should such be required (e.g., if an accident or a security breakdown occurred in a rail switching yard), significant additional cross-country transportation costs could result.

NRC Licensing for the Intermodal Transfer Facility

Our assessment assumes, based on Senate Bill 104, that NRC licensing is not required for the intermodal transfer facility at Caliente (NV). Should safety or security considerations (or litigation, or political action by affected parties) require NRC licensing, the result would be a delay in the pickup start date, with consequent implications for onsite storage costs at commercial reactor sites. Licensing could also require additional construction and operations costs at the intermodal transfer facility itself.

Delays in Heavy-Haul Operations

Heavy-haul operations could be delayed due to complications in negotiating or funding the necessary improvements in the public highways along the 365-mile route, and/or due to concerns in local communities along such routes. The result could be increased costs for heavy-haul construction and operations, and (more significantly) increased upstream costs for onsite storage and cross-country transportation.

Delays in Rail Spur Construction and Operation

Delays in procuring the required right-of-way and/or environmental permits along the 365-mile rail spur route could increase construction costs. Indirect effects could include an extension of heavy-haul operations (and the associated intermodal transfer and heavy-haul costs) and/or increased upstream costs for extended onsite storage or cross-country transportation.

Seismic Activity at NTS and the Central Storage Facility

Seismic activity is expected to be a major concern in the licensing of a centralized storage facility for up to 24,000 MTU of SNF at NTS Area 25. These or other concerns could lead to increased costs to meet NRC licensing requirements regarding the spent fuel transfer building, storage procedures and equipment, or decontamination facilities. If such requirements delay the operations of the centralized storage facility or reduce its throughput capacity, there could be significant additional upstream costs in onsite storage and/or excess transportation capacity developed but not fully used.

Delays in Site Characterization at Yucca Mountain

Several contingencies not addressed in this assessment could delay the completion of Yucca Mountain site characterization: e.g., a seismic event which damages surface or underground facilities and equipment at the exploratory studies facility; an unexpected geologic condition (e.g., a large body of perched water, a highly fractured unstable zone) encountered by the east-west tunnel currently under construction; discovery or confirmation of a health hazard for workers underground;* a major equipment failure which damages the heater test or causes an electrical fire or rock fall within the ESF. Any such contingency would increase site characterization costs and could indirectly increase costs in other components of the waste management program.

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* For example, cristobalite dust detected in 1996 in the original five-mile ESF was found to exceed OSHA limits and required respirators to worn by all personnel, thus reducing productivity.

Repository Construction and Operation

The construction and 60-year operation of a permanent repository in the heavily fractured tuff of Yucca Mountain involves many contingencies not addressed in this assessment: e.g., defects in the repository block (faulting, fracturing, perched water) which were undetected during characterization and which reduce capacity or require reconfiguration; variations in rock quality in the repository block which complicate thermal loading and affect capacity, ventilation or emplacement layout; escalating surface facility construction costs due to seismic events or NRC license requirements; complications in the operation of robotic equipment within emplacement drifts; the cost of waste containers fabricated from exotic materials to meet stringent performance standards.

Retrieval of Emplaced High-Level Waste

Performance standards require that SNF be retrievable for 50 years after initial emplacement. The feasibility of retrieval at any cost is uncertain at best. The costs, should retrieval be required, are not included in this assessment—very rough estimates are in the billions or tens of billions of dollars, depending on the complexity and extent of retrieval required. Also not included are the costs of dealing with the waste retrieved, should the retrieval be occasioned by hazards detected in the emplaced wastes.

Permanent Closure of the Geologic Repository

In closing the repository, the federal government warrants that the materials it contains will be safely isolated from the human environment, without further government involvement, in perpetuity. Yet the backfilling techniques proposed for closure are unproven as to feasibility or effectiveness. Some argue that the repository should remain unclosed or ventilated, implying that the government responsibility (and costs) could extend indefinitely.

2.3 IMPLICATIONS OF THE COST ESTIMATES

The implications of the total system cost estimates, and of the uncertainties not reflected in the cost estimates, are wide ranging. The key implications are that the probable cost of managing the nation's SNF and HLW is substantially greater than has been estimated by DOE, that the general taxpayer stands to bear about half of the projected cost.

While there are and will continue to be substantial uncertainties inherent in projecting the costs and revenues of a complex program over many years, two things are apparent—the Nuclear Waste Fund as currently constituted is woefully inadequate to meet the long-term costs of implementing current DOE plans and proposed legislation, and this shortfall is likely to increase rather than decrease over time.

This section of the report briefly elaborates on these and related implications of the independent assessment of total system costs.

Waste Management is More Costly than Estimated by DOE

The projected cost of managing SNF and HLW in accordance with the NWPA (as revised by the Amendments of 1987 and legislation proposed in Senate Bill 104 and House Bill 1270) and recent US

Appeals Court decisions is $53.9 billion—a figure about 18.9 billion (54.1 percent) greater than estimated by DOE in September 1995. The projected cost of managing SNF and HLW in fiscal years 1997-2071 is $47.8 billion—a figure $19.1 billion (66.8 percent) greater than DOE's estimates for the same period.

Program Uncertainties Could Further Increase Costs

The above estimates do not include the cost implications of uncertainties in a program that involves many scientific and technical challenges, difficult equity and perceptual issues, and consequent demands on our regulatory and political systems. Should any or some combination of these uncertainties materialize, they could significantly increase the above estimates of costs required to see the nation's high-level nuclear waste program through to a satisfactory conclusion. Even more difficult, perhaps, they could require a rethinking of the nation's waste management program at a point when even more funds have been expended and wastes are partly emplaced, partly in central storage, and partly at commercial reactor and other DOE sites.

NWF Revenues will Likely Further Contract

This assessment assumes that all commercial nuclear plants operating in 1997 will continue to operate (and generate revenues to the Nuclear Waste Fund) through their license term. DOE's fee adequacy assessment makes a similar assumption.* In recent months, however, several utilities have announced that they intend to or are considering early shutdown of several plants—e.g., Big Rock, Oyster Creek, Maine Yankee, Zion 1 and 2.

Early shutdowns would reduce the expense of waste management under the NWPA, by reducing the amount of spent fuel which must be stored on an interim basis, transported or emplaced. However, the reductions in NWF revenues as a consequence of early shutdowns will likely be much greater than the corresponding reductions in expenses. Early shutdowns reduce revenues on a one-to-one basis for each kilowatt of expected nuclear power not generated by a commercial reactor. Early shutdowns reduce waste management costs at the margins of an overall program which must be fully developed in any case. The effects of early shutdowns in reducing Nuclear Waste Fund revenues are likely to be substantially greater than their effects in reducing program costs. The assumptions of this assessment (all reactors operating in mid-1997 continue to operate through license term) represent the "best case" scenario of revenues and expenses for the NWF.

Fund Management Could Diminish Investment Revenues

Nuclear utilities, frustrated by prospective delays in DOE pickup of spent nuclear fuel and by the inclusion of the Nuclear Waste Fund in the general federal budget, have proposed that annual fee collections be limited to the amounts actually appropriated by Congress for implementation of the

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* "The 1.0 mil per KWh fee revenue used in this analysis was derived from the no-new-orders end of reactor life projection of net electricity generation prepared in 1994 by the EIA. It is assumed in this projection that commercial units will operate for 40 years from the issuance of their operating licenses without extension, reactor performance will not be affected by aging, and the equilibrium-cycle capacity factor will increase slightly from 74 percent in 1995 through 2014 to between 75 and 76 percent until 2034." DOE/RW-0490, pg. 5.

DOE/OCRWM program. This would place the program on a current cost basis, and reduce the projected balance in the Nuclear Waste Fund, the investment of which was intended by the Nuclear Waste Policy Act to support the implementation of the program over the decades after nuclear reactors shut down.

The General Taxpayer Stands to Pay $26 Billion

DOE's most recent assessment of the one-mil per kilowatt hour fee on sales of nuclear generated power, established by the NWPA to meet the costs of permanent disposal of commercial SNF, estimates that the fee provides a revenue base of $28.1 billion (FY'96$) from which to meet projected program expenditures.* The independent cost assessment estimates program costs at $53.9 billion (FY'96$), suggesting that the general taxpayer liability is about $25.8 billion, or about half (48 percent) of total program expenditure.**

A Small Portion of Total Costs are "Sunk"

Though the DOE/OCRWM waste management program is now in its fifteenth year, only 11.3 percent of estimated TSLCC have been incurred through FY 1996; 88.7 percent will be incurred in future years. Thus, despite the huge investment at Yucca Mountain and the large investments in investigating sites at Hanford, Deaf Smith County and elsewhere, just over ten percent of the costs which the nation should expect to spend for permanent disposal of HLNW have been "sunk." In determining future directions for the program, sunk costs should be relegated to a lesser role than they seem to have been in many policy determinations to this point.

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* Nuclear Waste Fund Fee Adequacy: an Assessment (October 1996) DOE/RW-0490; Analysis of the Total System Life Cycle Cost (September 1995) DOE/RW-0479. The fee adequacy assessment (pg 11) estimates that the fund balance at the end of FY'94, plus projected income from fee payments and investments, will generate $22.8 billion ($24.1 billion in FY'96 dollars), sufficient to offset the civilian share of TSLCC as estimated by DOE in September 1995. DOE's September 1995 analysis of TSLCC (pg 39) estimates the civilian share at $26.6 billion ($28.1 billion in FY '96 dollars). Our discussion assumes that the fund will generate the higher figure—noting, however, that higher estimates of annual costs would draw down the fund balance more rapidly than assumed in DOE's fee adequacy assessment, thus reducing investment income to the NWF.

** As mentioned, the Nuclear Waste Fund (and the one-mil per kilowatt hour fee) created by the Nuclear Waste Policy Act (Section 302) was intended to pay for the disposal of only those wastes generated in the production of commercial nuclear power. The independent assessment estimated the costs attributable to commercial SNF, distinguishing these from the costs attributable to DOE SNF and HLW. Comparing the costs attributable to commercial SNF ($43.5 billion, FY'96$) against DOE's estimate of revenues generated in the Nuclear Waste Fund ($28.1 billion, FY'96$), we estimate a shortfall of $15.4 billion—that is, expenses attributable to commercial SNF that will not be met by the Nuclear Waste Fund as currently constituted. The $43.5 billion estimate of costs attributable to commercial SNF is 80.68 percent of projected costs (see Appendix D), plus a like percentage of actual expenditures through FY 1996 (see Appendix B).

2.4 SOURCES FOR TOTAL SYSTEM COST ASSESSMENT

Several sources were consulted in preparing the independent assessment of total system costs for the permanent disposal of the nation's SNF and high-level waste.

USDOE Assessment of Total System Costs

The Nuclear Waste Policy Act requires DOE to prepare "an estimate, on an annual basis, of the costs required to construct and operate the repositories anticipated to be needed . . . and to carry out any other activities under this Act" (Section 301 (a) (10)). Based on the estimate of costs, the Act requires that DOE "shall annually review the amount of the fees (on sales of civilian nuclear power). . . to evaluate whether collection of the fee will provide sufficient revenues to offset the costs. . ." (Section 302 (a) (4)). The former requirement is generally referred to as the assessment of "total system life cycle costs" and is part of DOE's responsibility to develop and maintain a mission plan for management of the nation's high-level nuclear waste. The latter requirement is referred to as the "fee adequacy assessment," and is part of DOE's responsibility to manage the nuclear waste fund established by the NWPA.

This assessment included a thorough review of DOE's most recent analysis of total civilian costs (published in September 1995), and a comparative review of estimates prepared in 1986, 1989 and 1990. DOE's assessments describe waste management assumptions (e.g., projected inventory, number of repositories, repository media, etc.) but do not describe their cost analysis procedures or cost factors.

Our review compared DOE estimates of total system costs, selecting comparable waste management assumptions (e.g., single repository, in tuff) and adjusting for changes in the projected inventory and for constant dollars. The key observation is that, in a program that has had many changes of direction and adjustments in cost, the DOE estimates of TSLCC have been very consistent. The 1995 estimate is only about ten percent above the initial estimate prepared in 1986, only seven to eight percent higher than the estimate from 1989, and virtually identical to the 1990 estimate prepared to reflect the effects of the 1987 amendments to the NWPA.

USGAO Reports to Congress

In response to requests from Congress and its committees, the General Accounting Office (GAO) has made numerous inquiries into various aspects of DOE's program for management of the nation's high-level nuclear wastes and/or the site characterization project at Yucca Mountain. Some GAO inquiries have focused directly on program costs or revenues; other have focused on management issues which have a significant but indirect bearing on costs. The GAO has found numerous persistent causes for concern:

- A September 1994 report concluded that comprehensive review of the disposal program is needed
- A December 1994 report expressed concerns about DOE's management and organization of the Nevada repository project.
- A September 1993 report inquired about funds spent to identify a monitored retrievable storage facility site.

- A May 1993 report observed that Yucca Mountain project was behind schedule and facing major scientific uncertainties.

- A May 1992 report concluded that DOE's repository site investigations would be a long and difficult task.

- A March 1992 report concluded that the development of casks for transporting spent fuel needs modification.

- A June 1992 report evaluated the status of actions to improve DOE user-fee assessments.

GAO's major review of total system costs in the DOE/OCRWM program was published in June 1990* and concluded that changes were needed in DOE user-fee assessments to avoid shortfalls in the Nuclear Waste Fund. The review evaluated DOE's estimates of total system cost, but did not investigate costs analysis procedures in detail, nor did it validate cost factors. Much of GAO's review focused on the one mil per kilowatt hour fee and the uncertainties regarding its adequacy to support projected expenses.

GAO has reviewed 80 projects designated by DOE as major systems acquisitions and identified many which suffered significant cost overruns or schedule slippages:** e.g.,

- The final cost of the Fuels and Materials Examination Facility at Hanford (WA) was 39 percent above the original estimate, and the completion schedule slipped 14 months. The $234 million facility is now used for storage and office space.

- The costs of the West Valley Demonstration Project in New York increased 226 percent from an original estimate of $446 million to a final cost of $1,008.5 million, and the originally estimated completion date slipped seven years and five months.

- The cost of the Super Conducting Supercollider in Texas increased from an original estimate of $5.9 billion to over $11 billion before the project was terminated in October 1993.

- The vitrification plant at the Savannah River Site in South Carolina was completed in November 1996—62 percent over original budget and 6½ years behind schedule.

GAO notes the many causes for cost overruns and schedule slippages in large and technically demanding projects, but finds several underlying causes (unclear or changing missions, incremental project funding, a flawed system of incentives, insufficient DOE personnel to effectively oversee contractor operations) common to many DOE major systems acquisitions.

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* USGAO: "Nuclear Waste: Changes Needed in DOE User-Fee Assessments to Avoid Funding Shortfall" (GAO/RCED-90-95, June 7, 1990).

** USGAO: "Department of Energy: Opportunity to Improve Management of Major System Acquisitions" (GAO/RCED-97-17, November 1996).

DOE/NRC Management Information

This assessment included significant efforts to collect, organize and analyze information collected by DOE or NRC. Examples include:

- DOE expenditures, as reported in detail in "status of obligation authority" reports.
- DOE records of spent fuel discharges (by reactor, current location, number and type of assemblies, MTU) through 1995.
- NRC data on operating and shutdown commercial nuclear power reactors (Information Digest: Appendix A).
- DOE projections of spent fuels discharges under no-new-orders, end-of-license term assumptions (DOE/RW-0431, June 1995)
- DOE's Integrated Data Base Report (DOE/RW-006, December 1996) including estimates of high-level defense waste and DOE spent nuclear fuel.

Other Sources for the Independent Assessment

Other information sources used in this assessment include data received from the American Railroad and American Trucking Associations, inputs from sources in the nuclear industry (e.g., the Nuclear Energy Institute and its consultant Energy Resources International), and construction industry standards.

The State of Nevada began the independent assessment in late 1996. Independent contractors were engaged to collect available information on the current and projected inventory requiring permanent disposal, the costs of continued onsite storage due to delay in DOE pickup, the costs of cross-country transportation, the costs of heavy-haul and rail transportation in Nevada, the costs of centralized storage, and the costs of repository characterization, licensing, construction, operations, and closure. Independent contractors were asked to estimate contingency, project management and program management costs—arriving at a total cost for the life-cycle of the DOE program. Waste management assumptions were specified so as to reflect a program which responds as practicable to initiatives currently underway as part of DOE's May 1996 revised program plan, the requirements of currently proposed legislation (e.g., S.104/HR.1270), the remedies resulting from the November 14, 1997 decision in Northern States Power Company et al versus USDOE, and recent DOE/OCRWM policy shifts. An outside contractor was engaged to ensure that the independent cost analysis used reasonable assumptions, costing procedures and cost factors.

Chapter 3 of this report describes the inventory requiring permanent disposal; the strategy for managing the waste inventory; the types of costs required by the waste management strategy; the schedules for storage, pickup and emplacement which determine cost streams over time; and the key cost analysis procedures used in this assessment.

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3. THE INDEPENDENT COST ANALYSIS: WASTE INVENTORY, WASTE MANAGEMENT ASSUMPTIONS, COST ANALYSIS PROCEDURES

In its September 1995 analysis of the total system life-cycle cost (TSLCC) of the civilian radioactive waste program, the US Department of Energy (DOE) describes its assumptions regarding waste management strategy—the inventory, the transportation requirements, the schedule for disposal. However, DOE's report does not describe its costing procedures or cost factors, or the rationale for the costing procedures and factors.

This section describes at a general level the waste management assumptions and cost analysis procedures and cost factors used in an independent assessment of total system cost. We discuss the inventory requiring permanent disposal; the strategy for managing the waste inventory; the types of costs required by the waste management strategy; the schedules for storage, pickup and emplacement which determine cost streams over time; and the key cost analysis procedures used in this assessment.

Throughout the independent assessment we have used the "best available" input data and cost assumptions. Much of the input data comes from DOE, and we have made particular efforts to locate and obtain the most recent DOE data available. Many of the cost assumptions come from nuclear industry sources or construction industry standards. Supplementary inquiries have been conducted to provide a basis for estimates of project and program management costs, additional PETT payments, and numerous other factors.

3.1 THE INVENTORY REQUIRING PERMANENT DISPOSAL: THREE GROUPS

This assessment divides the inventory requiring permanent disposal in a geologic repository into three broad categories:

a) Current and projected inventories of spent nuclear fuel stored at commercial reactor sites. This category includes all discharges of spent fuel assemblies from commercial reactors, less those which for various reasons have been shipped to other sites such as Morris (IL), West Valley (NY), and the Idaho National Engineering and Environmental Laboratory (INEEL)—i.e., the broad category of SNF for which utilities expected the federal government to begin taking responsibility on January 31, 1998.

b) Current and projected inventories of spent nuclear fuel at other sites—chiefly federal government sites, but also private sites such as the Morris facility and various universities with research reactors. The inventories include SNF from commercial reactors (e.g., Three Mile Island, Cooper Station, Dresden) which has been shipped offsite (e.g., to INEEL, Morris, West Valley), SNF from Navy and foreign research reactors which will be shipped to INEEL and the Savannah River Site (SRS) for storage while awaiting shipment to Yucca Mountain for disposal, and SNF

generated at defense reactors—chiefly Hanford. In the que for DOE pickup, this category has second priority (in this assessment) to spent fuel stored at commercial reactor sites.

c) Projected HLW, which will be vitrified and canistered at four defense sites (Hanford, Savannah River, INEEL and West Valley) before being shipped* to Nevada for permanent disposal at Yucca Mountain.

Current (1995) Discharges of SNF

This study included an assessment of spent fuel discharges through 1995, identifying the date, origin, current location, metric tons uranium (MTU) and assemblies of each discharge, and distinguishing discharges currently located at reactor sites (inventory group "a" above) from those at other sites (group "b"). At the end of 1995, 1,275 discharges totaling 31,747 MTU in 111,015 assemblies were stored at commercial reactor sites (inventory group "a"). Another 850 MTU originated at commercial reactors but had been shipped for storage at other sites (e.g., Morris, INEEL, West Valley); these form part of inventory group "b" in the current assessment.

Projected Discharges (1996+) from Commercial Reactors

This study also included an assessment of projected spent fuel discharges from currently operating commercial nuclear reactors, through the end of their license term. Projected discharges are consistent with those presented in DOE's most recent projection of spent fuel storage requirements.** However, adjustments were made in the early projection years to account for actual discharges in 1994 and 1995, which are projection years in the DOE study. Also a random number method was used to prioritize projected discharges within a given year. Finally, projected discharges from four reactors included in the DOE projections (TVA's Bellefonte 1&2 and Watts Bar 1&2) were removed from this assessment—reflecting a judgement that, though NRC construction permits had been issued, these plants would not have commercial operation. Thus, inventory group "a" in this assessment reflects a no-new-orders, *modified* end-of-license-term projection of spent fuel discharges from commercial nuclear reactors.

The projected spent fuel discharges after 1995 total 50,598 MTU. Combined with the 31,747 MTU currently stored at commercial reactor sites, the total inventory in group "a" is estimated at 82,345 MTU. This is SNF which is or will be stored at commercial reactor sites, and which*** is the focus of the federal government's obligations for interim storage and pickup under the Northern States Power et al versus USDOE court decision of November 14, 1997.

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* Beginning in 2015, according to assumptions used in DOE's September 1995 TSLCC (pg. 8) and in this assessment.

** Spent Fuel Storage Requirements 1994-2042 DOE/RW-0431, June 1995.

*** Along with SNF stored at the General Electric Facility at Morris (IL).

Spent Nuclear Fuel Not Located at Commercial Reactor Sites

Regarding inventory group "b", this study included an assessment of current and projected spent fuel *not* located at commercial reactor sites. One component in this group is SNF which originated at commercial reactors but which has since been shipped for storage at other sites such as Morris, West Valley, and INEEL. As mentioned, this component totals 850 MTU.* Another component is spent fuel discharges from DOE weapons reactors, Navy reactors, foreign research reactors and other fuel in the DOE/DOD complex. This fuel, which totals 2,666.5 MTU, has been grouped according to the probable locations from which it would be shipped to Yucca Mountain.

Combining both components, inventory group "b" includes 3,516.5 MTU (roughly similar to the spent fuel expected to be discharged from six BWR reactors.)** which would be shipped to Yucca Mountain from Hanford (2,132 MTU), INEEL (325 MTU), SRS (214 MTU), Morris (674 MTU), West Valley (147 MTU), or other sites (24 MTU).

High-Level Waste at Four Defense Sites

Highly-radioactive wastes have accumulated at DOE defense sites (particularly Hanford, INEEL and Savannah River) in liquid, sludge, salt cake, slurry, calcine, capsule and other forms. DOE intends to stabilize these wastes in glass columns about 2 feet in diameter and 10 to 15 feet in length. The glass will then be canistered for storage onsite until it can be transported (beginning in 2015***) to Nevada for permanent disposal. This assessment assumes that 19,234 canisters of HLW will be produced.****

3.2 WASTE MANAGEMENT ASSUMPTIONS

Any estimate of total systems cost must reflect assumptions regarding how the current and projected inventory will be managed. The assumptions used in this assessment reflect current legislative proposals (primarily Senate Bill 104 and House Bill 1270), recent court decisions (e.g., Northern States Power et al versus USDOE, November 14, 1997), and DOE policies. The question posed is, what is the likely cost of a program which attempts to implement the directives in proposed legislation and the conclusions of recent court decisions? Some of the key waste management assumptions (which are summarized and compared with those of DOE's 9/95 TSLCC in Figure 5) include:

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* It also includes very small amounts of spent fuel discharged from DOE research reactors which is included in DOE's acceptance priority rankings.

** E.g., Clinton, Cooper Station, Duane Arnold, Fitzpatrick, Monticello, Vermont Yankee.

*** DOE TSLCC 9/95, pg. 8.

**** DOE IDB December 1996 pp. 50-51. The estimate increased from 13,789 in IDB September 1995, pp 64-65.

Figure 5. Waste Management Assumptions: Comparison

	DOE TSLCC: 9/95		INDEP ASSESS: 1/98	
# PERMANENT REPOSITORIES	Single repository for all SNF & HLW. Exceed 70,000 MTU limit for repos #1.		Same Same	
INTERIM STORAGE	No monitored retrievable or centralized storage facility. SNF stored at reactor sites (at utility expense) until shipped to YM, beginning 2010.		Central storage facility at NTS Area 25. SNF stored at reactor sites (at shared NWF/utility expense) until shipped to YM, beginning 2003.	
DOE PICKUP: SNF	Begins in 2010 & extends through 2040: Year 1: 300 MTU Year 2: 600 MTU Year 3: 1,200 MTU Year 4: 2,000 MTU Year 5: 3,000 MTU Year 6-30: 3,000 MTU Year 31: 1,854 MTU		Begins in 2003 & extends through 2033: Year 1: 1,211 MTU Year 2: 1,215 MTU Year 3: 2,025 MTU Year 4: 2,011 MTU Year 5 2,704 MTU Year 6-30: 3,021 MTU (Avg) Year 31: 1,179 MTU	
DOE PICKUP: HLW	Begins in 2015 & extends through 2040: Year 1-23 750 canisters Year 24: 175 canisters Year 25: 345 canisters Year 26: 576 canisters		Begins in 2015 & extends through 2040: Year 1-23 750 canisters Year 24: 750 canisters Year 25: 750 canisters Year 26: 484 canisters	
INVENTORY	SNF: 83,954 MTU HLW: 18,346 Canisters		SNF: 85,861 MTU 82,345 Comm reactor sites 3,517 DOE & other HLW: 19,234 Canisters	
INTERIM STORAGE/ PERMANENT DISPOSAL	SNF is packaged & emplaced as received at the YM repository.		Same	
NWF OBLIGATIONS:				
Inventory	Commercial		SNF at commercial sites	
Waste Mgt Activ				
Interim strg	Not Applic		Shared re pickup start and rate	
X-ctry transp	Yes, re SNF %		Yes, re SNF %	
Nevada transp	Yes, re SNF %		Yes, re SNF %	
Central strg	Not Applic		Yes, re SNF %	
Repository	Yes, re SNF %		Yes, re SNF %	
Program mgt	Yes, re SNF %		Yes, re SNF %	
NEVADA TRANSP:				
Intermodal Transf	Not Applic		Yes, by 2003	
Heavy-Haul	Not Applic		Yes, 2003-2008	
Rail Spur	Yes, 2010+, _____ miles		Yes, 2008+, 365 miles	
TRANSP CASKS:				
Rail	MPC @ 125/75 tons, as req.		Same	
Hwy	High-capacity LWT cask, as req.		Same	
TRANSP CHOICES:	Reactor Facilities	Cask Shipments	Sites	Cask Shipments
LWT: Comm SNF in Que	4	1,441	26	14,769
Other SNF			4*	2,151
Small rail	23	4,216	19	5,382
Large rail	92	9,189	28	4,256
HLW rail			4	3,847
Sub-total	119	14,846	81	30,405

* Multiple sites, grouped to 4 for analysis
Note: Some numbers may not add due to rounding.

A Single Repository for All SNF and HLW

Our assessment assumes that all current and projected SNF and HLW is emplaced in a single repository at Yucca Mountain in Nevada. Implicitly, we assume that Section 114(d) of the NWPA would be changed to authorize DOE to exceed the 70,000 MTU limit for the first repository.* DOE's 9/95 TSLCC makes similar assumptions.

Previous DOE TSLCC assessments have assumed that the first repository would accommodate 62,907 MTU of SNF and 7,093 MTU of HLW.** Under our assumptions, about 22,954 MTU of SNF and about 40,984 MTU of vitrified HLW that would (under provisions of NWPA Section 114d) be stored in a second repository would instead be disposed at Yucca Mountain.***

A Centralized Storage Facility at NTS Area 25

Our assessment assumes that a centralized storage facility, with capacity to store all SNF accepted and not yet emplaced, would be developed at Area 25 of the NTS. Implicitly, we assume that legislation would override the provisions of the NWPA that interim and permanent facilities should not be in the same state (Section 141(g)) and that the permanent facility must be authorized for construction before an interim facility can be authorized at all (Section 148(d)(1)).

DOE's 9/95 TSLCC, adhering to the provisions of the 1987 Amendments to the NWPA, assumes no Monitored Retrievable Storage or centralized storage facility. Implicitly, it assumes that SNF will be stored at reactor sites (at utility expense) until shipped to Yucca Mountain for permanent disposal.

Early and Rapid DOE Pickup from Commercial Sites

Proposed legislation would require DOE pickup from commercial sites to begin in 2002 or 2003 (at 1,200 MTU) and rapidly increase (1,200 MTU in year two, 2,000 MTU in year three, 2,700 MTU in year four) to a plateau level of 3,000 MTU per year. Our assessment assumes that operation of a central storage facility begins in 2003, and that thereafter DOE pickup from commercial sites proceeds as specified in proposed legislation.

DOE's 9/95 TSLCC assumes that DOE pickup from commercial sites begins in 2010 (at 300 MTU) and increases gradually (600 MTU in year two, 1,200 MTU in year three, 2,000 MTU in year four) to a plateau level of 3,000 MTU, which extends to 2040. Our analysis accepts DOE's 9/95 assumption

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* An important uncertainty is whether Yucca Mountain can be shown to have the capacity to safely emplace SNF and HLW in such volume.

** E.g., DOE TSLCC May 1989 Tables A-3&4 (two-repository system).

*** SNF: 85,861 MTU projected inventory - 62,907 MTU in first repository = 22,954 MTU
HLW: 48,077 MTU projected inventory - 7,093 MTU in first repository = 40,984 MTU
19,234 canisters times estimated MTU per canister at Hanford, Savannah River, INEEL and West Valley = 48,077 MTU vitrified HLW.

that pickup of HLW from four defense sites begins in 2015 and extends (at a plateau rate of 750 canister shipments per year) until all canisters have been removed to Nevada.

Intermodal Transfer and Heavy-Haul

There is currently no rail link to Yucca Mountain. Our assessment assumes that the development of a long rail spur would begin in FY 2002 and would require at least five years. Furthermore, shipment of the volumes anticipated entirely on public highways is assumed to be unacceptable. Therefore, our assessment, consistent with proposed legislation, assumes that early shipment requires an intermodal transfer facility at Caliente and heavy-haul operation on Nevada's public highways. We further assume that heavy-haul through Las Vegas or across the NTS is infeasible; therefore, heavy-haul shipments are routed north of the Nellis Air Force Range to Tonopah, then south along US 95 to Yucca Mountain.

DOE's 9/95 TSLCC assumes that shipments begin in 2010, by which time a rail spur to Yucca Mountain would be available. Under these waste management assumptions, rail shipments would not require heavy-haul in Nevada to reach Yucca Mountain.

Central Storage at NTS Area 25

Consistent with provisions of proposed legislation (HR-1270), our assessment assumes that, as SNF is received in Nevada (beginning in 2003), it would be stored above-ground at a centralized facility at NTS Area 25 until the repository is ready for operation in 2010. We further assume that SNF which arrives uncanistered (by legal-weight truck) will be stored in metal casks, while SNF which arrives in dual-purpose canisters (by rail/heavy-haul) will be placed in concrete storage facilities.

DOE's 9/95 TSLCC assumes that SNF and HLW is packaged and emplaced (for permanent disposal) as it is received at the Yucca Mountain repository, which is assumed to begin operation in 2010.

Federal Government Obligation for Onsite Storage at Commercial Reactor Sites

As a result of the November 14, 1997 court decision in Northern States Power et al versus USDOE (and follow-on litigation to specify the implications of that decision), our assessment assumes that the federal government will have a financial obligation for continued onsite storage of SNF after it would have been picked up under an oldest-fuel-first priority ranking beginning in 1998. A calculation of the annual inventory at each site under the two cases (pickup beginning in 1998 and proceeding at S-104 rates versus pickup beginning in 2003) provides the basis for calculation of the federal government and NWF obligation for extended onsite storage at commercial reactor sites.

DOE's 9/95 TSLCC implicitly assumes that the federal government has no obligation for onsite storage of SNF at commercial reactor sites—even though pickup would not begin until 2010.

Canisters and Casks for Storage and Transportation

Our assessment assumes that a dual-purpose canister system for rail shipments (and storage onsite and/or at a centralized facility) would be made available. But utilities are under no obligation to use it in onsite dry storage, and, as long as early shipment is a prospect, may not, given the circumstances at

particular reactor sites, have a financial incentive to do so. We have analyzed the circumstances at 77 sending sites and identified 16 which appear to have a financial incentive to use dual-purpose canisters for onsite storage in a program in which pickup begins in 2003. While a high-capacity LWT cask is currently not certified, we assume that such a cask would be made available in order to reduce (by a factor of four) the number of cask shipments on public highways.

DOE's 9/95 TSLCC assumes that a multiple-purpose canister system is developed by DOE and certified by NRC, as is the high-capacity cask for legal-weight truck shipment of uncanistered SNF. It further assumes that these federally-developed systems are used in preference to other storage/transportation systems.

Transportation Mode and Cask Choices

Based on a review of pool loading capabilities (e.g., operating crane capacity, cask set-down area, pool depth) at commercial reactor sites, our assessment assumes that as many as 26 sites (36 percent) will choose to ship by legal-weight truck. Utilities have no financial incentive to upgrade pool loading capabilities merely to facilitate rail shipment rather than shipment by LWT, which is legal under USDOT regulation.

Though DOE has made no commitment to transport rail casks by dedicated train, and has a long-standing challenge to rail carrier estimates of the cost of dedicated train shipment, we assume that SNF mixed with general rail freight would be unacceptable, and that dedicated trains would be used for all rail shipment.

DOE's 9/95 TSLCC assumes that, of 119 reactor facilities, only 4 (3.4 percent will ship by legal-weight truck. Further "all SNF rail shipments are assumed to be made by dedicated train."*

3.3 THE TOTAL SYSTEM COST CATEGORIES

The waste management assumptions described above require an analysis of total system cost in seven major categories, several of which have not been addressed in previous DOE TSLCC assessments.

Extended Onsite Storage (Master Code 1.0)

This assessment estimated the costs of extended onsite storage for 73 commercial reactor sites (master code 1.1), assuming DOE pickup beginning in 2003 rather than in 1998. Onsite storage costs include: the costs of dry storage for SNF discharges in excess of current pool capacity, the cost of operating spent fuel pools as interim storage facilities after shutdown of their associated reactors, and the cost of limited upgrades of pool loading capabilities to accommodate casks of a specified type, size and weight.**

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* DOE 9/95 TSLCC, pg. 8.

** The NWF obligation for these costs is based on the projected inventory at each site compared to the projected inventory had DOE pickup begun in 1998 and proceeded at S-104 rates.

This category also includes the costs of extended onsite storage of SNF not stored at commercial reactor sites (master code 1.2). For this analysis, multiple sites (Morris, Ft. St. Vrain, West Valley, DOE defense sites, university research reactors) are combined into four, and inventory estimates in MTU are translated into BTU assembly equivalents. The analysis assumes all such costs are supported by defense appropriations, except for those at Morris.

HLW at four defense sites will require vitrification, canistering and onsite storage while awaiting shipment to Yucca Mountain (master code 1.3). However, such costs are assumed to be the responsibility of the DOE Office of Environmental Restoration and Waste Management, not DOE/OCRWM.

Cross-Country Transportation (Master Code 2.0)

Cross-country transportation includes the cost of high-capacity casks for LWT shipment of uncanistered SNF and the cost of rail casks for shipment of canistered SNF or HLW; the cost of trailers for LWT shipment and cask and buffer cars for rail shipment; the cost of operating, maintaining, replacing and decommissioning this equipment; the carrier, escort and inspection costs for LWT and rail shipments; and the cost of heavy-haul to a nearby railhead for rail shipment from sites which do not or no longer have a rail spur. These costs are estimated for transportation of commercial SNF stored at commercial reactor sites (master code 2.1), other SNF (master code 2.2), and HLW (master code 2.3).

Also included in cross-country transportation is an estimate of the costs of technical assistance training required of DOE/OCRWM under NWPA Section 180(c) (master code 2.4)

Nevada Transportation (Master Code 3.0)

Cross-country transportation includes the cost of LWT shipment to Yucca Mountain, and of rail shipment to Caliente (NV). Nevada transportation includes the costs of moving rail casks from Caliente to the central storage facility at NTS Area 25 or the geologic repository at Yucca Mountain. These include the cost of an intermodal transfer facility at Caliente (master code 3.1), a heavy-haul operation between Caliente and the central storage facility (master code 3.2), and the construction and operation of a government-owned rail spur between Caliente and Yucca Mountain (master code 3.3).

The Centralized Storage Facility (Master Code 4.0)

The costs of a centralized storage facility at NTS Area 25 include: the costs of designing and licensing such a facility (master code 4.1), the costs of site development and facility construction (master code 4.2), the costs of storage equipment (master code 4.3) and of facility operations (master code 4.4). The costs of storage equipment include the costs of metal casks for SNF arriving uncanistered by LWT and concrete storage for SNF arriving by rail in dual-purpose canisters. Storage equipment also includes the cost of dual-purpose canisters for rail shipments from 31 reactor sites at which onsite storage has used pools or dry-storage in storage-only canisters. The estimates reflect the projected inventory at the CSF, considering both the flows of SNF shipped to Nevada and those emplaced for permanent geologic disposal.

The Geologic Repository (Master Code 5.0)

Repository costs include the actual expenditure for "first repository" development and evaluation through FY 1996, and the costs of completing site characterization at Yucca Mountain (master code 5.1), the design and license application costs at Yucca Mountain (master code 5.2); the cost of constructing, equipping and operating surface facilities (master code 5.3) and underground facilities (master code 5.4); and the cost of about 11,000 waste containers for emplacement of 85,861 MTU of SNF (master code 5.5).

Other Development and Evaluation Costs (Master Code 6.1)

Other development and evaluation costs include fees paid to the Nuclear Regulatory Commission (master code 6.1), and support for the Nuclear Waste Technical Review Board (master code 6.2). These costs are not independently estimated. Estimates from the DOE 9/95 TSLCC (converted to FY'96$) are applied in this assessment.

Other Program Costs (Master Code 7.0)

Other program costs include payments equal to taxes (master code 7.1) and benefits (master code 7.2) as provided for under NWPA Sections 116(c)(3) and 170-171. Estimates from the DOE 9/95 TSLCC (converted to FY'96 $) are applied in this assessment. However, an estimate of additional PETT related to components not included in the current DOE program (Nevada transportation and centralized storage) is included, based on the construction and major equipment costs of these facilities.

Contingency Costs

Continency costs are estimated as a percentage of direct costs in the categories above. A review of projected costs in the DOE 9/95 TSLCC was conducted, relating contingency to base costs for various cost elements. The results were used as points of reference for estimating contingency costs in this assessment. A 15 percent contingency factor was used for onsite storage, cross-country transportation and the intermodal transfer portion of Nevada transportation. A 20 percent contingency factor was used for the heavy-haul and rail spur portions of Nevada transportation and for repository costs other than site characterization. Lower contingency factors were used for the completion of Yucca Mountain site characterization and for other development and evaluation and program costs. Overall in this assessment, contingency comprises 11.0 percent of total projected costs, and 16.3 percent of direct costs.*

Contingency addresses the potential for complications in the implementation of the program components as described—complications in scheduling, meeting state-local and federal regulations, construction, procurement or hiring. As applied in this assessment, contingency does not address the major uncertainties in the program—e.g., the potential for major accidents,** special construction

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* By comparison, in DOE's September 1995 estimate of TSLCC, contingency comprises 14.1 percent of total projected costs and 18.6 percent of "base" costs.

** Contracted emergency response is included for two incidents (not involving releases or fatalities) in heavy-haul operations (master code 3.2) and nine incidents in rail spur operations (master code 3.3).

problems, unanticipated licensing requirements, etc. Such uncertainties are discussed in section 2.2 of this report.

Project Management Costs

This study included an assessment of project and program management costs in the DOE/OCRWM program in fiscal years 1988-1996. Using annual reports of DOE/OCRWM expenditures, selected budget and reporting codes were identified as "project" or "program" management, and tabulated for the relevant fiscal years, thus dividing total costs into three broad categories—direct costs, project management costs, and program management costs. Distinct from program management, which involves overall direction of the DOE/OCRWM program, "project management" is the management of specific activities for which direct costs have been estimated. This tabulation suggests that project management comprised 24.1 percent of direct costs over the nine-year period FY 1988-96, and 23.9 percent over the most recent five-year period FY 1992-96. Project management costs in the Yucca Mountain project (B&R category 1.2) have been higher than in the DOE/OCRWM program overall—31.2 percent in the FY 1988-96 period, and 28.3 percent in the FY 1992-96 period.

The above analysis was used as a point of reference in estimating project management costs associated with projected direct expenditure. In most categories, project management is estimated at 15 percent of direct costs plus one-third of contingency costs. In some categories (e.g, technical assistance training (master code 2.4), site characterization (master code 5.1.1), other development and evaluation (master code 6.0), and other program (master code 7.0) costs, project management is assumed to have been included in direct costs. Overall in this assessment, project management comprises 9.2 percent of total projected costs, and 13.6 percent of direct costs.

Program Management

The assessment described above also estimated program management costs in the DOE/OCRWM program, representing these as a percentage of all other (direct and project management) costs. Generally but not exclusively or necessarily conducted at DOE's headquarters in Washington, program management involves the overall direction, advocacy, coordination and financial management of the DOE/OCRWM program. The assessment suggests that program management costs comprised 8.3 percent of all other costs over the nine-year period FY 1988-96, and 15.1 percent over the more recent five-year period FY 1992-96.

The analysis of recent DOE/OCRWM expenditure was used as a point of reference in estimating program management costs associated with other projected expenditure. In most cost categories, program management was estimated at 15 percent of the subtotal of direct, contingency and project management. Overall, program management comprises 12.5 percent of total projected costs, and 14.2 percent of the direct, contingency and project management cost sub-total.

3.4 WASTE MANAGEMENT SCHEDULE: PICKUP, INTERIM STORAGE, EMPLACEMENT

Several schedules must mesh in a national waste management program—the schedules by which spent fuel is discharged from nuclear reactors (or HLW vitrified and canistered at DOE defense sites) and stored onsite while awaiting pickup, the start date and rate of DOE pickup of SNF and HLW for transport to the central storage facility or repository, and the rate at which SNF and HLW is emplaced in the

geologic repository. These rates determine the inventory in onsite storage, the inventory in transit, the inventory in centralized above-ground storage, and the inventory emplaced in each year of the waste management program. These inventories, or their year-to-year changes, drive the cost streams in this assessment. The inventory assumptions are discussed in section 3.1, above. This section discusses the schedules for DOE pickup and emplacement.

Priority for Pickup of SNF

DOE pickup from commercial reactor sites is estimated on an oldest-fuel-first basis,* using the overall acceptance rates specified in currently proposed legislation, and summing for all storage locations at a particular site. This results in different pickup schedules at each commercial reactor site—depending on the start of commercial operations and the rate of discharges at each reactor relative to others across the nation. Thus, for example, pickup at Big Rock Point, which began commercial operation in March 1963, would start in year 1, while pickup at Callaway (commercial operations: December 1984) would begin in year 7, and pickup at Braidwood (commercial operations: July 1988) would begin in year 9.

Pickup Start Date and Schedule

If pickup begins in 2003 as assumed in this assessment, and proceeds at rates specified in current legislation (at least 1,200 MTU in years one and two, at least 2,000 MTU in year three, etc.), 81,683 MTU will have been picked up through 2031 (year 29 of the acceptance and transportation program). This assessment assumes that the remaining SNF at commercial reactor sites (662 MTU) would be picked up in 2032,** along with 2,338 MTU of SNF stored elsewhere. The remaining SNF not stored at reactor sites would be picked up in 2033.

Consistent with DOE assumptions in its 9/95 TSLCC, this assessment assumes that pickup of HLW begins in 2015 and proceeds at 750 canisters annually until all are removed from their current storage sites. At this rate, shipment of currently projected HLW canisters would extend through 2040.

This assessment prioritizes pickup of HLW based on the cumulative production and storage of canisters at each site (Hanford, INEEL, Savannah River, West Valley). This prioritization may not meet the terms of agreements between DOE and the host states for its facilities. For example, canister production at INEEL is projected (IDB December 1996) to extend through 2035 and pickup would extend through 2040.

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* As described in the "standard contract" (10 CFR 961).

** Some SNF may not have been discharged from reactors. Shutdown at Comanche Peak 2, for example, is scheduled for February 2033. The study assumes that the final discharges from Comanche Peak, Limerick 2 and Vogtle 2 are available for pickup in year 30, and do not require a hiatus in a shipment campaign which proceeds at S-104 rates.

Implications for Reactor Sites

This assessment assumes that a central storage facility at the NTS (and the associated intermodal transfer facility at Caliente and heavy-haul around Nellis Air Force Range) begin operation in FY 2003, not in 1998 when the federal government obligations for commercial waste management begin. For example, given the priority of its discharges, the Beaver Valley site can expect pickup of 16.1 MTU in year four, 48.7 MTU in year five, and 35.2 MTU in year six—that is, 2006, 2007, and 2008 assuming DOE's first pickup year is 2003.

Implications for the Nuclear Waste Fund

In a November 14, 1997 decision, the US Court of Appeals for the District of Columbia Circuit concluded in Northern States Power et al versus USDOE that the federal government has an obligation under the standard contract (NWPA Section 302) to remediate utility costs attributable to delays in pickup start date or shortfalls in pickup rates. However, it declined to specify the remedy until delays actually begin, and it did not determine whether the costs of delay would be drawn from the Nuclear Waste Fund or from some other source such as the general fund.

In the absence of a court-approved formula, this assessment allocated the costs of delay based on an estimate of the projected inventory at each site (assuming pickup beginning in 2003 and proceeding at S-104 rates) compared to the inventory had pickup begun in 1998. The percentage of the projected inventory which would have been picked up had pickup begun in 1998 is applied to subtotal of costs for dry storage, pool operations after reactor shutdown and pool loading upgrades. The resulting estimated costs of delay are assumed to be an obligation of the Nuclear Waste Fund.

The estimated NWF obligation for onsite storage costs varies by site and by year. Overall, the NWF obligation is about 52.2 percent of the direct costs of dry storage, pool operations after reactor shutdown and pool loading upgrades at commercial reactor sties. The percentage is higher for sites that ship by legal-weight truck and sites that ship by rail after dry storage in storage-only canisters than for sites that ship by rail after storage in dual-purpose canisters.

3.5 COST ANALYSIS PROCEDURES: SITE-BY-SITE ANALYSIS

This assessment conducted a site-specific analysis for 73 commercial reactor sites, 4 sites* where DOE and other SNF is stored, and 4 HLW sites. The site-specific analysis estimates the annual inventory in pools and in dry storage; the DOE pickup from each site and the number of cask shipments by transportation mode and cask type; onsite storage costs (dry storage, pool operations after reactor shutdown, pool loading upgrades, additional dual-purpose canisters required for rail transport, and necessary heavy-haul to nearby rail heads); and the NWF obligation for onsite storage costs due to pickup delay. Site-by-site estimates of annual cask shipments (by transportation mode and cask type) provide the basis for estimates of transportation costs (cask shipment, escort and inspection; transportation cask and equipment purchases, operations and maintenance, and decommissioning), and (combined with assumptions regarding emplacement) the type, number and cost of storage equipment required at the central storage facility.

* Multiple sites, grouped as four for this assessment.

Site-by-Site Information

The following information was collected or developed for the reactors, pools and dry storage facilities at each site:

- The current (1995) inventory in each pool (joined or shared pools were treated as a single wet storage location) and existing dry storage facility.

- The projected additional discharges from each reactor to each pool. An analysis of the origin and storage location of SNF discharges through 1995 was used to allocate projected discharges from reactors to pools.

- The license shutdown date of each reactor and its associated pool. Information from the NRC Information Digest (1996 Edition) was used; joined or shared pools received the latter shutdown date among the reactors served.

- The maximum capacity (in assemblies) of each pool, and the full core reserve to be added to that capacity upon shutdown of the associated reactor. This information was assembled from DOE's June 1995 projection of spent fuel storage requirements (DOE/RW-0431).

- The operating cost of each pool during reactor operations and after reactor shutdown. In absence of reliable data which distinguishes the cost of reactor and pool operations, we applied an average annual cost for pool operations, adjusted for the size of PWR and BWR pools at individual sites.

- The mode and cask for shipments from each storage location at each site. This study used the results of an assessment of "current capabilities" transportation choices published in July 1996.* (The second strategy option for onsite storage was associated with the "MPC Base Case" transportation choices developed in the same assessment.) As mentioned, under current capabilities transportation choices about 44 percent of storage locations ship by LWT, versus about 21 percent in the MPC base case assessment and 3.4 percent in DOE's September 1995 TSLCC.

- Requirements to upgrade pool loading capabilities in order to ship casks of the specified type. These requirements were based on a review of data collected in DOE's 1990 Facility Infrastructure Capacity Assessment, and an assessment to relate loading capabilities to the dimensions and loaded weight of the high-capacity LWT cask and the small and large rail casks assumed for this assessment.

- Requirements for heavy-haul to a nearby rail spur. The requirements were based on review of data collected in DOE's 1990 Near Site Transportation Infrastructure study, and an assessment to relate near-site infrastructure capabilities to transportation choices (i.e., rail or LWT) at each site.

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* The Transportation of Spent Nuclear Fuel and High-Level Waste, NV NWPO, July 1996, pg 39.

- The pickup schedule for spent fuel and HLW at each site, given a start date and pickup rate for all projected spent nuclear fuel stored at commercial reactor and other sites, as discussed in section 3.4, above.

The Inventory Flow at Storage Sites

The information described above was applied in a model of inventory flow for each of 73 commercial reactor sites.* In the model:

- Additional discharges (after 1995) from a reactor are stored in a designated pool until the pool capacity is reached. Discharges in excess of pool capacity require dry storage. It is assumed that dry storage could be provided at any site where it may be required, and would be provided to meet additional storage requirements in excess of pool capacity.

- Two strategies for onsite storage are available for each site: The first option assumes that at least one pool is retained in operation for interim storage and that necessary dry storage uses storage-only canisters. Pickup is prioritized among spent fuel locations in such a way that a pool (rather than dry storage is the last storage facility at a site to shutdown). An operating pool is used to load all legal-weight truck or rail transportation casks.

  In the second onsite storage strategy option, pool inventories are moved to dry storage in the years after reactor shutdown, and dry storage uses dual-purpose canisters. Pickup is prioritized in such a way that pools shut down prior to dry storage facilities; dual-purpose canisters are loaded dry to rail transport casks.

- In a preliminary run, the onsite storage costs for each option were compared for each site—given the assumptions for pickup start date, rate and priority in this scenario. The second option for onsite storage was assumed for 16 rail shipment sites for which onsite storage costs under option two are at least ten percent below those for option one. This assessment assumes that utilities select a strategy for onsite storage based on cost, given reasonably credible expectations for DOE pickup—not in order to facilitate a desirable overall plan for cross-country transportation or centralized storage, the costs for which are the obligation of the Nuclear Waste Fund, not individual utility ratebases.

Dry Storage Costs (Master Code 1.1.1, 1.2.1)

A May 1995 study by Energy Resources International, "Utility At-Reactor Spent Fuel Storage Requirements and Costs" estimated the costs of a 500 MTU dry storage facility operated over 20 years, considering the upfront, incremental, operating and decommissioning costs of such a facility. Total costs were estimated at 34 to 50 million, of which the incremental costs of metal storage canisters, concrete bunkers, loading and consumables comprise 60-65 percent.

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* Hope Creek and Salem reactors (owned by Public Service Electric and Gas Company) were combined as a single storage/shipment site. Fitzpatrick (owned by the Port Authority of New York) and Nine Mile Point (owned by Niagara Mohawk Power) were combined as a single storage/shipment site.

Using the framework of the ERI study, an analysis was conducted to apply the results in a model of inventory flow which estimates the annual inventory requiring dry storage at a particular site.

- Upfront costs (licensing, construction, equipment, engineering and startup testing) are incurred two years ahead of a projected need for additional dry storage. However, with the exception of equipment, all upfront costs are reduced by 25 to 33 percent for subsequent 500 MTU facilities that may be required at a particular site.

- Incremental costs (storage-only canisters, concrete overpack, pad extensions, loading) are incurred with increases in the dry storage inventory at a particular site. The ERI estimate of incremental costs for a 500 MTU dry storage facility are apportioned among the total PWR or BWR assemblies that could be stored at such a facility, and applied in this assessment as the needs occur.

- Annual operations costs (NRC fees, security, monitoring) are incurred in each year that a 500 MTU facility has inventory. For subsequent dry storage facilities that may be required at a particular site, operations costs are reduced 25 to 33 percent.

- Decommissioning costs are estimated at 12.5 percent of the initial (incremental) cost of storage-only canisters, concrete overpack and pads—i.e., the elements likely to be radioactively contaminated. These costs are incurred in the year after the facility's shutdown.

- Under the second option for dry storage at a rector site, the cost of canisters is increased by 50 percent to reflect the robust dual-purpose canister used, but the decommissioning costs attributable to storage-only canisters (about 12.5 percent of purchase costs under option 1) are eliminated as an on-site storage cost, since the dual-purpose canister would be used for transportation as well as on-site storage.

Pool Operations After Reactor Shutdown (Master Code 1.1.2, 1.2.2)

In this assessment, pool operations are an onsite storage cost only in years after reactor shutdown. Otherwise, pool operations are considered a cost of operating the associated reactor. Data which reliably distinguishes the cost of reactor operations from those of associated pools were not available to this study. Industry sources have estimated pool operations costs at $8.0 million annually after shutdown. This assessment assumes that the average annual cost of pool operations is $6.3 million, a cost which is adjusted for the size of PWR and BWR pools at various reactor sites.

Pool Loading Upgrades (Master Code 1.1.3)

Though the transportation choices assumed in this assessment conform to current pool loading capabilities at reactor sites, some improvements to operating crane capacity, cask set-down area or pool depth are nevertheless required at a few sites—based on the assessment of current conditions conducted in a recent transportation study.* Greater emphasis on rail over legal-weight truck transport, or on the

* The Transportation of SNF and HLW: A Systematic Basis for Planning and Management at National, Regional and Community Levels (July 1996), Nevada NWPO.

use of large rail over small rail casks, would require greater investment to upgrade pool loading capabilities at more reactor sites.

Cask Shipment (Master Code 2.1.1, 2.2.1, 2.3.1)

Annual cask shipments by site and transportation mode/cask provide the basis for estimates of cask shipment miles and for truck or rail carrier costs, using revenues per ton-mile factors. Rail shipment miles are estimated based on default (least-time, using Class A railroads) routes from the origin site or the nearest railhead to Caliente. Highway shipment miles are based on the default (least-time, using interstate highways) routes from the origin site to Yucca Mountain. Each shipment includes a backhaul to the next pickup; backhaul milage is based on the average milage of one-way shipments for each cask type.

The tonnage includes the estimated weight of the loaded cask and its trailer or cask car, plus (in the case of rail shipments) the weight of buffer cars and ballast used in dedicated trains. The backhaul tonnage is adjusted for the weight of SNF or HLW removed at the central storage facility or repository. The revenues per ton-mile factors are based on an evaluation of information regarding the tonnage, revenue and average haul of general and hazmat rail and truck freight shipments received from the American Railroad Association and American Trucking Association. The rates for rail shipment used in this assessment are about five times general freight rates, and the rates for highway shipment are about three times general freight rates. These estimates may be conservatively low, given the special attention required in shipment of high-level radioactive waste, and the effects of dedicated train shipment on other freight traffic on Class A railroads.

Shipment Escort (Master Code 2.1.2, 2.2.2, 2.3.2)

This assessment assumes that each legal-weight truck cask shipment and each dedicated train is escorted. The costs are estimated on a per hour basis, considering the number of casks in the shipment and the average speed of the cross-country shipment.

Shipment Inspection (Master Code 2.1.3, 2.2.3, 2.3.3.)

This assessment assumes that each shipment is inspected twice—once en route at a designated crew change location or safe haven, and once on arrival at the central storage facility or repository in Nevada. Inspections include not only the casks but the shipment tackle, the truck trailers or rail cask cars, and the truck or locomotive. Inspection costs are estimated on a per inspection basis.

Transportation Cask and Equipment Purchases (Master Code 2.1.4, 2.2.4, 2.3.4)

This assessment assumes that casks and transportation equipment will be purchased for use exclusively in the shipment campaign. Purchases include transportation casks of the type and number required in a particular shipment year, the purchases of truck trailers and rail cask (or buffer) cars used in cross-country shipment, and the replacement of casks and equipment after 20 years—regardless of the level of use, but only if shipments continue to be made.

The requirement for casks-on-hand is the annual number of cask shipments of a particular type, divided by the annual number of round trips (turnover). We assume 15 round trips per year for all cask types, even though the particulars vary. (For example, the average one-way travel time is 49 hours for

LWT shipments versus 83 hours for small rail and 93 hours for large rail shipments. The shipment preparation and/or inspection for a dedicated train might be greater than for a LWT shipment). The estimated costs for casks and equipment are drawn from sources in the nuclear industry.

Transportation Cask and Equipment Operations and Maintenance (Master Code 2.1.5, 2.2.5, 2.3.5)

Annual operations and maintenance costs are estimated as a percentage of the initial purchase costs, but are applied only to the extent that the cask and equipment is in use in a particular year. The annual use of the cask and equipment inventory is estimated by comparing cask shipments with fleet capacity. The cask shipment capacity of the fleet is estimated by multiplying the number of casks in the inventory by annual turnover. Cask shipments divided by fleet capacity gives the fleet capacity in use. Except for HLW shipments, which are assumed to proceed (from four defense sites), at a steady 750 canisters per year, annual variation in cask shipments reduces the fleet capacity in use to under 50 percent.

Transportation Cask and Equipment Decommissioning (Master Code 2.1.6, 2.2.6, 2.3.6)

Decommissioning costs are incurred as the casks and equipment go out of service and are estimated as a percentage of original purchase costs. Rail cask cars and truck trailers are assumed to have some salvage value which offsets the decommissioning costs of the casks themselves.

Heavy-Haul to Rail Head (Master Code 2.1.7)

Several sites which, under the assumptions used in this assessment, would choose onsite storage option two do not or no longer have an onsite rail spur. The cost of heavy-haul to a nearby railhead is estimated based on a cost per shipment plus a cost per ton-mile, and is assumed to be the obligation of the Nuclear Waste Fund.

Centralized Storage of SNF Arriving Uncanistered (Master Code 4.3.1)

This assessment assumes that SNF arriving uncanistered at the centralized storage facility is placed in metal casks for above-ground storage. The metal casks are assumed to be similar to the NAC ST cask, with capacity for 57 BWR or 27 PWR assemblies. The number of such casks required is based on the cumulative inventory arriving at the central storage facility by legal-weight truck, less the cumulative inventory emplaced (assuming the same emplacement rates for SNF which arrives at the CSF canistered or uncanistered). The cost for metal casks is estimated on a per cask basis, assuming no operation and maintenance cost, and a need to replace only five percent after 20 years.

Centralized Storage of SNF Arriving Canistered (Master Code 4.3.2)

This assessment assumes that SNF arriving in dual-purpose rail canisters is placed in concrete bunkers or vaults for centralized above-ground storage. The cost for construction and decommissioning of concrete storage facilities is estimated on a per assembly basis, using factors consistent with those used in estimates of the incremental costs of onsite dry storage.

Additional Canisters Required for Rail Shipment (Master Code 4.3.3)

Rail shipment sites which have (under onsite storage option one) used storage-only canisters or spent fuel pools for onsite dry storage require dual-purpose canisters for rail shipment. The cost of such canisters (consistent with the cost of those purchased for onsite dry storage) is incurred at pickup and is the obligation of the Nuclear Waste Fund.

3.6 COST ANALYSIS PROCEDURES: NEVADA COMPONENTS

Standard engineering analysis procedures were used to estimate the design, construction, equipment and operations costs of Nevada components of the DOE/OCRWM waste management program—intermodal transfer at Caliente, heavy-haul between Caliente and NTS Area 25, rail spur construction and operations between Caliente and Yucca Mountain, centralized storage at NTS Area 25, and geologic disposal. A design concept for each of these components was developed through review of DOE and other sources, then detailed in over 200 cost items, sub-items and elements. Each cost item or element was described or dimensioned, then costed in terms of units purchased at a specified unit cost. Unit costs were developed from standard construction and other industry sources. The allocation of item costs to years in which costs are incurred was based on the overall schedule for transport and emplacement assumed for this assessment and discussed in section 3.4, above.

Intermodal Transfer Facility (Master Code 3.1)

Thirty-five cost items and elements are considered in estimating the cost of constructing and operating an intermodal transfer facility at Caliente. Major items include the construction of a rail spur to the site and the construction of rail sidings (20 car capacity); the purchase of two switch engines; the installation of a 150-ton crane, the construction of a wastewater treatment plant (1,500 person capacity) for the town of Caliente;* and the construction of a truck service center. Over 40 percent of total systems cost for this component is the cost of staff, utilities and equipment maintenance over a 62-month operations period.

Heavy-Haul to NTS Area 25 (Master Code 3.2)

Twenty-four cost items and elements are considered in estimating the cost of heavy-haul from Caliente around the north and west sides of the Nellis Air Force Range to a central storage facility at NTS Area 25. Major costs include the construction of slow lanes (up and downgrade); the upgrading of existing road surface and selected road base and bridges; the purchase of major equipment for the heavy-haul operations (transporters, tractors, pusher trucks, escort vehicles, communications); and the consumables (tires, fuel, etc.) for the heavy-haul operation.

Rail Spur Construction and Operation (Master Code 3.3)

The 365-mile rail spur from Caliente to Yucca Mountain is costed as a government owned and operated "short-line" railroad. Twenty-two cost items are considered, of which by far the largest is the construction of the 365-mile single track rail line. Other significant items include the cost of staff and other operations over a 33-year period; the design costs for the rail line and its ancillary facilities, the

* As specified in Senate Bill 104.

purchase of locomotives, signal systems and other major equipment; and cost of periodic overhaul of major equipment.

The Central Storage Facility (Master Code 4.0)

Thirty-eight cost items and elements are considered in estimating the cost of the facility for centralized above-ground storage at NTS Area 25. By far, the largest is the cost of metal and concrete storage for SNF arriving canistered and uncanistered but not yet emplaced (see section 3.5, above). Other major items include the construction of storage pads and access alleys; the construction of a large reinforced concrete transfer facility (used in part as a staging location for the accumulation of uncanistered SNF to be loaded into metal storage casks); and the cost of staff, utilities and equipment maintenance during operation.

The Repository (Master Code 5.0)

Ninety cost items and elements are considered in projecting the cost for completing site characterization at Yucca Mountain and for construction and operation of the geologic repository. The major surface facility items are the construction of a waste handling building and a disposal container receiving facility. Major underground construction includes the cost of driving service and emplacement drifts and turnouts. The cost of staff, utilities and equipment maintenance (above-ground and underground) during emplacement, care-taking and closure/decommissioning is a major cost, as is the cost of designing surface and underground facilities (upfront and ongoing during operations). The purchase of about 11,000 containers for emplacement of SNF is also a major cost.

3.7 COST PROCEDURES: OTHER PROGRAM COMPONENTS

Several other program components considered in previous DOE estimates of TSLCC do not lend themselves to cost assessment via the site-by-site analysis used for onsite storage and transportation or the engineering cost analysis used for Nevada components.

Technical Assistance Training: NWPA Section 180 (c) (Master Code 2.4)

This analysis estimated the cost of technical assistance training required by NWPA Section 180(c) to prepare affected states, counties and Indian tribes to effectively prepare for and respond to emergencies (accidents or incidents) in a shipment campaign involving (under assumptions used in this assessment) 30,400 cask shipments and 65 million cask shipment miles by rail and truck. The state, local and Tribal responsibilities are for "awareness" and "first response", and do not include the full cost of responding to, or cleaning-up after, accidents or incidents.

Costs are estimated in terms of estimated annual payments to 40 states,* 10 particularly affected counties, 4 regional organizations of states, and an unspecified number of Indian Tribes and organizations. The costs also include contracts and agreements (with federal agencies and labs) to prepare and deliver the training.

Costs are assumed to begin two years ahead of the first shipment (2003 in this assessment) and to extend at a relatively high "gear-up"level over ten years, then to continue at a lower "maintenance"

* Two groups of five states are assumed to be affected to a greater degree than the remaining 30.

level throughout the SNF shipment campaign, and at an even lower level during the remaining years of the HLW shipment campaign.

Repository Site Characterization (Master Code 5.1)

Through FY 1996, DOE expended $4.376 million (FY'96$) on characterization of the nation's first geologic repository for high-level radioactive wastes. Of this, $2.768 million (63.3 percent) was spent at Yucca Mountain, $691 million (15.8 percent) at the Hanford site in Washington, and $741 million (16.9 percent) at the Deaf Smith County site in Texas. An additional $158 million was spent in the mid-1980's in preliminary characterization for the nation's second repository.

In 1991, DOE estimated that characterization at Yucca Mountain would require expenditure of $6,531 million, of which $1,869 million is included in DOE's funding request for FY 1997 or its projected funding requirements for FY 1998-2002. The difference between the 1991 estimate ($6,531 million) and the expenditure through FY 1996 ($4,376 million) is included as the remaining expenditure for site characterization in this assessment. This estimate is assumed to include contingency and project management. The cost of the recently-authorized east-west tunnel in the exploratory studies facility (estimated via engineering costing procedures) is included in addition to the site characterization estimates from 1991. Note that DOE's estimate of funding requirements for site characterization "reflect activities specified in the revised Program Plan through submission of a license application to the Nuclear Regulatory Commission"*—implying that site characterization does not include activities subsequent to submission of the license application, or not reflected in the current Program Plan.

Other Development and Evaluation Costs (Master Code 6.0)

All DOE expenditure to-date has been "development and evaluation"—a broad category which includes the exploratory studies facility at Yucca Mountain, site characterization at Yucca Mountain and other sites, and various planning activities related to waste acceptance, transportation, and interim or monitored retrievable storage.

In this assessment, projected expenditure for development and evaluation are specified for Yucca Mountain site characterization (master code 5.1) or included in estimates for program management. However, DOE's 9/95 TSLCC included estimates for NRC fees, support of the Nuclear Waste Technical Review Board and the Nuclear Waste Negotiator (whose activities began in 1990 and were terminated in 1995). This assessment uses DOE's estimates (adjusted to FY'96$) for these "other development and evaluation costs"—even though the waste management assumptions for this assessment could require activity by NRC, the NWTRB and other review or regulatory agencies which was not anticipated in 1995.

Other Program Costs (Master Code 7.0)

This assessment uses DOE's 9/95 estimates (adjusted to FY'96$) for Payments Equal to Taxes and Benefits. However, several program components required by the waste management assumptions of this assessment (intermodal transfer, heavy-haul, rail spur and centralized storage) were not anticipated in previous estimates of TSLCC. For these components, PETT was estimated based on the direct construction and major equipment costs of the facilities that would form an assessment base were the

* Civilian Radioactive Waste Management Program: Funding Requirements (FY 1997-FY 2002), Table 3.

facilities privately-owned and operated. Other factors are the years in which PETT is applicable, the assessment rate (35 percent in Nevada), tax rates (selected FY'96 unit tax rates in Lincoln and Nye Counties), and the portion of the rail spur likely to be located in the two counties.

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APPENDIX A: ACRONYMS

We have attempted to explain acronyms in the body of the text. The following is a summary list and explanation of the more commonly used acronyms:

CSF: Central Storage Facility
A facility for above-ground dry storage of large volumes of spent fuel previously located in spent fuel pools or dry storage at multiple reactor sites. The facility would include equipment for opening and reloading casks and canisters, but not for consolidation of spent fuel or other operations envisioned for the Monitored Retrievable Storage (MRS) facility specified in the NWPA.

DOE: The US Department of Energy
In this report "DOE" generally refers to the Department's Office of Civilian Radioactive Waste Management (DOE/OCRWM) established by the Nuclear Waste Policy Act to dispose of spent nuclear fuel and other highly radioactive wastes.

ESF: The Exploratory Studies Facility
A five-mile tunnel into and across the emplacement block within Yucca Mountain, in which DOE will conduct tests and experiments critical to determining the suitability of the mountain for permanent geologic disposal.

HLW: High-Level Waste
Highly radioactive material, containing fission products, traces of uranium and plutonium and other transuranic elements, that results from chemical reprocessing of spent fuel.

LWT: Legal-Weight Truck
Legal weight on the nation's highways is generally 80,000 lbs, or 40 tons, including the payload, shipping tackle, truck and trailer.

MTU: Metric Tons Uranium

NRC: The Nuclear Regulatory Commission
Previously part of the Atomic Energy Commission, the NRC is the regulatory body responsible for licensing the repository, nuclear reactors and their pools and dry storage facilities, a centralized dry storage facility, and transportation casks and canisters.

NWF: The Nuclear Waste Fund
Established by the Nuclear Waste Policy Act (Section 302) with revenues from the one mil per kilowatt hour fee on sales of nuclear-generated power to ensure full recovery of the costs of long-term storage and permanent disposal of commercial SNF.

NWPA: The Nuclear Waste Policy Act of 1982
The act is Public Law 97-425, January 7, 1983. It established DOE/OCRWM and its responsibilities to dispose of commercial spent fuel, in return for the payment of fees on sales of nuclear generated power. The act was amended by Title V of Public Law 100-203 in December 1997. Proposed legislation in the Senate (S-104) and House (HR-1270) would replace the NWPA.

PETT: Payments Equal to Taxes
Section 116(c)(3) of the NWPA, requires DOE to grant to the State of Nevada or any affected unit of government amounts equal to the taxes on comparable non-Federal real property and industrial activity.

SNF: Spent Nuclear Fuel
Fuel that has been irradiated in a nuclear reactor to the point that it no longer contributes efficiently to the nuclear chain reaction. Spent fuel is thermally hot and highly radioactive.

TSLCC: Total System Life Cycle Cost
Life cycle costing was created during the 1970's to consider the ownership (operations) as well as the acquisition (design and construction) costs of military systems, and to compare systems over their "life cycle", taking into account the value of money spent at various points in time. See "Life Cycle Costing: Techniques, Models and Applications" by B.S. Dhillon, 1989.

APPENDIX B: TOTAL SYSTEM COSTS: FY 1983-FY 2071

The table presents annual and cumulative estimates of total systems costs—distinguishing repository and site characterization from other program activity, and comparing estimates of the independent cost assessment with those of DOE published in September 1995. The DOE estimates are those presented in the September 1995 report, adjusted to FY'96$. The independent cost analysis combines two sources:

- A tabulation of actual program expenditures (compiled from SOAR #9 reports) from FY 1983 through FY 1996, adjusted to FY'96$.
- Projected expenditures from FY 1997 forward, as discussed in Chapter 3, in FY'96$. The charts compare cumulative total systems costs, distinguishing repository from other program activity.

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INDEPENDET COST ASSESSMENT: ACTUAL DOE/OCRWM EXPENSES (FY'83-'96); PROJECTED EXPENSES (FY'97-'71)
DOE/OCRWM TSLCC (9/95): MIL CONSTANT (FY'96) $

	Annual Expenses.... INDEP COST ASSESS			DOE TSLCC: 9/95			Cumulative Expenses.... INDEP COST ASSESS			DOE TSLCC: 9/95		
	TOTAL	Reposl SiteC	Other	TOTAL	Repos	Other	TOTAL	Reposl SiteC	Other	TOTAL	Repos	Other
1983	280.9	248.0	32.9	250.7	233.0	17.6	281	248	33	251	233	18
1984	417.6	332.6	85.0	378.5	310.7	67.8	698	581	118	629	544	85
1985	461.5	322.8	138.7	425.1	327.4	97.7	1160	903	257	1054	871	183
1986	567.9	416.6	151.3	528.8	422.4	106.4	1728	1320	408	1583	1294	290
1987	649.7	503.8	145.9	610.9	508.8	102.0	2378	1824	554	2194	1802	392
1988	508.1	394.5	113.6	478.4	381.7	96.7	2886	2218	667	2672	2184	488
1989	469.0	299.3	169.7	413.8	284.1	129.7	3355	2518	837	3086	2468	618
1990	371.9	249.6	122.4	394.9	239.0	155.9	3727	2767	960	3481	2707	774
1991	348.1	211.0	137.1	366.6	214.7	151.8	4075	2978	1097	3848	2922	926
1992	364.6	225.2	139.4	392.0	225.3	166.7	4439	3203	1236	4240	3147	1092
1993	402.6	250.0	152.6	431.0	251.2	179.8	4842	3453	1389	4671	3399	1272
1994	428.7	295.7	133.1	460.3	295.6	164.8	5271	3749	1522	5131	3694	1437
1995	523.1	388.9	134.1	558.3	382.1	176.2	5794	4138	1656	5689	4076	1613
1996	334.3	237.7	96.5	646.0	464.8	181.2	6128	4376	1752	6335	4541	1794
1997	420.9	389.9	31.0	693.9	503.5	190.4	6549	4766	1783	7029	5045	1985
1998	573.4	417.1	156.3	684.5	481.8	202.7	7122	5183	1940	7714	5526	2187
1999	645.6	417.8	227.8	668.4	459.7	208.7	7768	5600	2167	8382	5986	2396
2000	892.7	415.4	477.3	609.4	394.3	215.1	8661	6016	2645	8991	6380	2611
2001	669.8	415.4	254.5	606.6	291.4	315.2	9330	6431	2899	9598	6672	2926
2002	1028.2	380.2	648.0	485.7	215.4	270.2	10359	6811	3547	10084	6887	3197
2003	1488.4	365.6	1122.8	472.9	215.1	257.8	11847	7177	4670	10557	7102	3454
2004	1180.5	240.8	939.7	588.4	330.0	258.4	13028	7418	5610	11145	7432	3713
2005	1792.9	755.6	1037.3	675.0	423.2	251.8	14820	8173	6647	11820	7856	3965
2006	2031.3	853.7	1177.6	698.8	458.3	240.5	16852	9027	7825	12519	8314	4205
2007	1721.3	876.8	844.5	770.4	481.2	289.2	18573	9904	8669	13289	8795	4494
2008	1998.7	1120.8	877.8	931.0	667.4	263.6	20572	11025	9547	14220	9462	4758
2009	1052.7	269.9	782.8	982.1	663.1	319.0	21624	11295	10330	15202	10126	5077
2010	996.5	301.5	695.0	733.2	373.5	359.7	22621	11596	11025	15936	10499	5436
2011	1044.6	350.4	694.1	598.1	185.9	412.1	23666	11947	11719	16534	10685	5849
2012	1007.1	413.6	593.4	638.4	210.2	428.2	24673	12360	12312	17172	10895	6277
2013	1012.9	451.4	561.4	641.7	235.7	406.0	25685	12812	12874	17814	11131	6683
2014	953.4	448.7	504.7	699.0	277.7	421.2	26639	13260	13378	18513	11409	7104
2015	1030.0	448.7	581.4	734.2	326.7	407.5	27669	13709	13960	19247	11735	7511
2016	1008.3	448.7	559.6	677.7	324.3	353.5	28677	14158	14519	19925	12060	7865
2017	1031.7	448.7	583.0	671.8	323.6	348.1	29709	14606	15102	20596	12383	8213
2018	1032.7	450.6	582.1	669.4	318.7	350.8	30742	15057	15685	21266	12702	8564
2019	1061.5	448.7	612.8	660.6	317.1	343.5	31803	15506	16297	21926	13019	8907
2020	1047.0	448.7	598.3	662.5	316.0	346.5	32850	15954	16896	22589	13335	9254
2021	1034.5	448.7	585.8	663.7	316.6	347.2	33884	16403	17482	23253	13652	9601
2022	1047.9	448.7	599.2	660.3	318.4	341.9	34932	16852	18081	23913	13970	9943
2023	1200.9	465.7	735.2	665.9	316.1	349.8	36133	17317	18816	24579	14286	10293
2024	1066.8	448.7	618.2	663.9	317.4	346.5	37200	17766	19434	25243	14604	10639
2025	1118.0	448.7	669.4	663.8	315.5	348.3	38318	18215	20103	25906	14919	10987
2026	1083.4	448.7	634.7	667.5	315.5	352.0	39402	18663	20738	26574	15235	11339
2027	1139.1	448.7	690.4	667.1	318.3	348.8	40541	19112	21429	27241	15553	11688
2028	1097.6	450.6	647.1	659.2	316.7	342.5	41638	19563	22076	27900	15870	12031
2029	1102.2	448.7	653.5	674.7	319.4	355.3	42740	20011	22729	28575	16189	12386
2030	1080.3	448.7	631.6	656.8	302.3	354.4	43821	20460	23361	29232	16491	12740
2031	918.9	448.7	470.2	636.6	290.1	346.5	44740	20909	23831	29868	16781	13087
2032	1464.8	448.7	1016.2	652.9	292.5	360.5	46204	21357	24847	30521	17074	13447
2033	767.4	451.4	316.1	655.3	290.5	364.8	46972	21809	25163	31177	17364	13812
2034	554.2	401.8	152.5	502.9	293.4	209.6	47526	22210	25316	31680	17658	14022
2035	588.3	401.8	186.6	430.2	290.8	139.3	48114	22612	25502	32110	17949	14161
2036	519.8	401.8	118.0	407.7	290.5	117.2	48634	23014	25620	32517	18239	14278
2037	520.3	401.8	118.5	411.2	284.7	126.5	49155	23416	25739	32929	18524	14405
2038	522.1	403.6	118.5	341.4	236.5	104.9	49677	23819	25857	33270	18760	14510
2039	442.2	323.2	119.0	343.6	247.6	96.0	50119	24143	25976	33614	19008	14606
2040	163.3	51.9	111.4	305.9	241.7	64.1	50282	24194	26088	33919	19250	14670
2041	80.6	31.7	48.9	56.3	17.4	38.9	50363	24226	26137	33976	19267	14709
2042	57.8	24.2	33.6	24.7	12.8	11.8	50420	24250	26170	34000	19280	14721
2043	75.7	24.2	51.5	24.5	12.8	11.7	50496	24274	26222	34025	19293	14732
2044	58.1	24.2	34.0	24.4	12.8	11.6	50554	24299	26256	34049	19305	14744
2045	39.6	24.2	15.4	24.3	12.8	11.4	50594	24323	26271	34074	19318	14755

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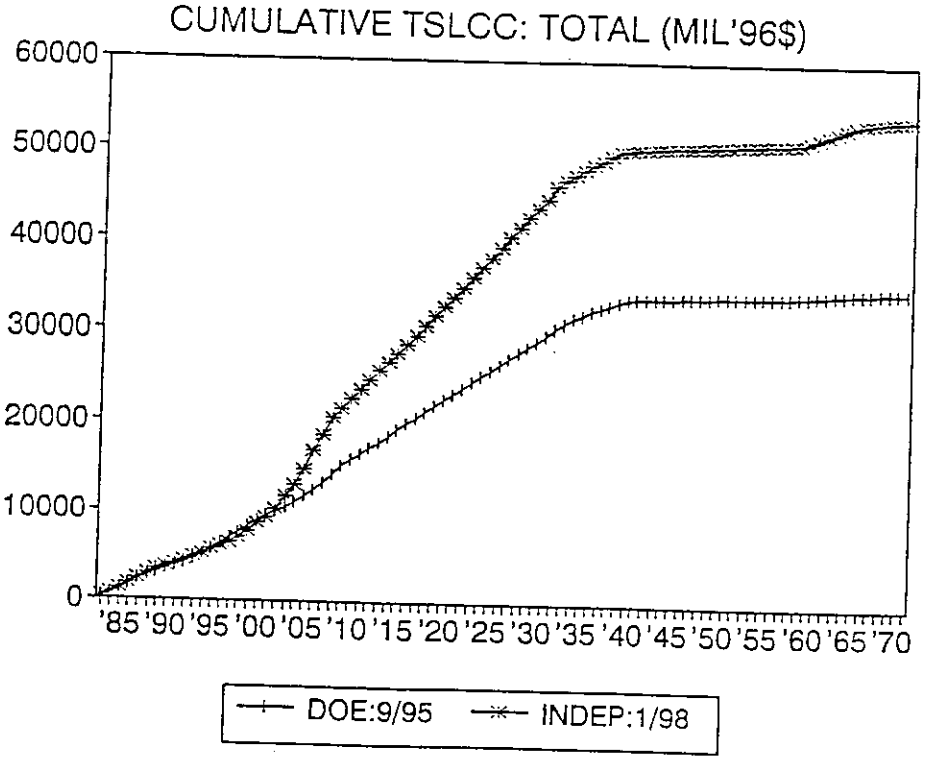
INDEPENDET COST ASSESSMENT: ACTUAL DOE/OCRWM EXPENSES (FY'83-'96); PROJECTED EXPENSES (FY'97-'71)
DOE/OCRWM TSLCC (9/95): MIL CONSTANT (FY'96) $

	Annual Expenses.... INDEP COST ASSESS			DOE TSLCC: 9/95			Cumulative Expenses.... INDEP COST ASSESS			DOE TSLCC: 9/95		
	TOTAL	Repos1 SiteC	Other	TOTAL	Repos	Other	TOTAL	Repos1 SiteC	Other	TOTAL	Repos	Other
2046	38.1	24.2	13.9	24.1	12.8	11.3	50632	24347	26285	34098	19331	14767
2047	39.3	24.2	15.1	24.0	12.8	11.2	50671	24371	26300	34122	19344	14778
2048	49.8	36.4	13.4	31.3	20.2	11.1	50721	24407	26313	34153	19364	14789
2049	46.3	36.4	9.9	31.2	20.2	10.9	50767	24444	26323	34184	19384	14800
2050	45.0	33.3	11.6	29.2	18.4	10.8	50812	24477	26335	34213	19403	14811
2051	34.9	24.2	10.7	23.5	12.8	10.7	50847	24501	26346	34237	19415	14821
2052	76.9	24.2	52.8	23.4	12.8	10.6	50924	24526	26399	34260	19428	14832
2053	33.6	24.2	9.4	23.3	12.8	10.5	50958	24550	26408	34284	19441	14842
2054	33.5	24.2	9.3	23.2	12.8	10.4	50991	24574	26417	34307	19454	14853
2055	38.3	24.2	14.1	23.1	12.8	10.3	51029	24598	26431	34330	19467	14863
2056	32.8	23.7	9.1	23.0	12.8	10.2	51062	24622	26440	34353	19480	14873
2057	32.7	23.7	9.0	22.9	12.8	10.1	51095	24645	26449	34376	19492	14883
2058	44.8	36.0	8.9	30.3	20.2	10.0	51140	24681	26458	34406	19513	14893
2059	46.4	37.6	8.8	31.2	21.2	9.9	51186	24719	26467	34437	19534	14903
2060	403.0	393.6	9.4	73.1	61.5	11.6	51589	25113	26477	34510	19595	14915
2061	339.7	330.4	9.3	63.1	51.6	11.5	51929	25443	26486	34573	19647	14926
2062	339.6	330.4	9.2	63.0	51.6	11.4	52268	25773	26495	34636	19699	14938
2063	339.5	330.4	9.1	62.9	51.6	11.3	52608	26104	26504	34699	19750	14949
2064	339.5	330.4	9.1	62.8	51.6	11.3	52947	26434	26513	34762	19802	14960
2065	339.4	330.4	9.0	62.7	51.6	11.2	53287	26765	26522	34825	19853	14972
2066	151.8	142.9	8.9	33.2	22.1	11.1	53439	26907	26531	34858	19875	14983
2067	136.6	127.7	8.8	30.7	19.7	11.0	53575	27035	26540	34889	19895	14994
2068	136.5	127.7	8.8	30.7	19.7	11.0	53712	27163	26549	34919	19915	15005
2069	136.4	127.7	8.7	30.6	19.7	10.9	53848	27291	26557	34950	19934	15016
2070	32.3	23.7	8.6	14.2	3.3	10.8	53881	27314	26566	34964	19938	15026
2071	24.9	16.4	8.5	13.0	2.2	10.8	53905	27331	26575	34977	19940	15037
TOT	53905	27331	26575	34977	19940	15037						
'97+	47777	22955	24822	28642	15399	13243						
%97+	88.6%	84.0%	93.4%	81.9%	77.2%	88.1%						



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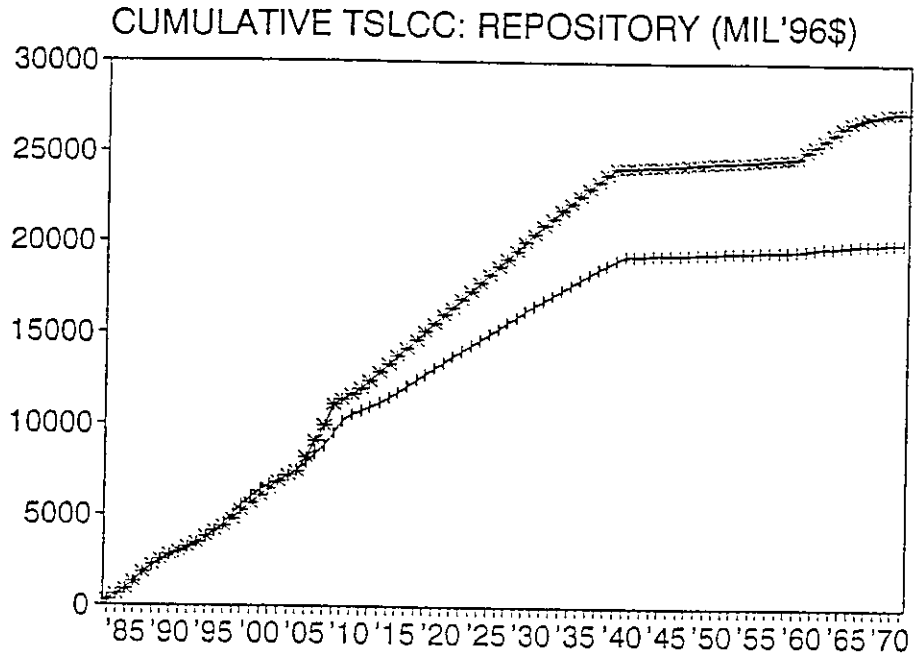
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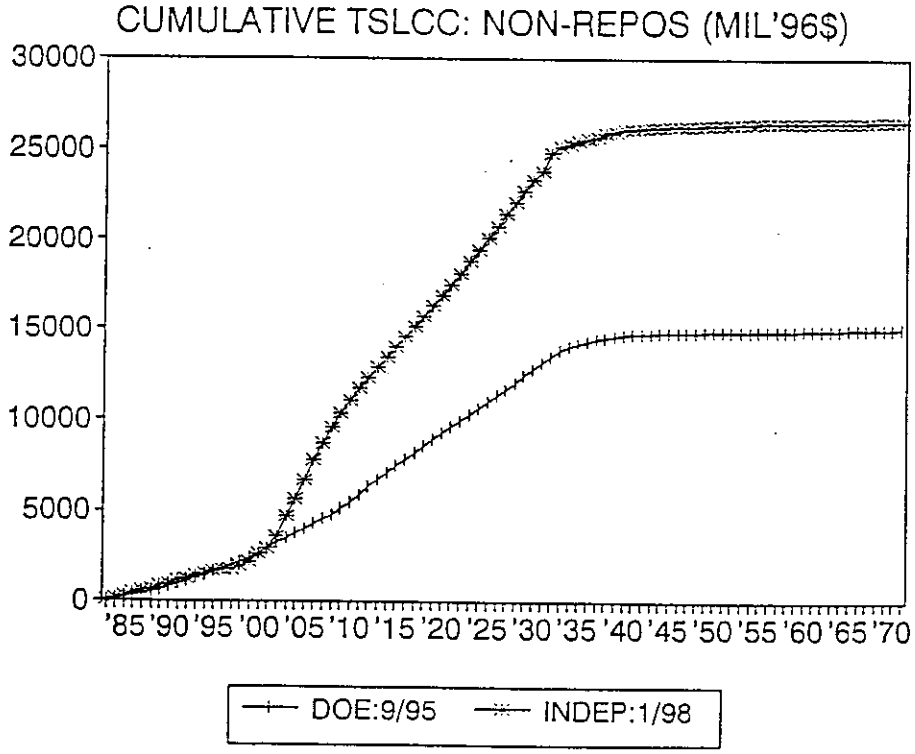
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DOE:9/95
INDEP:1/98

APPENDIX C: PROJECTED TOTAL SYSTEMS COSTS: FY 1997 - FY 2071 (MIL'96$)

The Table presents projected systems costs by "master code" categories. Master code categories were used in the assembly of estimates developed by various costing procedures (discussed in Section 3.4-6). The total in this instance is the total *projected* costs for FY 1997 through FY 2071. These estimates exclude costs which are the responsibility of other offices within DOE (e.g., the vitrification, canistering and interim storage of HLW), or of nuclear utilities (e.g., the cost for onsite storage of SNF that utilities are and will be required to store even if pickup had begun in 1998 and proceeded at S-104 rates). The table also presents the distribution of projected expenses, a calculation of the net present value of the projected costs streams (assuming three percent real interest rate), and the NPV percentage of total projected costs in constant dollar terms.

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THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM: PROJECTED PROGRAM COSTS (FY 1997-FY 2071: MIL'96$)

MASTER	Description	Total	%total	%categ	NPV	NPV%TOT
1.0	ONSITE STORAGE COSTS	4278.9	9.0%	100.0%	2215.5	51.8%
1.1	Commercial SNF in Que	3886.1	8.1%	90.8%	1970.5	50.7%
1.1.1	Dry Storage	575.9	1.2%	13.5%	360.1	62.5%
1.1.1.1	Opt 1/LWT: 26 sites	133.0	0.3%	3.1%	85.1	64.0%
1.1.1.2	Opt 1/R125: 17 sites	100.6	0.2%	2.4%	64.6	64.3%
1.1.1.3	Opt 2/R125: 11 sites	202.3	0.4%	4.7%	125.2	61.9%
1.1.1.4	Opt 1/R75: 14 sites	32.1	0.1%	0.8%	21.9	68.3%
1.1.1.5	Opt 2/R75: 5 sites	108.0	0.2%	2.5%	63.2	58.5%
1.1.2	Pool Op after Reactor Shutdn	3273.2	6.9%	76.5%	1582.5	48.3%
1.1.2.1	Opt 1/LWT: 26 sites	1350.9	2.8%	31.6%	674.9	50.0%
1.1.2.2	Opt 1/R125: 17 sites	799.3	1.7%	18.7%	349.7	43.7%
1.1.2.3	Opt 2/R125: 11 sites	236.8	0.5%	5.5%	130.6	55.1%
1.1.2.4	Opt 1/R75: 14 sites	757.3	1.6%	17.7%	353.9	46.7%
1.1.2.5	Opt 2/R75: 5 sites	129.0	0.3%	3.0%	73.5	57.0%
1.1.3	Pool Loading Upgrades	37.0	0.1%	0.9%	27.9	75.4%
1.1.3.1	Opt 1/LWT: 26 sites	1.0	0.0%	0.0%	0.8	79.3%
1.1.3.2	Opt 1/R125: 17 sites	8.7	0.0%	0.2%	5.9	68.0%
1.1.3.3	Opt 2/R125: 11 sites	17.6	0.0%	0.4%	13.6	77.0%
1.1.3.4	Opt 1/R75: 14 sites	0.9	0.0%	0.0%	0.7	83.7%
1.1.3.5	Opt 2/R75: 5 sites	8.7	0.0%	0.2%	6.8	78.5%
1.2	DOE SNF & SNF not in Que	392.8	0.8%	9.2%	245.1	62.4%
1.2.1	Dry Storage	5.4	0.0%	0.1%	4.3	80.3%
1.2.2	Pool Op after Reactor Shutdn	387.4	0.8%	9.1%	240.7	62.1%
1.2.3	Pool Loading Upgrades	0.0	0.0%	0.0%	0.0	NA
1.3	DOE High-Level Waste	NA	0.0%	0.0%	0.0	NA
2.0	X-COUNTRY TRANSPORTATION	5968.2	12.5%	100.0%	3103.7	52.0%
2.1	Commercial SNF in Que	4269.3	8.9%	71.5%	2355.1	55.2%
2.1.1	Cask Shipment Costs	3060.3	6.4%	51.3%	1683.1	55.0%
2.1.1.1	Legal-Wt Truck	1870.6	3.9%	31.3%	1056.4	56.5%
2.1.1.2	Large Rail	571.5	1.2%	9.6%	301.6	52.8%
2.1.1.3	Small Rail	618.1	1.3%	10.4%	325.1	52.6%
2.1.2	Shipment Escort Costs	158.4	0.3%	2.7%	88.0	55.5%
2.1.2.1	Legal-Wt Truck	115.7	0.2%	1.9%	65.5	56.6%
2.1.2.2	Large Rail	17.6	0.0%	0.3%	9.3	52.9%
2.1.2.3	Small Rail	25.1	0.1%	0.4%	13.2	52.5%
2.1.3	Cask Inspection Costs	73.4	0.2%	1.2%	40.2	54.8%
2.1.3.1	Legal-Wt Truck	44.4	0.1%	0.7%	25.0	56.3%
2.1.3.2	Large Rail	12.8	0.0%	0.2%	6.7	52.7%
2.1.3.3	Small Rail	16.2	0.0%	0.3%	8.5	52.7%
2.1.4	Cask & Equip Purchases	560.8	1.2%	9.4%	333.3	59.4%
2.1.4.1	Legal-Wt Truck	290.5	0.6%	4.9%	177.0	60.9%
2.1.4.2	Large Rail	125.9	0.3%	2.1%	72.8	57.8%
2.1.4.3	Small Rail	144.3	0.3%	2.4%	83.6	57.9%
2.1.5	Cask & Equip O&M	327.0	0.7%	5.5%	178.1	54.5%
2.1.5.1	Legal-Wt Truck	162.9	0.3%	2.7%	91.6	56.3%
2.1.5.2	Large Rail	77.9	0.2%	1.3%	41.0	52.7%
2.1.5.3	Small Rail	86.3	0.2%	1.4%	45.5	52.7%
2.1.6	Cask & Equip Decomm	78.1	0.2%	1.3%	25.7	32.9%
2.1.6.1	Legal-Wt Truck	41.4	0.1%	0.7%	14.0	33.7%
2.1.6.2	Large Rail	16.8	0.0%	0.3%	5.4	32.0%
2.1.6.3	Small Rail	19.8	0.0%	0.3%	6.3	32.1%
2.1.7	Hvy Haul to Railhead	11.4	0.0%	0.2%	6.6	58.5%
2.2	DOE Spent Nuclear Fuel	590.1	1.2%	9.9%	197.4	33.5%
2.2.1	Cask Shipment Costs	196.3	0.4%	3.3%	67.4	34.3%
2.2.2	Shipment Escort Costs	10.0	0.0%	0.2%	3.4	34.3%
2.2.3	Cask Inspection Costs	6.5	0.0%	0.1%	2.2	34.3%
2.2.4	Cask & Equip Purchases	309.4	0.6%	5.2%	107.7	34.8%
2.2.5	Cask & Equip O&M	23.7	0.0%	0.4%	8.1	34.3%
2.2.6	Cask & Equip Decomm	44.1	0.1%	0.7%	8.5	19.3%
2.3	DOE High-Level Wastes	505.1	1.1%	8.5%	207.6	41.1%
2.3.1	Cask Shipment Costs	349.6	0.7%	5.9%	143.3	41.0%
2.3.2	Shipment Escort Costs	12.3	0.0%	0.2%	5.0	41.0%
2.3.3	Cask Inspection Costs	11.6	0.0%	0.2%	4.7	40.6%
2.3.4	Cask & Equip Purchases	74.4	0.2%	1.2%	33.0	44.3%
2.3.5	Cask & Equip O&M	47.2	0.1%	0.8%	19.2	40.6%
2.3.6	Cask & Equip Decomm	9.9	0.0%	0.2%	2.4	24.5%
2.4	Technical Assist Trng: 180(c)	603.7	1.3%	10.1%	343.6	56.9%

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PROJECTED PROGRAM COSTS (FY 1997-FY 2071: MIL'96$)

MASTER	Description	Total	%total	%categ	NPV	%NPV
3.0	NEVADA TRANSPORTATION	3244.7	6.8%	100.0%	2433.5	75.0%
3.1	Intermodal Transfer Facility	92.3	0.2%	2.8%	75.9	82.2%
3.1.1	Land and ROW	0.5	0.0%	0.0%	0.4	94.3%
3.1.2	Construction	25.1	0.1%	0.8%	22.5	89.6%
3.1.2.1	Security Construction	5.6	0.0%	0.2%	5.1	91.5%
3.1.2.2	Site Work	2.7	0.0%	0.1%	2.4	91.5%
3.1.2.3	Facility Construction	16.8	0.0%	0.5%	14.9	88.7%
3.1.3	Major Equipment	3.2	0.0%	0.1%	2.8	86.3%
3.1.4	Operations	63.5	0.1%	2.0%	50.2	79.0%
3.1.4.1	Staff	55.9	0.1%	1.7%	44.2	79.0%
3.1.4.2	Other	7.6	0.0%	0.2%	6.0	79.0%
3.2	Heavy Haul to CSF	437.2	0.9%	13.5%	381.2	87.2%
3.2.1	Engineering	15.4	0.0%	0.5%	14.3	92.9%
3.2.2	Infrastructure Upgrade	248.0	0.5%	7.6%	227.0	91.5%
3.2.3	Midway Service Facility	9.3	0.0%	0.3%	8.4	90.9%
3.2.4	Equipment	36.9	0.1%	1.1%	30.5	82.7%
3.2.5	Operations	127.6	0.3%	3.9%	100.8	79.0%
3.2.5.1	Staff	49.9	0.1%	1.5%	39.5	79.0%
3.2.5.2	Road Maintenance	62.8	0.1%	1.9%	49.6	79.0%
3.2.5.3	Other	14.9	0.0%	0.5%	11.8	79.0%
3.3	Rail Spur to CSF/YMP	2715.1	5.7%	83.7%	1976.5	72.8%
3.3.1	Misc Upfront Costs	119.3	0.2%	3.7%	106.0	88.8%
3.3.2	Construction	1896.1	4.0%	58.4%	1497.2	79.0%
3.3.2.1	Rail Spur Const	1867.3	3.9%	57.5%	1475.3	79.0%
3.3.2.2	Ancillary Facil Const	28.8	0.1%	0.9%	21.9	75.9%
3.3.3	Major Equipment	20.9	0.0%	0.6%	15.5	74.4%
3.3.4	Operations	678.8	1.4%	20.9%	357.7	52.7%
3.3.4.1	Staff	556.7	1.2%	17.2%	293.4	52.7%
3.3.4.2	Other	122.1	0.3%	3.8%	64.3	52.7%
4.0	CENTRALIZED STORAGE FACILITY	9179.3	19.2%	100.0%	5327.1	58.0%
4.1	Misc Upfront Costs	65.2	0.1%	0.7%	60.5	92.9%
4.2	Construction	429.7	0.9%	4.7%	372.7	86.7%
4.2.1	Security Construction	8.4	0.0%	0.1%	7.4	88.0%
4.2.2	Site Work & Access	6.6	0.0%	0.1%	5.8	87.9%
4.2.3	Pads & Alleys	233.3	0.5%	2.5%	198.4	85.0%
4.2.4	Facility Construction	181.3	0.4%	2.0%	161.1	88.8%
4.3	Major Equipment	8469.2	17.7%	92.3%	4728.6	55.8%
4.3.1	Storage Casks, Metal	3782.1	7.9%	41.2%	2269.5	60.0%
4.3.2	Storage Casks, Concrete	628.4	1.3%	6.8%	395.4	62.9%
4.3.3	Addl Canisters for Rail Ship	4020.0	8.4%	43.8%	2029.9	50.5%
4.3.4	Other	38.6	0.1%	0.4%	33.8	87.5%
4.4	Operations	215.2	0.5%	2.3%	165.2	76.8%
4.4.1	Staff	204.1	0.4%	2.2%	156.7	76.8%
4.4.2	Other	11.1	0.0%	0.1%	8.5	76.8%
5.0	REPOSITORY	22955.1	48.0%	100.0%	11693.3	50.9%
5.1	Site Characterization	2553.8	5.3%	11.1%	2282.5	89.4%
5.1.1	As Proposed in 1991	2478.6	5.2%	10.8%	2212.7	89.3%
5.1.2	East-West Tunnel	75.2	0.2%	0.3%	69.8	92.9%
5.2	Design & License Application	1079.2	2.3%	4.7%	623.2	57.7%
5.2.1	Design: Upfront & Ongoing	973.6	2.0%	4.2%	529.3	54.4%
5.2.2	Prepare License	105.6	0.2%	0.5%	93.8	88.9%
5.3	Surface Facilities	6142.5	12.9%	26.8%	3143.1	51.2%
5.3.1	Construction	2397.7	5.0%	10.4%	1737.0	72.4%
5.3.1.1	North	2265.0	4.7%	9.9%	1658.9	73.2%
5.3.1.2	South	132.7	0.3%	0.6%	78.1	58.9%
5.3.2	Equipment	78.7	0.2%	0.3%	48.0	61.0%
5.3.3	Operations	3666.2	7.7%	16.0%	1358.1	37.0%
5.3.3.1	Staff	3530.7	7.4%	15.4%	1309.9	37.1%
5.3.3.2	Other	135.5	0.3%	0.6%	48.2	35.6%
5.4	Underground Facilities	7158.2	15.0%	31.2%	3004.6	42.0%
5.4.1	Construction	5052.4	10.6%	22.0%	1988.1	39.3%
5.4.2	Equipment	284.3	0.6%	1.2%	199.4	70.1%
5.4.3	Operations	1821.4	3.8%	7.9%	817.1	44.9%
5.4.3.1	Staff	703.8	1.5%	3.1%	234.9	33.4%
5.4.3.2	Other	1117.6	2.3%	4.9%	582.2	52.1%
5.5	Waste Containers	6021.4	12.6%	26.2%	2639.9	43.8%
6.0.0	OTHER DEVEL & EVAL COSTS	433.6	0.9%	100.0%	304.8	70.3%
6.1.0	NRC Fees	400.0	0.8%	92.3%	277.7	69.4%
6.2.0	NWTRB	33.6	0.1%	7.7%	27.1	80.7%
6.3.0	Nuclear Waste Negotiator	0.0	0.0%	0.0%	0.0	NA
7.0.0	OTHER PROGRAM COSTS	1717.8	3.6%	100.0%	755.5	44.0%
7.1.0	PETT Payments	1233.0	2.6%	71.8%	539.4	43.7%
7.1.1	DOE TSLCC 9/95	348.0	0.7%	20.3%	129.2	37.1%
7.1.2	Re Addl NV Components	885.0	1.9%	51.5%	410.1	46.3%
7.2.0	Benefits	484.8	1.0%	28.2%	216.2	44.6%
	GRAND TOTAL	47777.4	100.0%	100.0%	25833.5	54.1%

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APPENDIX D: PROJECTED DIRECT AND NON-DIRECT SYSTEMS COSTS: FY 1997 THROUGH FY 2071 (MIL'96$)

Direct costs are estimated via procedures discussed in sections 3.5 through 3.7, above. Other "non-direct" costs (contingency, project and program management) are discussed in section 3.3. The following table presents total projected direct, contingency, project management and program management costs by master code category. (Also included are estimates of the projected obligations of the Nuclear Waste Fund for costs attributable to commercial SNF.) A subsequent table presents these as percentages of total projected costs. A final table presents the factors used to estimate contingency and other non-direct costs in the independent assessment.

The factors are applied at the most detailed master code level, with results summed for higher levels. Contingency factors are applied to direct costs. Project management factors are applied to the sum of direct plus one-third of contingency costs. Program management factors are applied to the sum of direct, contingency and project management costs. Total projected costs are the sum of direct, contingency and project and program management costs. Factors used to estimate the obligation of the Nuclear Waste Fund are applied to total projected costs.

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THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM: DIRECT & NON-DIRECT COSTS (FY 1997-FY 2071: MIL'96$)

MASTER	Description	DIRECT	CONTNG	PROJCT	PROGRM	TOTAL	NWFOBL
1.0	ONSITE STORAGE COSTS	2845.7	426.9	448.2	558.1	4278.9	3963.7
1.1	Commercial SNF in Que	2584.5	387.7	407.1	506.9	3886.1	3886.1
1.1.1	Dry Storage	383.0	57.5	60.3	75.1	575.9	575.9
1.1.1.1	Opt 1/LWT: 26 sites	88.4	13.3	13.9	17.3	133.0	133.0
1.1.1.2	Opt 1/R125: 17 sites	66.9	10.0	10.5	13.1	100.6	100.6
1.1.1.3	Opt 2/R125: 11 sites	134.5	20.2	21.2	26.4	202.3	202.3
1.1.1.4	Opt 1/R75: 14 sites	21.3	3.2	3.4	4.2	32.1	32.1
1.1.1.5	Opt 2/R75: 5 sites	71.8	10.8	11.3	14.1	108.0	108.0
1.1.2	Pool Op after Reactor Shutdn	2176.9	326.5	342.9	426.9	3273.2	3273.2
1.1.2.1	Opt 1/LWT: 26 sites	898.4	134.8	141.5	176.2	1350.9	1350.9
1.1.2.2	Opt 1/R125: 17 sites	531.6	79.7	83.7	104.3	799.3	799.3
1.1.2.3	Opt 2/R125: 11 sites	157.5	23.6	24.8	30.9	236.8	236.8
1.1.2.4	Opt 1/R75: 14 sites	503.6	75.5	79.3	98.8	757.3	757.3
1.1.2.5	Opt 2/R75: 5 sites	85.8	12.9	13.5	16.8	129.0	129.0
1.1.3	Pool Loading Upgrades	24.6	3.7	3.9	4.8	37.0	37.0
1.1.3.1	Opt 1/LWT: 26 sites	0.7	0.1	0.1	0.1	1.0	1.0
1.1.3.2	Opt 1/R125: 17 sites	5.8	0.9	0.9	1.1	8.7	8.7
1.1.3.3	Opt 2/R125: 11 sites	11.7	1.8	1.8	2.3	17.6	17.6
1.1.3.4	Opt 1/R75: 14 sites	0.6	0.1	0.1	0.1	0.9	0.9
1.1.3.5	Opt 2/R75: 5 sites	5.8	0.9	0.9	1.1	8.7	8.7
1.2	DOE SNF & SNF not in Que	261.2	39.2	41.1	51.2	392.8	77.6
1.2.1	Dry Storage	3.6	0.5	0.6	0.7	5.4	1.1
1.2.2	Pool Op after Reactor Shutdn	257.7	38.6	40.6	50.5	387.4	76.5
1.2.3	Pool Loading Upgrades	0.0	0.0	0.0	0.0	0.0	0.0
1.3	DOE High-Level Waste	NA	NA	NA	NA	NA	NA
2.0	X-COUNTRY TRANSPORTATION	4044.9	582.9	561.9	778.5	5968.2	4883.9
2.1	Commercial SNF in Que	2839.4	425.9	447.2	556.9	4269.3	4269.3
2.1.1	Cask Shipment Costs	2035.3	305.3	320.6	399.2	3060.3	3060.3
2.1.1.1	Legal-Wt Truck	1244.1	186.6	195.9	244.0	1870.6	1870.6
2.1.1.2	Large Rail	380.1	57.0	59.9	74.5	571.5	571.5
2.1.1.3	Small Rail	411.1	61.7	64.7	80.6	618.1	618.1
2.1.2	Shipment Escort Costs	105.4	15.8	16.6	20.7	158.4	158.4
2.1.2.1	Legal-Wt Truck	77.0	11.5	12.1	15.1	115.7	115.7
2.1.2.2	Large Rail	11.7	1.8	1.8	2.3	17.6	17.6
2.1.2.3	Small Rail	16.7	2.5	2.6	3.3	25.1	25.1
2.1.3	Cask Inspection Costs	48.8	7.3	7.7	9.6	73.4	73.4
2.1.3.1	Legal-Wt Truck	29.5	4.4	4.7	5.8	44.4	44.4
2.1.3.2	Large Rail	8.5	1.3	1.3	1.7	12.8	12.8
2.1.3.3	Small Rail	10.8	1.6	1.7	2.1	16.2	16.2
2.1.4	Cask & Equip Purchases	373.0	55.9	58.7	73.1	560.8	560.8
2.1.4.1	Legal-Wt Truck	193.2	29.0	30.4	37.9	290.5	290.5
2.1.4.2	Large Rail	83.8	12.6	13.2	16.4	125.9	125.9
2.1.4.3	Small Rail	96.0	14.4	15.1	18.8	144.3	144.3
2.1.5	Cask & Equip O&M	217.5	32.6	34.3	42.7	327.0	327.0
2.1.5.1	Legal-Wt Truck	108.3	16.2	17.1	21.2	162.9	162.9
2.1.5.2	Large Rail	51.8	7.8	8.2	10.2	77.9	77.9
2.1.5.3	Small Rail	57.4	8.6	9.0	11.3	86.3	86.3
2.1.6	Cask & Equip Decomm	51.9	7.8	8.2	10.2	78.1	78.1
2.1.6.1	Legal-Wt Truck	27.6	4.1	4.3	5.4	41.4	41.4
2.1.6.2	Large Rail	11.2	1.7	1.8	2.2	16.8	16.8
2.1.6.3	Small Rail	13.2	2.0	2.1	2.6	19.8	19.8
2.1.7	Hvy Haul to Railhead	7.6	1.1	1.2	1.5	11.4	11.4
2.2	DOE Spent Nuclear Fuel	392.4	58.9	61.8	77.0	590.1	123.3
2.2.1	Cask Shipment Costs	130.6	19.6	20.6	25.6	196.3	45.0
2.2.2	Shipment Escort Costs	6.6	1.0	1.0	1.3	10.0	2.6
2.2.3	Cask Inspection Costs	4.3	0.6	0.7	0.8	6.5	1.2
2.2.4	Cask & Equip Purchases	205.8	30.9	32.4	40.4	309.4	61.1
2.2.5	Cask & Equip O&M	15.8	2.4	2.5	3.1	23.7	4.7
2.2.6	Cask & Equip Decomm	29.4	4.4	4.6	5.8	44.1	8.7
2.3	DOE High-Level Wastes	335.9	50.4	52.9	65.9	505.1	0.0
2.3.1	Cask Shipment Costs	232.5	34.9	36.6	45.6	349.6	0.0
2.3.2	Shipment Escort Costs	8.2	1.2	1.3	1.6	12.3	0.0
2.3.3	Cask Inspection Costs	7.7	1.2	1.2	1.5	11.6	0.0
2.3.4	Cask & Equip Purchases	49.5	7.4	7.8	9.7	74.4	0.0
2.3.5	Cask & Equip O&M	31.4	4.7	4.9	6.2	47.2	0.0
2.3.6	Cask & Equip Decomm	6.6	1.0	1.0	1.3	9.9	0.0
2.4	Technical Assist Trng: 180(c)	477.2	47.7	0.0	78.7	603.7	491.3

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DIRECT & NON-DIRECT COSTS (FY 1997-FY 2071: MIL'96$)

MASTER	Description	DIRECT	CONTNG	PROJCT	PROGRM	TOTAL	NWFOBL
3.0	NEVADA TRANSPORTATION	2077.0	412.3	332.2	423.2	3244.7	2400.8
3.1	Intermodal Transfer Facility	61.4	9.2	9.7	12.0	92.3	92.3
3.1.1	Land and ROW	0.3	0.0	0.0	0.1	0.5	0.5
3.1.2	Construction	16.7	2.5	2.6	3.3	25.1	25.1
3.1.2.1	Security Construction	3.7	0.6	0.6	0.7	5.6	5.6
3.1.2.2	Site Work	1.8	0.3	0.3	0.3	2.7	2.7
3.1.2.3	Facility Construction	11.2	1.7	1.8	2.2	16.8	16.8
3.1.3	Major Equipment	2.2	0.3	0.3	0.4	3.2	3.2
3.1.4	Operations	42.3	6.3	6.7	8.3	63.5	63.5
3.1.4.1	Staff	37.2	5.6	5.9	7.3	55.9	55.9
3.1.4.2	Other	5.1	0.8	0.8	1.0	7.6	7.6
3.2	Heavy Haul to CSF	279.6	55.9	44.7	57.0	437.2	437.2
3.2.1	Engineering	9.9	2.0	1.6	2.0	15.4	15.4
3.2.2	Infrastructure Upgrade	158.5	31.7	25.4	32.3	248.0	248.0
3.2.3	Midway Service Facility	5.9	1.2	1.0	1.2	9.3	9.3
3.2.4	Equipment	23.6	4.7	3.8	4.8	36.9	36.9
3.2.5	Operations	81.6	16.3	13.1	16.6	127.6	127.6
3.2.5.1	Staff	31.9	6.4	5.1	6.5	49.9	49.9
3.2.5.2	Road Maintenance	40.1	8.0	6.4	8.2	62.8	62.8
3.2.5.3	Other	9.5	1.9	1.5	1.9	14.9	14.9
3.3	Rail Spur to CSF/YMP	1736.0	347.2	277.8	354.1	2715.1	1871.3
3.3.1	Misc Upfront Costs	76.3	15.3	12.2	15.6	119.3	82.2
3.3.2	Construction	1212.4	242.5	194.0	247.3	1896.1	1306.8
3.3.2.1	Rail Spur Const	1193.9	238.8	191.0	243.6	1867.3	1286.9
3.3.2.2	Ancillary Facil Const	18.4	3.7	2.9	3.8	28.8	19.9
3.3.3	Major Equipment	13.4	2.7	2.1	2.7	20.9	14.4
3.3.4	Operations	434.0	86.8	69.4	88.5	678.8	467.8
3.3.4.1	Staff	355.9	71.2	57.0	72.6	556.7	383.7
3.3.4.2	Other	78.1	15.6	12.5	15.9	122.1	84.1
4.0	CENTRALIZED STORAGE FACILITY	5972.3	1060.8	948.9	1197.3	9179.3	8686.4
4.1	Misc Upfront Costs	41.7	8.3	6.7	8.5	65.2	62.5
4.2	Construction	274.7	54.9	44.0	56.0	429.7	412.1
4.2.1	Security Construction	5.4	1.1	0.9	1.1	8.4	8.0
4.2.2	Site Work & Access	4.3	0.9	0.7	0.9	6.6	6.4
4.2.3	Pads & Alleys	149.2	29.8	23.9	30.4	233.3	223.8
4.2.4	Facility Construction	116.0	23.2	18.6	23.7	181.3	173.9
4.3	Major Equipment	5518.3	970.0	876.2	1104.7	8469.2	8005.4
4.3.1	Storage Casks, Metal	2418.2	483.6	386.9	493.3	3782.1	3319.9
4.3.2	Storage Casks, Concrete	401.8	80.4	64.3	82.0	628.4	628.4
4.3.3	Addl Canisters for Rail Ship	2673.6	401.0	421.1	524.4	4020.0	4020.0
4.3.4	Other	24.7	4.9	4.0	5.0	38.6	37.0
4.4	Operations	137.6	27.5	22.0	28.1	215.2	206.4
4.4.1	Staff	130.5	26.1	20.9	26.6	204.1	195.7
4.4.2	Other	7.1	1.4	1.1	1.4	11.1	10.6
5.0	REPOSITORY	15249.6	2616.4	2095.0	2994.1	22955.1	17015.5
5.1	Site Characterization	2205.3	7.5	7.9	333.1	2553.8	1982.0
5.1.1	As Proposed in 1991	2155.3	0.0	0.0	323.3	2478.6	1923.6
5.1.2	East-West Tunnel	50.0	7.5	7.9	9.8	75.2	58.3
5.2	Design & License Application	690.0	138.0	110.4	140.8	1079.2	837.5
5.2.1	Design: Upfront & Ongoing	622.5	124.5	99.6	127.0	973.6	755.6
5.2.2	Prepare License	67.5	13.5	10.8	13.8	105.6	81.9
5.3	Surface Facilities	3927.5	785.5	628.4	801.2	6142.5	4512.9
5.3.1	Construction	1533.0	306.6	245.3	312.7	2397.7	1761.6
5.3.1.1	North	1448.2	289.6	231.7	295.4	2265.0	1664.1
5.3.1.2	South	84.8	17.0	13.6	17.3	132.7	97.5
5.3.2	Equipment	50.3	10.1	8.0	10.3	78.7	57.8
5.3.3	Operations	2344.1	468.8	375.1	478.2	3666.2	2693.6
5.3.3.1	Staff	2257.5	451.5	361.2	460.5	3530.7	2594.0
5.3.3.2	Other	86.6	17.3	13.9	17.7	135.5	99.5
5.4	Underground Facilities	4576.9	915.4	732.3	933.7	7158.2	5259.1
5.4.1	Construction	3230.4	646.1	516.9	659.0	5052.4	3712.0
5.4.2	Equipment	181.8	36.4	29.1	37.1	284.3	208.9
5.4.3	Operations	1164.6	232.9	186.3	237.6	1821.4	1338.2
5.4.3.1	Staff	450.0	90.0	72.0	91.8	703.8	517.1
5.4.3.2	Other	714.6	142.9	114.3	145.8	1117.6	821.1
5.5	Waste Containers	3850.0	770.0	616.0	785.4	6021.4	4423.9
6.0.0	OTHER DEVEL & EVAL COSTS	412.9	20.6	0.0	0.0	433.6	336.5
6.1.0	NRC Fees	381.0	19.0	0.0	0.0	400.0	310.5
6.2.0	NWTRB	32.0	1.6	0.0	0.0	33.6	26.0
6.3.0	Nuclear Waste Negotiator	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	OTHER PROGRAM COSTS	1561.6	156.2	0.0	0.0	1717.8	1260.5
7.1.0	PETT Payments	1120.9	112.1	0.0	0.0	1233.0	904.8
7.1.1	DOE TSLCC 9/95	316.4	31.6	0.0	0.0	348.0	255.4
7.1.2	Re Addl NV Components	804.5	80.5	0.0	0.0	885.0	649.4
7.2.0	Benefits	440.7	44.1	0.0	0.0	484.8	355.8
	GRAND TOTAL	32164.1	5276.0	4386.1	5951.2	47777.4	38547.3

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THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM: DIRECT & NON-DIRECT PROGRAM COSTS (% TOTAL PROJECTED)

MASTER	Description	DIRECT	CONTNG	PROJCT	PROGRM	TOTAL	NWFOBL
1.0	ONSITE STORAGE COSTS	66.5%	10.0%	10.5%	13.0%	100.0%	92.6%
1.1	Commercial SNF in Que	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1	Dry Storage	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1.1	Opt 1/LWT: 26 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1.2	Opt 1/R125: 17 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1.3	Opt 2/R125: 11 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1.4	Opt 1/R75: 14 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.1.5	Opt 2/R75: 5 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2	Pool Op after Reactor Shutdn	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2.1	Opt 1/LWT: 26 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2.2	Opt 1/R125: 17 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2.3	Opt 2/R125: 11 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2.4	Opt 1/R75: 14 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.2.5	Opt 2/R75: 5 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3	Pool Loading Upgrades	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3.1	Opt 1/LWT: 26 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3.2	Opt 1/R125: 17 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3.3	Opt 2/R125: 11 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3.4	Opt 1/R75: 14 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.1.3.5	Opt 2/R75: 5 sites	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
1.2	DOE SNF & SNF not in Que	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
1.2.1	Dry Storage	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
1.2.2	Pool Op after Reactor Shutdn	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
1.2.3	Pool Loading Upgrades	NA	NA	NA	NA	NA	NA
1.3	DOE High-Level Waste	NA	NA	NA	NA	NA	NA
2.0	X-COUNTRY TRANSPORTATION	67.8%	9.8%	9.4%	13.0%	100.0%	81.8%
2.1	Commercial SNF in Que	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.1	Cask Shipment Costs	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.1.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.1.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.1.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.2	Shipment Escort Costs	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.2.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.2.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.2.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.3	Cask Inspection Costs	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.3.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.3.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.3.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.4	Cask & Equip Purchases	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.4.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.4.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.4.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.5	Cask & Equip O&M	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.5.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.5.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.5.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.6	Cask & Equip Decomm	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.6.1	Legal-Wt Truck	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.6.2	Large Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.6.3	Small Rail	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.1.7	Hvy Haul to Railhead	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
2.2	DOE Spent Nuclear Fuel	66.5%	10.0%	10.5%	13.0%	100.0%	20.9%
2.2.1	Cask Shipment Costs	66.5%	10.0%	10.5%	13.0%	100.0%	22.9%
2.2.2	Shipment Escort Costs	66.5%	10.0%	10.5%	13.0%	100.0%	25.8%
2.2.3	Cask Inspection Costs	66.5%	10.0%	10.5%	13.0%	100.0%	19.2%
2.2.4	Cask & Equip Purchases	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
2.2.5	Cask & Equip O&M	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
2.2.6	Cask & Equip Decomm	66.5%	10.0%	10.5%	13.0%	100.0%	19.8%
2.3	DOE High-Level Wastes	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.1	Cask Shipment Costs	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.2	Shipment Escort Costs	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.3	Cask Inspection Costs	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.4	Cask & Equip Purchases	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.5	Cask & Equip O&M	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.3.6	Cask & Equip Decomm	66.5%	10.0%	10.5%	13.0%	100.0%	0.0%
2.4	Technical Assist Trng: 180(c)	79.1%	7.9%	0.0%	13.0%	100.0%	81.4%

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DIRECT & NON-DIRECT PROGRAM COSTS (% TOTAL PROJECTED)

MASTER	Description	DIRECT	CONTNG	PROJCT	PROGRM	TOTAL	NWFOBL
3.0	NEVADA TRANSPORTATION	64.0%	12.7%	10.2%	13.0%	100.0%	74.0%
3.1	Intermodal Transfer Facility	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.1	Land and ROW	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.2	Construction	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.2.1	Security Construction	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.2.2	Site Work	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.2.3	Facility Construction	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.3	Major Equipment	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.4	Operations	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.4.1	Staff	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.1.4.2	Other	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
3.2	Heavy Haul to CSF	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.1	Engineering	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.2	Infrastructure Upgrade	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.3	Midway Service Facility	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.4	Equipment	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.5	Operations	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.5.1	Staff	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.5.2	Road Maintenance	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.2.5.3	Other	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
3.3	Rail Spur to CSF/YMP	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.1	Misc Upfront Costs	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.2	Construction	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.2.1	Rail Spur Const	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.2.2	Ancillary Facil Const	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.3	Major Equipment	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.4	Operations	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.4.1	Staff	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
3.3.4.2	Other	63.9%	12.8%	10.2%	13.0%	100.0%	68.9%
4.0	CENTRALIZED STORAGE FACILITY	65.1%	11.6%	10.3%	13.0%	100.0%	94.6%
4.1	Misc Upfront Costs	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.2	Construction	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.2.1	Security Construction	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.2.2	Site Work & Access	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.2.3	Pads & Alleys	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.2.4	Facility Construction	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.3	Major Equipment	65.2%	11.5%	10.3%	13.0%	100.0%	94.5%
4.3.1	Storage Casks, Metal	63.9%	12.8%	10.2%	13.0%	100.0%	87.8%
4.3.2	Storage Casks, Concrete	63.9%	12.8%	10.2%	13.0%	100.0%	100.0%
4.3.3	Addl Canisters for Rail Ship	66.5%	10.0%	10.5%	13.0%	100.0%	100.0%
4.3.4	Other	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.4	Operations	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.4.1	Staff	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
4.4.2	Other	63.9%	12.8%	10.2%	13.0%	100.0%	95.9%
5.0	REPOSITORY	66.4%	11.4%	[illegible]	13.0%	100.0%	74.1%
5.1	Site Characterization	86.4%	0.3%	0.3%	13.0%	100.0%	77.6%
5.1.1	As Proposed in 1991	87.0%	0.0%	0.0%	13.0%	100.0%	77.6%
5.1.2	East-West Tunnel	66.5%	10.0%	10.5%	13.0%	100.0%	77.6%
5.2	Design & License Application	63.9%	12.8%	10.2%	13.0%	100.0%	77.6%
5.2.1	Design: Upfront & Ongoing	63.9%	12.8%	10.2%	13.0%	100.0%	77.6%
5.2.2	Prepare License	63.9%	12.8%	10.2%	13.0%	100.0%	77.6%
5.3	Surface Facilities	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.1	Construction	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.1.1	North	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.1.2	South	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.2	Equipment	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.3	Operations	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.3.1	Staff	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.3.3.2	Other	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4	Underground Facilities	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4.1	Construction	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4.2	Equipment	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4.3	Operations	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4.3.1	Staff	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.4.3.2	Other	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
5.5	Waste Containers	63.9%	12.8%	10.2%	13.0%	100.0%	73.5%
6.0.0	OTHER DEVEL & EVAL COSTS	95.2%	4.8%	0.0%	0.0%	100.0%	77.6%
6.1.0	NRC Fees	95.2%	4.8%	0.0%	0.0%	100.0%	77.6%
6.2.0	NWTRB	95.2%	4.8%	0.0%	0.0%	100.0%	77.6%
6.3.0	Nuclear Waste Negotiator	NA	NA	NA	NA	NA	NA
7.0.0	OTHER PROGRAM COSTS	90.9%	9.1%	0.0%	0.0%	100.0%	73.4%
7.1.0	PETT Payments	90.9%	9.1%	0.0%	0.0%	100.0%	73.4%
7.1.1	DOE TSLCC 9/95	90.9%	9.1%	0.0%	0.0%	100.0%	73.4%
7.1.2	Re Addl NV Components	90.9%	9.1%	0.0%	0.0%	100.0%	73.4%
7.2.0	Benefits	90.9%	9.1%	0.0%	0.0%	100.0%	73.4%
	GRAND TOTAL	67.3%	11.0%	9.2%	12.5%	100.0%	80.7%

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THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM: NON-DIRECT COST FACTORS

MASTER	Description	CONTNG	PROJCT	PROGRM	NWFND
1.0	ONSITE STORAGE COSTS				
1.1	Commercial SNF in Que				
1.1.1	Dry Storage				
1.1.1.1	Opt 1/LWT: 26 sites	15%	15%	15%	100%
1.1.1.2	Opt 1/R125: 17 sites	15%	15%	15%	100%
1.1.1.3	Opt 2/R125: 11 sites	15%	15%	15%	100%
1.1.1.4	Opt 1/R75: 14 sites	15%	15%	15%	100%
1.1.1.5	Opt 2/R75: 5 sites	15%	15%	15%	100%
1.1.2	Pool Op after Reactor Shutdn				
1.1.2.1	Opt 1/LWT: 26 sites	15%	15%	15%	100%
1.1.2.2	Opt 1/R125: 17 sites	15%	15%	15%	100%
1.1.2.3	Opt 2/R125: 11 sites	15%	15%	15%	100%
1.1.2.4	Opt 1/R75: 14 sites	15%	15%	15%	100%
1.1.2.5	Opt 2/R75: 5 sites	15%	15%	15%	100%
1.1.3	Pool Loading Upgrades				
1.1.3.1	Opt 1/LWT: 26 sites	15%	15%	15%	100%
1.1.3.2	Opt 1/R125: 17 sites	15%	15%	15%	100%
1.1.3.3	Opt 2/R125: 11 sites	15%	15%	15%	100%
1.1.3.4	Opt 1/R75: 14 sites	15%	15%	15%	100%
1.1.3.5	Opt 2/R75: 5 sites	15%	15%	15%	100%
1.2	DOE SNF & SNF not in Que				
1.2.1	Dry Storage	15%	15%	15%	20%
1.2.2	Pool Op after Reactor Shutdn	15%	15%	15%	20%
1.2.3	Pool Loading Upgrades	15%	15%	15%	20%
1.3	DOE High-Level Waste				
2.0	X-COUNTRY TRANSPORTATION				
2.1	Commercial SNF in Que				
2.1.1	Cask Shipment Costs				
2.1.1.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.1.2	Large Rail	15%	15%	15%	100%
2.1.1.3	Small Rail	15%	15%	15%	100%
2.1.2	Shipment Escort Costs				
2.1.2.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.2.2	Large Rail	15%	15%	15%	100%
2.1.2.3	Small Rail	15%	15%	15%	100%
2.1.3	Cask Inspection Costs				
2.1.3.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.3.2	Large Rail	15%	15%	15%	100%
2.1.3.3	Small Rail	15%	15%	15%	100%
2.1.4	Cask & Equip Purchases				
2.1.4.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.4.2	Large Rail	15%	15%	15%	100%
2.1.4.3	Small Rail	15%	15%	15%	100%
2.1.5	Cask & Equip O&M				
2.1.5.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.5.2	Large Rail	15%	15%	15%	100%
2.1.5.3	Small Rail	15%	15%	15%	100%
2.1.6	Cask & Equip Decomm				
2.1.6.1	Legal-Wt Truck	15%	15%	15%	100%
2.1.6.2	Large Rail	15%	15%	15%	100%
2.1.6.3	Small Rail	15%	15%	15%	100%
2.1.7	Hvy Haul to Railhead				
2.2	DOE Spent Nuclear Fuel				
2.2.1	Cask Shipment Costs	15%	15%	15%	23%
2.2.2	Shipment Escort Costs	15%	15%	15%	26%
2.2.3	Cask Inspection Costs	15%	15%	15%	19%
2.2.4	Cask & Equip Purchases	15%	15%	15%	20%
2.2.5	Cask & Equip O&M	15%	15%	15%	20%
2.2.6	Cask & Equip Decomm	15%	15%	15%	20%
2.3	DOE High-Level Wastes				
2.3.1	Cask Shipment Costs	15%	15%	15%	0%
2.3.2	Shipment Escort Costs	15%	15%	15%	0%
2.3.3	Cask Inspection Costs	15%	15%	15%	0%
2.3.4	Cask & Equip Purchases	15%	15%	15%	0%
2.3.5	Cask & Equip O&M	15%	15%	15%	0%
2.3.6	Cask & Equip Decomm	15%	15%	15%	0%
2.4	Technical Assist Trng: 180(c)	10%	0%	15%	81%

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NON-DIRECT COST FACTORS

MASTER	Description	CONTNG	PROJCT	PROGRM	NWFND
3.0	NEVADA TRANSPORTATION				
3.1	Intermodal Transfer Facility				
3.1.1	Land and ROW	15%	15%	15%	100%
3.1.2	Construction				
3.1.2.1	Security Construction	15%	15%	15%	100%
3.1.2.2	Site Work	15%	15%	15%	100%
3.1.2.3	Facility Construction	15%	15%	15%	100%
3.1.3	Major Equipment	15%	15%	15%	100%
3.1.4	Operations				
3.1.4.1	Staff	15%	15%	15%	100%
3.1.4.2	Other	15%	15%	15%	100%
3.2	Heavy Haul to CSF				
3.2.1	Engineering	20%	15%	15%	100%
3.2.2	Infrastructure Upgrade	20%	15%	15%	100%
3.2.3	Midway Service Facility	20%	15%	15%	100%
3.2.4	Equipment	20%	15%	15%	100%
3.2.5	Operations				
3.2.5.1	Staff	20%	15%	15%	100%
3.2.5.2	Road Maintenance	20%	15%	15%	100%
3.2.5.3	Other	20%	15%	15%	100%
3.3	Rail Spur to CSF/YMP				
3.3.1	Misc Upfront Costs	20%	15%	15%	69%
3.3.2	Construction				
3.3.2.1	Rail Spur Const	20%	15%	15%	69%
3.3.2.2	Ancillary Facil Const	20%	15%	15%	69%
3.3.3	Major Equipment	20%	15%	15%	69%
3.3.4	Operations				
3.3.4.1	Staff	20%	15%	15%	69%
3.3.4.2	Other	20%	15%	15%	69%
4.0	CENTRALIZED STORAGE FACILITY				
4.1	Misc Upfront Costs	20%	15%	15%	96%
4.2	Construction				
4.2.1	Security Construction	20%	15%	15%	96%
4.2.2	Site Work & Access	20%	15%	15%	96%
4.2.3	Pads & Alleys	20%	15%	15%	96%
4.2.4	Facility Construction	20%	15%	15%	96%
4.3	Major Equipment				
4.3.1	Storage Casks, Metal	20%	15%	15%	88%
4.3.2	Storage Casks, Concrete	20%	15%	15%	100%
4.3.3	Addl Canisters for Rail Ship	15%	15%	15%	100%
4.3.4	Other	20%	15%	15%	96%
4.4	Operations				
4.4.1	Staff	20%	15%	15%	96%
4.4.2	Other	20%	15%	15%	96%
5.0	REPOSITORY				
5.1	Site Characterization				
5.1.1	As Proposed in 1991	0%	0%	15%	78%
5.1.2	East-West Tunnel	15%	15%	15%	78%
5.2	Design & License Application				
5.2.1	Design: Upfront & Ongoing	20%	15%	15%	78%
5.2.2	Prepare License	20%	15%	15%	78%
5.3	Surface Facilities				
5.3.1	Construction				
5.3.1.1	North	20%	15%	15%	73%
5.3.1.2	South	20%	15%	15%	73%
5.3.2	Equipment	20%	15%	15%	73%
5.3.3	Operations				
5.3.3.1	Staff	20%	15%	15%	73%
5.3.3.2	Other	20%	15%	15%	73%
5.4	Underground Facilities				
5.4.1	Construction	20%	15%	15%	73%
5.4.2	Equipment	20%	15%	15%	73%
5.4.3	Operations				
5.4.3.1	Staff	20%	15%	15%	73%
5.4.3.2	Other	20%	15%	15%	73%
5.5	Waste Containers	20%	15%	15%	73%
6.0.0	OTHER DEVEL & EVAL COSTS				
6.1.0	NRC Fees	5%	0%	0%	78%
6.2.0	NWTRB	5%	0%	0%	78%
6.3.0	Nuclear Waste Negotiator	5%	0%	0%	78%
7.0.0	OTHER PROGRAM COSTS				
7.1.0	PETT Payments				
7.1.1	DOE TSLCC 9/95	10%	0%	0%	73%
7.1.2	Re Addl NV Components	10%	0%	0%	73%
7.2.0	Benefits	10%	0%	0%	73%
	GRAND TOTAL				

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APPENDIX E: ANNUAL PROJECTED TOTAL SYSTEMS COSTS (MIL'96$)

The following tables present projected costs on an annual basis. All figures include direct, contingency and project and program management costs, as estimated for the independent assessment.

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THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM:
PROJECTED PROGRAM COSTS (FY 1997-FY 2011; MIL'96$)

MASTER	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1.0	0.4	8.9	28.1	31.5	46.1	66.9	62.9	45.6	56.7	69.4	73.5	74.6	65.2	65.2	89.9
1.1	0.0	8.6	14.3	17.7	32.3	53.1	49.1	31.8	42.9	55.9	60.1	61.2	51.8	51.7	76.3
1.1.1	0.0	1.8	7.4	6.6	13.7	20.1	18.2	10.6	20.0	36.8	35.9	24.6	23.3	15.9	27.5
1.1.1.1	0.0	0.0	1.4	0.2	0.2	0.2	4.5	0.3	11.9	12.8	20.9	13.2	3.1	6.3	3.2
1.1.1.2	0.0	0.0	1.4	0.3	0.1	5.7	6.7	2.4	4.7	13.6	4.1	4.6	7.4	1.2	4.6
1.1.1.3	0.0	1.3	4.2	3.3	11.9	12.0	6.5	5.7	1.7	4.6	1.6	4.3	8.3	5.5	6.2
1.1.1.4	0.0	0.0	0.0	2.3	1.0	1.7	0.2	2.0	1.3	0.3	5.7	1.7	1.5	1.1	1.3
1.1.1.5	0.0	0.4	0.3	0.4	0.6	0.5	0.2	0.3	0.3	5.5	3.5	0.8	2.9	1.7	12.1
1.1.2	0.0	6.8	6.9	11.1	18.6	21.3	23.1	20.9	22.9	17.7	21.8	30.6	28.5	35.9	44.8
1.1.2.1	0.0	2.5	2.6	4.2	7.9	9.1	9.9	8.5	7.8	7.0	7.3	14.5	13.1	22.2	25.0
1.1.2.2	0.0	1.4	1.4	2.3	3.5	4.1	4.4	4.8	5.9	5.3	5.5	6.1	3.2	3.6	3.5
1.1.2.3	0.0	0.8	0.8	1.2	1.9	2.2	2.4	2.6	3.2	0.0	0.0	0.0	3.2	3.6	3.6
1.1.2.4	0.0	1.5	1.5	2.4	3.7	4.2	4.6	5.0	6.1	5.5	5.7	6.3	5.7	6.4	6.3
1.1.2.5	0.0	0.6	0.6	1.0	1.5	1.8	1.9	0.0	0.0	0.0	3.3	3.7	3.3	0.0	6.4
1.1.3	0.0	0.0	0.0	0.0	0.0	11.6	7.7	0.3	0.0	1.4	2.4	6.0	0.0	0.0	4.0
1.1.3.1	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0
1.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.4	2.7	0.0	0.0	0.0
1.1.3.3	0.0	0.0	0.0	0.0	0.0	5.1	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
1.1.3.4	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.5	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0
1.2	0.4	0.4	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.4	13.4	13.4	13.4	13.4	13.6
1.2.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2
1.2.2	0.0	0.0	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.1	13.1	13.1	13.1	13.1	13.4
1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.0	0.0	0.0	0.0	0.0	21.5	21.5	234.3	96.2	161.0	159.6	199.4	189.4	166.8	163.9	169.9
2.1	0.0	0.0	0.0	0.0	0.0	0.0	212.8	74.7	139.5	138.1	177.9	167.9	145.3	142.4	144.3
2.1.1	0.0	0.0	0.0	0.0	0.0	0.0	71.5	58.9	87.1	95.5	120.6	121.0	122.8	108.3	118.0
2.1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	58.1	44.7	59.9	73.7	89.7	80.3	83.2	62.5	73.9
2.1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	4.5	6.0	10.8	10.6	16.3	23.3	21.0	22.1	20.0
2.1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	8.9	8.3	16.4	11.2	14.6	17.3	18.6	23.7	24.0
2.1.2	0.0	0.0	0.0	0.0	0.0	0.0	4.2	3.4	4.8	5.4	6.7	6.5	6.6	5.5	6.2
2.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	3.7	2.8	3.8	4.6	5.7	5.1	5.2	3.8	4.6
2.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.5	0.7	0.6	0.7	0.6
2.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.7	0.5	0.6	0.7	0.8	1.0	1.0
2.1.3	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.4	2.0	2.2	2.8	2.8	2.9	2.6	2.8
2.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	1.4	1.7	2.0	1.8	1.9	1.5	1.8
2.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.5	0.5	0.5	0.5
2.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.3	0.4	0.5	0.5	0.6	0.6
2.1.4	0.0	0.0	0.0	0.0	0.0	0.0	128.7	5.0	36.3	25.3	35.3	24.7	0.0	13.5	4.5
2.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	91.6	0.0	3.2	25.3	25.3	0.0	0.0	0.0	0.0
2.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	10.1	5.0	15.1	0.0	10.1	20.1	0.0	0.0	0.0
2.1.4.3	0.0	0.0	0.0	0.0	0.0	0.0	27.1	0.0	18.0	0.0	0.0	4.5	0.0	13.5	4.5
2.1.5	0.0	0.0	0.0	0.0	0.0	0.0	5.6	5.6	8.7	9.2	11.7	12.2	12.6	11.9	12.6
2.1.5.1	0.0	0.0	0.0	0.0	0.0	0.0	4.8	3.7	5.0	6.2	7.5	6.7	7.1	5.5	6.4
2.1.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8	1.4	1.4	2.1	3.0	2.9	3.1	2.7
2.1.5.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.2	2.4	1.6	2.1	2.4	2.6	3.3	3.4
2.1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.5	0.6	0.8	0.5	0.5	0.3
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
2.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
2.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2.2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4	0.0	0.0	0.0	0.0	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5

PROJECTED PROGRAM COSTS (FY 1997-FY 2011; MIL'96$)

MASTER	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3.0	3.9	88.3	139.6	141.7	66.4	412.1	432.7	451.6	445.3	466.6	20.6	20.6	20.6	20.6	20.6
3.1	0.0	0.5	9.8	12.6	5.9	12.7	12.7	12.7	12.7	12.7	0.0	0.0	0.0	0.0	0.0
3.1.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2	0.0	0.0	9.8	12.6	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.1	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.2	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.3	0.0	0.0	1.5	12.6	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.3	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4	0.0	0.0	0.0	0.0	0.0	12.7	12.7	12.7	12.7	12.7	0.0	0.0	0.0	0.0	0.0
3.1.4.1	0.0	0.0	0.0	0.0	0.0	11.2	11.2	11.2	11.2	11.2	0.0	0.0	0.0	0.0	0.0
3.1.4.2	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0	0.0
3.2	3.9	87.8	91.0	90.0	19.1	25.5	25.5	43.4	25.5	25.5	0.0	0.0	0.0	0.0	0.0
3.2.1	3.9	3.9	3.9	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.2	0.0	82.7	82.7	82.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.3	0.0	1.3	4.5	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.4	0.0	0.0	0.0	0.0	19.1	0.0	0.0	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5	0.0	0.0	0.0	0.0	0.0	25.5	25.5	25.5	25.5	25.5	0.0	0.0	0.0	0.0	0.0
3.2.5.1	0.0	0.0	0.0	0.0	0.0	10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0
3.2.5.2	0.0	0.0	0.0	0.0	0.0	12.6	12.6	12.6	12.6	12.6	0.0	0.0	0.0	0.0	0.0
3.2.5.3	0.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
3.3	0.0	0.0	38.8	39.1	41.4	373.9	394.4	395.5	407.1	428.3	20.6	20.6	20.6	20.6	20.6
3.3.1	0.0	0.0	38.8	39.1	41.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2	0.0	0.0	0.0	0.0	0.0	373.9	373.9	375.0	386.5	386.9	0.0	0.0	0.0	0.0	0.0
3.3.2.1	0.0	0.0	0.0	0.0	0.0	373.5	373.5	373.5	373.5	373.5	0.0	0.0	0.0	0.0	0.0
3.3.2.2	0.0	0.0	0.0	0.0	0.0	0.4	0.4	1.5	13.1	13.4	0.0	0.0	0.0	0.0	0.0
3.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9	0.0	0.0	0.0	0.0	0.0
3.3.4	0.0	0.0	0.0	0.0	0.0	0.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
3.3.4.1	0.0	0.0	0.0	0.0	0.0	0.0	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
3.3.4.2	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
4.0	0.0	32.3	32.9	274.2	70.7	95.1	339.7	295.0	325.9	436.5	505.2	547.0	484.1	392.2	371.6
4.1	0.0	32.3	32.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2	0.0	0.0	0.0	243.4	64.7	58.3	58.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.1	0.0	0.0	0.0	5.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.2	0.0	0.0	0.0	4.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.3	0.0	0.0	0.0	58.3	58.3	58.3	58.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.4	0.0	0.0	0.0	180.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	0.0	0.0	0.0	25.9	6.0	6.0	250.6	264.3	295.2	405.8	474.5	516.3	484.1	392.2	371.6
4.3.1	0.0	0.0	0.0	0.0	0.0	0.0	220.2	217.7	215.2	332.8	355.3	350.3	285.3	177.7	157.7
4.3.2	0.0	0.0	0.0	0.0	0.0	0.0	22.1	23.8	42.6	35.0	51.4	65.3	63.2	68.5	54.8
4.3.3	0.0	0.0	0.0	0.0	0.0	0.0	7.5	22.8	37.4	38.0	67.7	100.7	135.7	146.1	159.1
4.3.4	0.0	0.0	0.0	25.9	6.0	6.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4	0.0	0.0	0.0	0.0	0.0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	0.0	0.0	0.0
4.4.1	0.0	0.0	0.0	0.0	0.0	29.2	29.2	29.2	29.2	29.2	29.2	29.2	0.0	0.0	0.0
4.4.2	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.0	0.0	0.0
5.0	389.9	417.1	417.8	415.4	415.4	380.2	365.6	240.8	755.6	853.7	876.8	1120.8	269.9	301.5	350.4
5.1	389.9	417.1	382.6	345.0	345.0	345.0	329.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.1	389.9	379.5	345.0	345.0	345.0	345.0	329.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.2	0.0	37.6	37.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2	0.0	0.0	35.2	70.4	70.4	35.2	35.2	35.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
5.2.1	0.0	0.0	0.0	35.2	35.2	35.2	35.2	35.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
5.2.2	0.0	0.0	35.2	35.2	35.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3	0.0	0.0	0.0	0.0	0.0	0.0	1.2	44.7	572.1	664.5	680.0	635.8	72.5	72.5	72.5
5.3.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2	7.4	534.8	627.3	642.7	547.9	0.0	0.0	0.0
5.3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	480.9	593.0	641.7	547.9	0.0	0.0	0.0
5.3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	6.1	53.9	34.2	0.9	0.0	0.0	0.0	0.0
5.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.6	0.0	0.0	0.0
5.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.3	37.3	37.3	37.3	37.3	72.5	72.5	72.5
5.3.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.2	35.2	35.2	35.2	35.2	70.4	70.4	70.4
5.3.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	160.9	161.4	167.0	174.7	452.4	143.7	143.7	143.7
5.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	113.1	113.5	119.2	126.9	120.2	95.8	95.8	95.8
5.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	284.3	0.0	0.0	0.0
5.4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8
5.4.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
5.4.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	31.6	63.2	112.2
6.0.0	26.8	26.8	26.8	26.8	31.2	31.2	29.0	24.6	19.0	13.5	13.5	13.5	13.5	13.5	3.3
6.1.0	24.4	24.4	24.4	24.4	28.9	28.9	26.6	22.2	16.6	11.1	11.1	11.1	11.1	11.1	3.3
6.2.0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	0.0
6.3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	0.0	0.0	0.4	3.0	18.6	21.2	24.2	26.7	29.3	32.0	32.3	32.7	32.6	39.6	38.8
7.1.0	0.0	0.0	0.4	3.0	9.2	12.2	15.4	18.1	21.0	23.9	24.5	25.0	25.2	25.5	25.3
7.1.1	0.0	0.0	0.0	0.0	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	4.8
7.1.2	0.0	0.0	0.4	3.0	3.9	6.9	10.1	12.8	15.7	18.6	19.2	19.7	19.9	20.2	20.5
7.2.0	0.0	0.0	0.0	0.0	9.3	9.1	8.8	8.6	8.3	8.1	7.9	7.6	7.4	14.1	13.5
	420.9	573.4	645.6	892.7	669.8	1028.2	1488.4	1180.5	1792.9	2031.3	1721.3	1998.7	1052.7	996.5	1044.6

EIS001887

THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM:
PROJECTED PROGRAM COSTS (FY 2012-FY 2026; MIL'96$)

MASTER	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1.0	76.2	82.5	126.7	149.9	157.9	181.9	180.5	187.3	180.4	196.8	190.4	187.5	198.7	232.8	228.6
1.1	62.8	69.1	113.3	136.4	144.5	168.5	167.1	173.9	167.0	183.4	177.0	174.1	185.3	219.4	215.2
1.1.1	22.1	24.9	29.2	32.9	38.0	26.1	19.3	20.2	14.1	8.0	8.3	7.5	9.1	19.6	10.5
1.1.1.1	1.7	7.3	4.8	7.1	3.9	1.7	1.1	2.8	0.7	1.7	0.8	3.3	3.2	11.5	1.2
1.1.1.2	2.0	4.2	3.4	0.6	8.8	2.6	1.9	3.0	2.1	0.3	2.3	0.3	0.3	2.5	0.3
1.1.1.3	2.5	7.2	12.7	16.6	12.0	12.6	9.7	10.7	7.7	4.6	4.1	2.7	4.0	2.9	6.6
1.1.1.4	1.1	0.1	0.5	5.6	1.3	0.4	1.3	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.5	14.8	6.0	7.8	3.1	12.1	8.8	5.4	3.2	2.5	1.5	1.0	1.1	1.6	2.7	2.4
1.1.2	40.7	43.2	81.6	103.5	106.5	142.4	147.7	153.7	152.9	175.4	168.7	166.7	176.1	199.9	204.7
1.1.2.1	21.0	21.8	36.8	46.0	48.8	69.9	77.5	78.3	88.1	100.7	90.7	87.1	83.9	69.8	60.7
1.1.2.2	3.0	2.6	6.8	6.6	7.0	7.8	8.3	14.9	11.7	13.4	24.8	32.5	39.6	73.0	83.3
1.1.2.3	3.0	2.7	15.9	26.9	21.8	25.1	30.4	25.3	23.8	21.5	9.6	5.3	0.0	0.0	0.0
1.1.2.4	5.3	8.6	12.8	15.5	16.5	22.4	24.1	25.9	24.9	34.7	38.8	41.8	52.6	57.1	55.1
1.1.2.5	8.4	7.5	9.3	8.6	12.4	17.1	7.5	8.3	4.4	5.0	4.8	0.0	0.0	0.0	5.5
1.1.3	0.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.2	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.2	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.0	152.8	149.4	144.2	215.5	166.3	160.0	168.3	173.1	161.3	162.5	178.8	311.7	178.7	196.6	168.9
2.1	131.3	134.2	129.0	142.4	132.1	126.7	135.6	141.0	129.8	131.2	147.8	280.8	148.0	166.0	138.8
2.1.1	110.6	113.0	108.6	120.0	111.4	106.5	110.0	111.0	109.2	110.4	124.9	112.8	120.0	104.9	92.1
2.1.1.1	68.8	71.0	63.8	76.7	68.0	61.3	66.7	63.1	67.4	65.3	81.1	73.0	74.5	58.2	46.9
2.1.1.2	21.3	20.9	22.6	21.6	19.7	20.7	24.7	19.7	21.3	20.7	21.4	19.2	21.4	20.2	24.9
2.1.1.3	20.6	21.2	22.2	21.7	23.8	24.5	18.6	28.2	20.5	24.4	22.4	20.6	24.1	26.5	20.2
2.1.2	5.7	5.9	5.6	6.2	5.8	5.3	5.6	5.6	5.6	5.5	6.6	5.8	6.2	5.3	4.5
2.1.2.1	4.2	4.4	4.0	4.6	4.2	3.7	4.1	3.8	4.1	4.0	5.0	4.4	4.6	3.6	2.9
2.1.2.2	0.7	0.6	0.7	0.7	0.6	0.6	0.8	0.6	0.7	0.6	0.7	0.6	0.7	0.6	0.8
2.1.2.3	0.8	0.9	0.9	0.9	1.0	1.0	0.8	1.1	0.8	1.0	0.9	0.8	1.0	1.1	0.8
2.1.3	2.7	2.7	2.6	2.9	2.7	2.6	2.6	2.7	2.6	2.7	2.9	2.8	2.9	2.5	2.2
2.1.3.1	1.7	1.7	1.5	1.9	1.6	1.5	1.6	1.5	1.6	1.6	1.9	1.8	1.8	1.4	1.1
2.1.3.2	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6
2.1.3.3	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.7	0.5	0.7	0.6	0.5	0.6	0.7	0.6
2.1.4	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.0	0.0	0.0	0.0	128.7	5.0	36.3	25.3
2.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.6	0.0	3.2	25.3
2.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	10.1	5.0	15.1	0.0
2.1.4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	27.1	0.0	18.0	0.0
2.1.5	11.9	12.2	11.7	12.9	12.0	11.9	11.8	12.3	11.7	12.2	12.8	12.3	12.7	11.6	10.5
2.1.5.1	6.1	6.3	5.5	7.0	5.9	5.5	5.9	5.7	6.0	5.8	7.0	6.8	6.6	5.0	4.0
2.1.5.2	2.9	2.9	3.0	2.9	2.7	2.9	3.3	2.8	2.8	2.9	2.9	2.6	2.9	2.8	3.5
2.1.5.3	2.8	3.0	3.1	3.0	3.3	3.4	2.6	3.9	2.9	3.5	3.0	2.9	3.2	3.8	3.0
2.1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.1	0.7	4.9	3.6
2.1.6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.5	3.6
2.1.6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.7	2.0	0.0
2.1.6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	2.5	0.0
2.1.7	0.5	0.4	0.5	0.4	0.3	0.4	0.5	0.3	0.6	0.3	0.4	0.3	0.5	0.5	0.7
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3	0.0	0.0	0.0	57.9	19.0	18.1	17.5	17.0	16.4	16.1	15.9	15.7	15.5	15.4	14.9
2.3.1	0.0	0.0	0.0	17.8	16.2	15.3	14.6	14.2	13.6	13.3	13.1	12.9	12.8	12.7	12.1
2.3.2	0.0	0.0	0.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
2.3.3	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2.3.4	0.0	0.0	0.0	37.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.5	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
2.3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4	21.5	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2

PROJECTED PROGRAM COSTS (FY 2012-FY 2026; MIL'96S)

MASTER	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
3.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.5
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.5
3.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.5
3.3.4.1	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
3.3.4.2	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
4.0	301.8	267.2	171.8	154.3	174.0	180.0	172.6	191.9	196.3	166.5	170.3	176.5	181.4	180.9	178.5
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	301.8	267.2	171.8	154.3	174.0	180.0	172.6	191.9	196.3	166.5	170.3	176.5	181.4	180.9	178.5
4.3.1	115.1	95.1	10.5	16.1	22.8	24.1	22.3	22.4	47.9	22.5	28.7	32.7	37.9	8.9	5.1
4.3.2	42.7	24.5	6.0	4.3	2.8	2.4	6.9	4.6	3.3	1.7	3.8	0.7	5.4	4.0	7.4
4.3.3	144.0	147.6	155.3	133.9	148.5	153.5	143.5	164.9	145.0	142.3	137.9	143.1	138.1	167.9	165.9
4.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	413.6	451.4	448.7	448.7	448.7	448.7	450.6	448.7	448.7	448.7	448.7	465.7	448.7	448.7	448.7
5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
5.2.1	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
5.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3	72.5	75.2	72.5	72.5	72.5	72.5	74.4	72.5	72.5	72.5	72.5	89.5	72.5	72.5	72.5
5.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.2	0.0	2.8	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	17.1	0.0	0.0	0.0
5.3.3	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5
5.3.3.1	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4
5.3.3.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
5.4	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7
5.4.1	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
5.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8
5.4.3.1	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
5.4.3.2	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
5.5	175.3	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4
6.0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
6.1.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
6.2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	38.7	38.4	38.1	37.8	37.5	37.2	36.9	36.6	36.3	36.1	35.8	35.6	35.4	35.1	34.9
7.1.0	25.5	25.7	25.7	25.7	25.7	25.8	25.8	25.9	25.9	26.0	26.0	26.0	26.1	26.1	26.1
7.1.1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.2	20.7	20.8	20.9	20.9	20.9	20.9	21.0	21.0	21.1	21.1	21.2	21.2	21.3	21.3	21.3
7.2.0	13.2	12.8	12.4	12.0	11.7	11.4	11.0	10.7	10.4	10.1	9.8	9.5	9.3	9.0	8.8
	1007.1	1012.9	953.4	1030.0	1008.3	1031.7	1032.7	1061.5	1047.0	1034.5	1047.9	1200.9	1066.8	1118.0	1083.4

THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM:
PROJECTED PROGRAM COSTS (FY 2027-FY 2041; MIL'96$)

MASTER	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
1.0	249.8	241.5	217.4	153.0	49.1	13.4	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1	249.8	241.5	217.4	153.0	49.1	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1	12.0	7.0	3.5	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.2	5.7	0.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.3	3.8	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.5	0.7	2.1	0.3	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2	237.8	234.4	213.9	152.8	48.1	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.1	81.9	65.9	40.6	32.2	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.2	92.6	104.3	110.2	68.2	22.2	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.4	57.1	64.2	63.1	52.4	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.5	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	0.0	0.0	0.0	0.0	0.0	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.2	0.0	0.0	0.0	0.0	0.0	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.0	202.8	179.1	132.0	157.0	142.0	512.6	93.3	21.5	65.1	21.7	21.7	22.3	22.9	15.8	0.0
2.1	173.7	148.9	100.6	125.6	107.1	14.3	0.0	0.0	1.4	0.0	0.0	0.7	1.2	0.0	0.0
2.1.1	112.5	102.2	84.6	92.8	85.9	12.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.1	65.2	57.6	32.1	42.3	41.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.2	20.2	22.7	22.9	22.7	23.6	3.6	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.3	27.1	21.9	29.6	27.9	20.6	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2	5.7	5.2	3.9	4.4	4.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.1	4.0	3.6	2.0	2.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.2	0.6	0.7	0.7	0.7	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.3	1.1	0.9	1.2	1.1	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3	2.7	2.4	2.0	2.3	2.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.1	1.6	1.3	0.8	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.2	0.4	0.5	0.5	0.5	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.3	0.7	0.6	0.8	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4	35.3	24.7	0.0	13.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.1	25.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.2	10.1	20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.3	0.0	4.5	0.0	13.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5	12.1	10.9	10.0	10.8	9.8	1.6	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.1	5.9	4.9	2.8	3.8	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.2	2.6	3.1	3.1	3.1	3.3	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.3	3.6	3.0	4.1	3.8	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6	5.0	3.3	0.0	1.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	0.0	0.0
2.1.6.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.2	1.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
2.1.6.3	0.0	0.6	0.0	1.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
2.1.7	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2	0.0	0.0	0.0	0.0	3.6	466.9	71.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.1	0.0	0.0	0.0	0.0	0.0	136.4	59.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.2	0.0	0.0	0.0	0.0	0.0	7.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.3	0.0	0.0	0.0	0.0	0.0	4.3	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.4	0.0	0.0	0.0	0.0	3.2	303.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.5	0.0	0.0	0.0	0.0	0.0	15.9	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.6	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3	14.0	15.0	16.2	16.2	16.2	16.1	16.2	16.2	58.4	16.4	16.4	16.4	16.4	10.6	0.0
2.3.1	11.3	12.3	13.5	13.4	13.4	13.4	13.5	13.5	13.4	13.6	13.6	13.6	13.6	8.8	0.0
2.3.2	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.0
2.3.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.0
2.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	0.0	0.0	0.0	0.0	0.0	0.0
2.3.5	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.2	0.0
2.3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0
2.4	15.2	15.2	15.2	15.2	15.2	15.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	0.0

EIS001887

PROJECTED PROGRAM COSTS (FY 2027-FY 2041; MIL'96$)

MASTER	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
3.0	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0
3.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.1	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.2	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	0.0	0.0	0.0	0.0	0.0	0.0
4.0	179.2	168.2	246.0	263.7	221.4	432.2	164.8	61.5	63.8	59.3	59.9	59.3	59.3	58.9	15.1
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	179.2	168.2	246.0	263.7	221.4	432.2	164.8	61.5	63.8	59.3	59.9	59.3	59.3	58.9	15.1
4.3.1	20.8	6.1	6.1	7.9	2.6	380.4	159.0	53.7	50.7	51.4	52.0	51.4	51.4	51.0	13.1
4.3.2	3.5	0.4	5.1	4.4	3.1	2.0	5.8	7.9	7.6	7.9	7.9	7.9	7.9	7.9	2.0
4.3.3	154.9	161.6	234.8	251.4	215.6	49.8	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
4.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
5.0	448.7	450.6	448.7	448.7	448.7	448.7	451.4	401.8	401.8	401.8	401.8	403.6	323.2	51.9	31.
5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	0.0
5.2.1	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	0.0
5.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3	72.5	74.4	72.5	72.5	72.5	72.5	75.2	72.5	72.5	72.5	72.5	74.3	72.5	2.1	30.8
5.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.2	0.0	1.9	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
5.3.3	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	2.1	30.8
5.3.3.1	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	0.0	28.7
5.3.3.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
5.4	143.7	143.7	143.7	143.7	143.7	143.7	143.7	96.7	96.7	96.7	96.7	96.7	96.7	0.9	0.9
5.4.1	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	0.0	0.0
5.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3	47.8	47.8	47.8	47.8	47.8	47.8	47.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.4.3.1	11.7	11.7	11.7	11.7	11.7	11.7	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3.2	36.1	36.1	36.1	36.1	36.1	36.1	36.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.5	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	210.4	131.9	26.7	0.0
6.0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	0.6
6.1.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	0.6
6.2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	34.7	34.4	34.2	34.0	33.8	34.1	34.1	34.0	33.8	33.7	33.6	33.5	33.4	33.3	33.2
7.1.0	26.2	26.2	26.2	26.2	26.2	26.7	26.9	27.0	27.1	27.2	27.3	27.3	27.4	27.5	27.5
7.1.1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.2	21.3	21.3	21.4	21.4	21.4	21.9	22.1	22.2	22.3	22.3	22.4	22.5	22.6	22.7	22.7
7.2.0	8.5	8.3	8.0	7.8	7.6	7.4	7.1	6.9	6.7	6.6	6.4	6.2	6.0	5.8	5.7
	1139.1	1097.6	1102.2	1080.3	918.9	1464.8	767.4	554.2	588.3	519.8	520.3	522.1	442.2	163.3	80.6

THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM:
PROJECTED PROGRAM COSTS (FY 2042-FY 2056; MIL'96$)

MASTER	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.0	0.0	18.1	0.7	4.9	3.6	5.0	3.3	0.0	1.9	1.1	43.2	0.0	0.0	4.9	0.0
2.1	0.0	18.1	0.7	4.9	3.6	5.0	3.3	0.0	1.9	0.6	0.0	0.0	0.0	0.0	0.0
2.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6	0.0	18.1	0.7	4.9	3.6	5.0	3.3	0.0	1.9	0.6	0.0	0.0	0.0	0.0	0.0
2.1.6.1	0.0	13.1	0.0	0.5	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.2	0.0	1.3	0.7	2.0	0.0	1.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.3	0.0	3.7	0.0	2.5	0.0	0.0	0.6	0.0	1.9	0.6	0.0	0.0	0.0	0.0	0.0
2.1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	43.2	0.0	0.0	0.0	0.0
2.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	43.2	0.0	0.0	0.0	0.0
2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
2.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

EIS001887

PROJECTED PROGRAM COSTS (FY 2042-FY 2056; MIL'96$)

MASTER	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	24.2	24.2	24.2	24.2	24.2	24.2	36.4	36.4	33.3	24.2	24.2	24.2	24.2	24.2	23.7
5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3	23.2	23.2	23.2	23.2	23.2	23.2	35.5	35.5	32.4	23.2	23.2	23.2	23.2	23.2	22.8
5.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.3	23.2	23.2	23.2	23.2	23.2	23.2	35.5	35.5	32.4	23.2	23.2	23.2	23.2	23.2	22.8
5.3.3.1	21.2	21.2	21.2	21.2	21.2	21.2	33.4	33.4	30.3	21.2	21.2	21.2	21.2	21.2	21.2
5.3.3.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	1.7
5.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.4.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3.2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
6.1.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
6.2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	33.0	32.9	32.7	9.9	9.8	9.6	9.5	9.4	9.2	9.1	9.0	8.9	8.8	8.6	8.5
7.1.0	27.5	27.5	27.5	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.2	22.7	22.7	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.2.0	5.5	5.4	5.2	5.1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0	3.9	3.8	3.7
	57.8	75.7	58.1	39.6	38.1	39.3	49.8	46.3	45.0	34.9	76.9	33.6	33.5	38.3	32.8

EIS001887

THE CURRENTLY-PROPOSED HI-LEVEL NW MGT PROGRAM:
PROJECTED PROGRAM COSTS (FY 2057-FY 2071; MIL'96$)

MASTER	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PROJECTED PROGRAM COSTS (FY 2057-FY 2071; MIL'96$)

MASTER	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.1.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2.5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.3.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	23.7	36.0	37.6	393.6	330.4	330.4	330.4	330.4	330.4	142.9	127.7	127.7	127.7	23.[illegible]	16.4
5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3	22.8	35.0	36.7	113.8	95.7	95.7	95.7	95.7	95.7	41.9	37.6	37.6	37.6	7.7	5.6
5.3.1	0.0	0.0	0.0	5.5	4.6	4.6	4.6	4.6	4.6	2.0	1.8	1.8	1.8	0.3	0.2
5.3.1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.1.2	0.0	0.0	0.0	5.5	4.6	4.6	4.6	4.6	4.6	2.0	1.8	1.8	1.8	0.3	0.2
5.3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.3.3	22.8	35.0	36.7	108.3	91.0	91.0	91.0	91.0	91.0	39.9	35.8	35.8	35.8	7.4	5.4
5.3.3.1	21.2	33.4	35.0	106.6	89.4	89.4	89.4	89.4	89.4	38.3	34.1	34.1	34.1	5.8	3.8
5.3.3.2	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
5.4	0.9	0.9	0.9	279.8	234.7	234.7	234.7	234.7	234.7	101.0	90.2	90.2	90.2	16.0	10.8
5.4.1	0.0	0.0	0.0	225.6	189.1	189.1	189.1	189.1	189.1	81.0	72.2	72.2	72.2	12.2	8.0
5.4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.4.3	0.9	0.9	0.9	54.2	45.6	45.6	45.6	45.6	45.6	20.0	18.0	18.0	18.0	3.8	2.8
5.4.3.1	0.0	0.0	0.0	53.3	44.7	44.7	44.7	44.7	44.7	19.1	17.1	17.1	17.1	2.9	1.9
5.4.3.2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0.0	0.6	0.6	0.6	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
6.1.0	0.6	0.6	0.6	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
6.2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0.0	8.4	8.3	8.2	8.3	8.2	8.1	8.0	8.0	7.9	7.8	7.7	7.6	7.6	7.5	7.4
7.1.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7.1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.2.0	3.6	3.5	3.4	3.5	3.4	3.3	3.2	3.1	3.0	3.0	2.9	2.8	2.7	2.7	2.6
	32.7	44.8	46.4	403.0	339.7	339.6	339.5	339.5	339.4	151.8	136.6	136.5	136.4	32.3	24.9

ATTACHMENT U

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COMMENTS ON THE DEIS FOR YUCCA MOUNTAIN - AUGUST 1999

January 5, 2000

Introduction

426... The Draft Environmental Impact Statement (DEIS) for the Yucca Mountain high-level waste project was issued in August 1999 and includes an evaluation of environmental consequences (in terms of dose) of alternative repository design concepts and alternatives. The conclusion drawn from the results of these evaluations is that compliance is achieved.

There is however, strong evidence which casts doubt on the validity of the conclusions and these compliance assessments in light of NWPA and NEPA requirements. This evidence is related to the choice of groundwater pathways selected for the analyses.

At Yucca Mountain, the primary human exposure pathway is through ingestion of ground water. In conducting a performance assessment for Yucca Mountain, an accurate view of the groundwater flow field is essential. This is because the velocity of the groundwater is one of the most sensitive parameters in the transport equation, and therefore strongly influences dose calculations. The direction of the groundwater pathway is important as it dictates the hydrologic and geochemical character of the rock encountered along the pathway. Direction along with velocity strongly influence sorption and other important variables such as dilution and effective porosity in the saturated zone.

There has been considerable debate over the actual flow paths which would be followed by the radionuclides released from the repository. Modeling results performed by the State of Nevada (Lehman and Brown, 1994, Lehman and Brown, 1995) indicate major differences may exist in flow path direction, velocity, and sorptive capability compared to that used in the latest assessments by the DOE, including the DEIS, when all data sets are utilized.

By failing to evaluate credible alternative models of, or opposing views of the saturated zone, the DOE is not in compliance with NEPA. Being out of compliance with NEPA means automatic noncompliance with the NWPA. They are specifically out of compliance with NEPA 1502 for: not summarizing, discussing or using important data sets; They have failed to evaluate credible opposing viewpoints; and the DOE does not propose testing to reduce uncertainty in the choice between alternative conceptual flowpaths.

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In addition to these NEPA/NWPA compliance issues, several technical concerns are discussed which involve ranges of parameters utilized and parameters which could have been used but weren't. These points will be discussed separately below.

NEPA/NWPA Related Issues

1. Non-compliance with NEPA (1502.22)

427... The Nuclear Waste Policy Act requires that an EIS, consistent with the National Environmental Policy Act (NEPA) be prepared and accompany a recommendation for site approval. The amended NWPA (1987) still requires consistency with NEPA, but does not require the DOE to consider:

1. The need for the repository
2. Alternative sites to Yucca Mountain, or
3. Non-geological alternatives

NWPA Section 114(f) specifically states that all other provisions of NEPA apply. NEPA Section 1502.22 relates to incomplete or unavailable information. This section was developed as a result of dropping the "Worst case analysis" from previous NEPA provisions. NEPA regulations amended in 1986 now require that if information is available that would aid in evaluating uncertain effects, it must be obtained and analyzed unless it is too expensive to do so. If costs are prohibitive, then it must be disclosed as incomplete or unavailable information. Specifically, regulations require that if information cannot be obtained, the EIS must include :

1. A statement that such information is incomplete or unavailable.

2. A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment.

3. A summary of existing credible scientific evidence which is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment.

4. The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain DEIS is not in compliance with numbers 2, 3 or 4 above. While the DOE has stated that information used in determining the groundwater flow model is incomplete or unavailable, the existing credible scientific evidence which is relevant to evaluating reasonably foreseeable significant adverse impacts has not been summarized nor has it all been utilized in developing flowpaths.

Also, the impacts evaluation assumed the same groundwater flow paths and characteristics which

...427 were used in the DOE Viability Assessment and Total System Performance Assessment documents; i.e. a matrix type flow evaluation utilizing only 2D flow and 1D transport calculations. While these are generally accepted methods, they may not be representative of the saturated zone flow field that exists at Yucca Mountain today.

The DOE has not utilized all available and relevant data in their pathway identification or characterization. Because of this, the impacts in terms of dose to the Critical Group(s) or receptors may be misrepresented. While recognizing differing viewpoints regarding groundwater flow, the DEIS fails to analyze flowpaths from a full data set that considers this information. Because all data that have been generated are not considered in the impacts evaluation, there may be significant differences in the groundwater impacts projected in the DEIS. Unless these analyses are considered, impacts projected in the DEIS are inadequate for NEPA compliance and their credibility questionable.

In addition, the requirement to disclose all credible scientific evidence extends to responsible opposing views provided these are supported by theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain DEIS recognizes differing viewpoints regarding groundwater flow (Section 3.1.4.2. and Section 5.2.3.4.) and references the State of Nevada study of Lehman and Brown, but it fails to evaluate the impacts and actually gives little credibility to this alternative flowpath model. The DEIS admits that the alternative flowpath could produce different results, however, it states the extent to which the different viewpoint would affect the impacts is unknown but speculates the effects would be minimal (due to long canister lifetimes). This may not be the case, and in terms of doses to populations of the State of Nevada, any credible alternative must be evaluated.

2. NEPA Compliance - Required Evaluations

428 While NEPA regulations amended in May, 1986, eliminated the worst case analysis requirement, it did not eliminate the requirement that agencies evaluate the reasonably foreseeable significant adverse impacts of an action, even if information is unavailable or incomplete. Rather, it specified that the evaluation must be carefully conducted and based on credible scientific evidence. Furthermore, NEPA regulation (40 CFR 1502) requires disclosure of all credible scientific evidence, including responsible opposing views which are supported by theoretical approaches or research methods generally accepted in the scientific community.

We suggest that to be in compliance with NEPA that the DOE is required to consider effects of credible alternative models in the DEIS. While the DEIS recognizes differing viewpoints regarding groundwater flow (Section 3.1.4.2. and Section 5.2.3.4) and references the State of Nevada funded studies of Lehman and Brown, 1995, there has been no evaluation of the impacts.

3. Inadequate use of existing data in analyses to reduce uncertainty.

429... In order to evaluate the conclusions of either the Viability Assessment (TSPA/VA) or the Draft

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...429 Environmental Impact Statement (DEIS), the basic underlying assumptions of the latest Performance Assessments (TSPA) must be examined. The TSPA documents form the technical basis and justifications of DEIS or TSPA/VA conclusions. The relative importance of these assumptions to the outcomes of the TSPA also should be understood.

It has been known for some time that the Yucca Mountain ground water system has a range of temperatures associated with it, spatially It also has been hypothesized that certain features in the water table surface (embayments) are coincident with major faults. These facts lead to the hypothesis that faults and fractures dominate the flow of groundwater through the volcanic tuffs underlying Yucca Mountain. Measurements and interpretations by the USGS and our own analysis of water table fluctuations and groundwater temperature seem to collaborate this hypothesis.

In the hydrogeologic assessments of ground water pathways in complex systems such as exist at Yucca Mountain, heat may be used as a flowpath tracer. Using heat along with hydraulic head and chemistry measurements serves to constrain the results of analyses which tend to have non-unique solutions. The use of heat and chemical tracers can give a much more reliable answer to ground water flow directions in a complex system than the use of hydraulic head data alone. Unfortunately, the latest Total System Performance Assessment (TSPA) of Yucca Mountain (November 1998) which forms the technical basis for the TSPA/VA and DEIS did not include geologic structure, temperature, or chemistry data in their determination of saturated zone ground water flowpath velocities or directions. It is our contention that DOE must utilize all relevant data available to them in determining ground water flowpaths to potential receptors, not just selective or partial data sets.

The use of partial data sets is also addressed in NEPA 1502.22 item 3 above. The NEPA would require all data be summarized which are significant to impacts assessments. The DOE has utilized flow modeling in the DEIS which is based on one dimensional or two dimensional hydrologic or transport models which are only calibrated to hydraulic head measurements. Other data sets have been available, some since the late 1980's which could help the DOE better constrain and define the actual pathways taken by radionuclides from the repository to the receptors. These data sets include temperature (Sass, 1988), geochemistry developed by the USGS and Nye County, well hydraulics data obtained from Nye county pump tests and geologic structure information developed by the CNWRA.

The State of Nevada-funded studies utilized hydraulic head, temperature and structure explicitly in their 3-D modeling efforts. These studies have shown significant differences in flowpaths and are additionally supported by more recent geochemistry data sets and developing structural data. The flowpath evaluated by the DOE utilizing hydraulic head data only, one obtains a flowpath which is initially moving eastward and then southeastward. This flow path allows the radionuclides to move quickly from the fractured tuffs of Yucca Mountain into the Valley Fill sediments of Forty Mile Wash. This flow path allows the radionuclides to be in contact with "alluvium" (modeled as fine grained sediments) which naturally are expected to have high sorptive capability for radionuclides, for very long distances. Thus, traveling on the DOE pathway, sorption and dispersion would act to retard and disperse the radionuclides of concern,

...429 and yield minimal doses to affected populations.

On the other hand, if the preferred radionuclide pathway is as modeled by Lehman and Brown, 1994 and 1995, then it is likely that significant increases in calculated dose could occur. Comparing this flowpath to the DOE flowpath, a radionuclide would travel first south through the mountain block and then southeast or even possibly south west-for some time in the fractured tuff rock before emerging into the Valley Fill sediments south or southeast of the mountain block. These differences are important as the fractured tuff rock yields smaller values of sorptive capability. Further, velocities in the fractured tuff are expected to be orders of magnitude faster than those of the Valley Fill sediments. The pathway through the Valley Fill would also be much shorter via this route, minimizing sorption of radionuclides. It may also be expected to limit dispersion of radionuclides and volumetric flux rates used in the dispersion calculations. Nye County pump test data indicates compartmentalization of the flow field, possibly into small blocks. This small compartments will not have as large a volume of water as is assumed in the DEIS. These effects all combine to yield higher doses.

Technical Concerns Choice of Pathway and Receptor

1. Addressing Uncertainties

430 The Yucca Mountain DEIS acknowledges uncertainty in data in a number of technical areas, and identifies a number of on going and additional studies that it intends to conduct to address these uncertainties (DEIS Section 5.2.4). However, the DEIS does not discuss uncertainties in the groundwater flowpath, nor are there planned additional studies to address the potential for a different flowpath than that used in the impacts evaluation.

2. Location of Receptor and Receptor Type

431 As we commented on the VA, there are serious concerns about the selection of groundwater pathway and its associated hydrologic and geochemical parameters used for compliance assessments. As stated earlier there has been considerable debate over the actual flow paths which would be followed by the radionuclides released from the repository. We most likely have several different groundwater pathways for radionuclide travel and several differing populations to consider in the compliance determination, i.e., Lathrop Wells and Amargosa Valley. These flow path directions range from approximately 90° east To 180° south, roughly. The flow pathways are complicated to model accurately, because they are diverse, chemically and hydrologically and could be significantly different in terms of calculating radionuclide transport via the groundwater and concentrations at a given point. Further, EPA has not defined the Critical Group or receptor as yet.

3. Dilution Calculations

432... Appendix I. Section 1.4.5.4 discusses how the dilution factors were calculated. These numbers will need to be compared to annual yields of the basins to determine if they are representative. If

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...432 compartmentalization of the flow field is envisioned, then dilution volumes may only be fractions of the assumed yields.

A specific example can be cited on page 5-34 in Section 5.4.3, Table 5-13. This table shows population consequences from groundwater releases of radionuclides during 10,000 years after repository closure for the low thermal load scenario. Here the scaling factor for changing the dose rate for the maximally exposed individual into a dose rate for a member of the population was computed by diluting 46 acre-feet of water infiltrating through the repository by the annual water use in the Amargosa Valley of about 14,000 acre-feet. If exposures are to be calculated at Lathrop Wells, or anywhere along Highway 95 of north of Highway 95, then these dilution volumes are probably too high and not accurate, especially given a compartmentalized system.

4. Infiltration through the unsaturated zone.

433 The distribution of infiltration across the Yucca Mountain block is questioned. The distribution of infiltration used in the DEIS is highest at the crest. There are indicators which would suggest that peak infiltration is on the western flank of the mountain block. Infiltration in this western block region may be underestimated and its effect unknown.

5. Long Canister Lifetimes

434 The very long canister lifetimes assumed in these analyses force almost total dependance upon the proper working of the canister. There is no precedence for this lengthy canister performance, so total reliance on this engineered aspect of the system is not justified, nor is it what was envisioned in the NWPA or previous EPA standards. Defense in depth is not fully realized if this approach is taken. Further, corrosion models are highly dependent upon the system modeled, i.e., high temperature, low temperature, wet or dry repository. The environment under which corrosion is calculated has not been definitely specified. Rather DOE is keeping their options open making review of options and their effects complicated.

Summary

In summary, the DEIS for Yucca Mountain is not in compliance with the NWPA or NEPA. Additionally there are numerous instances where important parameters to the outcome of the assessments are not considered realistic or valid. DOE is in the process of reconsidering its saturated zone flow models. Until these models are finalized, and used in the analyses of consequences, no credance can be given to conclusions drawn in the DEIS.

ATTACHMENT V

EIS001887

THE TRANSPORTATION OF SPENT NUCLEAR FUEL AND HIGH-LEVEL WASTE:

A Systematic Basis for Planning and Management at National, Regional, and Community Levels

September 10, 1996

Prepared for
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ABBREVIATIONS

BN	Burlington Northern Railroad
BWR	Boiling Water Reactor
CCP	"Current Capabilities" Scenario
CNW	Chicago and North Western Railroad
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIS	Environmental Impact Statement
EM	Environmental Management
FICA	Facility Interface Capabilities Assessment
FRA	Federal Railroad Administration
GA	General Atomics
GE	General Electric
GTW	Grand Trunk Western Railroad
HANF	Hanford
HLW	High-Level Radioactive Waste
HM164	Hazardous Materials Regulation 164
HTG	High Temperature Gas
INEL	Idaho National Engineering Laboratory
LWT	Legal-Weight Truck
MPC	Multi Purpose Canister
MSC	Miscellaneous Spent Nuclear Fuel
MTU	Metric Tons of Uranium
MXR	"Maximum Rail" Scenario
NAC	Nuclear Assurance Corporation
NRC	Nuclear Regulatory Commission
NSP	Northern States Power
NSTI	Near-Site Transport Infrastructure
OCRWM	Office of Civilian Radioactive Waste Management
O-D	Origin-Destination
PSG&E	Public Service Gas & Electric
PWR	Pressurized Water Reactor
RSA	Regional Servicing Agent
RSC	Research Reactor Fuel
SF	Santa Fe Railroad
SNF	Spent Nuclear Fuel
SP	Southern Pacific Transportation Company
SRS	Savannah River Site
TMI	Three Mile Island
UP	Union Pacific Railroad
TVA	Tennessee Valley Authority
WVDP	West Valley Demonstration Project

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SUMMARY

To describe a national shipment campaign in a fashion which provides the inputs needed for risk and impact analysis as well as the information needed for coordinated planning and management requires an integrated assessment process for systematic consideration of at least the following factors:

- Waste origins, storage locations, and shipment sites
- Waste inventory: current and projected
- Waste acceptance startup and rate
- Priorities for waste acceptance and pickup
- Waste shipment groups
- Transportation cask options
- Transportation mode and cask choices by shipment site
- Routing criteria and routing options

Consideration of these factors enables one to provide useful information in response to basic questions regarding the shipment campaign in prospect under legislation proposed in the 104th Congress: e.g., How many cask shipments are expected? In which acceptance/pickup years? On which rail and highway routes? Through which states and communities? Sections 1 through 15 of this report discuss the factors in an integrated assessment process for a national shipment campaign, the assumptions used in this analysis, and the sources and bases for these assumptions. Sections 16 through 20 discuss the results of alternative scenarios involving three sets of transportation mode and cask choices, and two regional routing options. Section 21 illustrates a process for assembly of additional information on route features needed in risk analysis and management of transportation operations.

Three alternative sets of transportation cask choices at 80 shipment sites are considered:

- An assessment of *current capabilities* for cask loading and near-site transportation suggests that 32 commercial plant sites could choose to ship by legal-weight truck—either in currently-available casks for highway transport of uncanistered fuel or in a high-capacity cask such as the GA-4/9, if and when available.

- An *MPC base case* scenario of transportation choices could reduce to 17 the number of commercial sites shipping by legal-weight truck, and encourage 14 sites to use large-capacity rather than smaller capacity rail casks. However, implementation of the MPC base case requires investments to improve loading capabilities and/or near-site transportation at many sites, plus provision of as-yet-uncertified high-capacity transportation casks and canisters.

- A *maximum rail* scenario of transportation choices could reduce to three the number of commercial sites shipping by legal-weight truck. The maximum rail scenario is almost identical to the scenario assumed by DOE in its recent strategy study for transport to a potential repository at Yucca Mountain.

The *current capabilities* scenario results in 79,300 legal-weight truck casks shipped 62.3 million miles on 13,700 miles of the nation's public highways, *plus* 12,600 rail casks shipped 14.0 million miles

on 18,800 miles of the nation's railroads. The high-capacity legal-weight truck cask, if available and used consistently, could reduce highway transport to 31,400 casks shipped 14.7 million miles. Implementation of the *MPC base case* scenario with high-capacity truck casks could further reduce highway transport to 6,300 casks shipped 5.7 million miles over 10,200 miles of the nation's public highways. These reductions, however, would require investments to improve loading and/or near-site transportation capabilities at 29 sites, and would also involve increases in rail cask shipments (10 percent), rail cask shipment miles (9 percent), and rail route miles affected (13 percent). Implementation of the *maximum rail* scenario would further reduce highway transport to 1,150 high-capacity casks shipped 1.0 million miles over 4,200 miles of the nation's public highways. These reductions would require further investment in loading and/or near-site transportation capabilities at 14 sites, and it would also involve further increases in rail cask shipments (9 percent), rail cask shipment miles (10 percent) and rail route miles affected (11 percent).

Different phases of the 30-year shipment campaign affect different portions of the nation's rail and highway networks to different extents. For example, truck shipment comprises 35 percent of the 86,600 metric tons shipped under the *current capabilities* scenario of transportation choices, but 66 percent of the 4,400 metric tons shipped in the first three years of the 30-year shipment campaign. Truck shipment comprises 11 percent of the MTU shipped under the *MPC base case* scenario, but 27 percent in the first three years. These differences reflect the loading and near-site transportation capabilities of sites storing fuel with high-priority for acceptance and pickup.

Perspectives on a national shipment campaign tend to correlate with one's position as an origin, corridor or destination community for shipments of highly-toxic and long-lived radioactive materials. Under the *MPC base case* scenario (default routing), seven states comprising two percent of the nation's population are neither origins, corridors nor the destination for shipments of SNF or HLW. Another seven states comprising 18 percent of the nation's population are origins for such shipments but not corridors for shipments from other states. Still another seven states plus the District of Columbia are corridors but not origins for such shipments; these comprise seven percent of the nation's population. Twenty-eight states comprising 71 percent of the nation's population are both origins for SNF or HLW shipments and corridors for shipments originating elsewhere. The major corridor states under the MPC base case scenario (default routing) are Utah (65 sites), Nebraska (60 sites), Wyoming (58 sites), Illinois (47 sites), Iowa (32 sites), Kansas (28 sites), Missouri (27 sites) and Indiana (25 sites).

All shipments converge in Nevada, the destination state and intended permanent storage location for the nation's SNF and HLW. Nevada has about 0.5 percent of the nation's population. Under default routing, truck shipments enter the state on I-15, either from California moving north alongside the Las Vegas Strip, or from Arizona moving southwest through the Moapa Indian Reservation. Accessing US-95 at the interchange locally known as the "Spaghetti Bowl," truck shipments move northwest through rapidly developing Las Vegas suburbs, entering the Nevada Test Site at the Lathrop Wells, in the Nye County community of Amargosa Valley. Rail shipments enter the state on the Union Pacific railroad, either from California moving north alongside the Strip and through Las Vegas and the Moapa Indian Reservation, or from Utah south to the Lincoln County community of Caliente. At Caliente, rail casks would be transferred to heavy-haul trucks for shipment along U.S. highways and state roads, accessing the Nevada Test Site via a newly constructed road across the Nellis Air Force Range (a 162-mile journey), or continuing on public highways along a circuitous route north and west of the Nellis Air Force Range.

Many departures from default routing could occur as states consider designated alternative routes for "highway route-controlled quantities" of SNF and HLW, and as utilities consider alternative railheads for rail shipments and carriers consider implications for rail freight traffic. These departures have implications, some major, others minor, for the national routing system for SNF and HLW shipments—which route segments are affected, when and to what degree. One major option is a "consolidated southern" routing in which truck shipments from the East and Midwest are oriented to I-40 through St. Louis, Oklahoma City, and Albuquerque rather than to I-80 and I-70, and rail shipments are oriented to the Santa Fe lines through Kansas City, Amarillo and Barstow rather than to the Union Pacific through Nebraska and Wyoming or the Southern Pacific through Kansas and Colorado.

The assessment compares cask shipments under default and consolidated southern routing for five rail and five highway route segments in four states (Wyoming, Colorado, New Mexico, and Nevada). Consolidated southern routing could eliminate or substantially reduce rail and highway cask shipments on the selected Wyoming and Colorado route segments and on the Nevada route segments for shipments from the north. At the same time, however, consolidated southern routing would increase rail and highway shipments on route segments through New Mexico, Arizona and California (east of Barstow), and on the Nevada route segments for shipments from the south and alongside the Las Vegas Strip.

The national shipment campaign in prospect under legislation proposed in the 104th Congress involves 80 sites shipping on different schedules, by different modes, using large portions of the nation's major rail and highway systems, over a 30+ year period, through many states and communities which may have widely varying perspectives on the potential risks and impacts, and widely varying resources for planning and coordination with other affected states and with the relevant federal agencies. Policy considerations to limit, divert or manage impacts need to be combined with an integrated assessment process which provides all parties with systematically-developed information on the implications of the shipment campaign at national, regional, and community levels.

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INTRODUCTION

The 1982 Nuclear Waste Policy Act (NWPA) formalized the goal that spent nuclear fuel (SNF) and high-level radioactive waste (HLW) from roughly 80 temporary storage locations in 36 states should be transported to one or perhaps two permanent geologic repositories for permanent disposal. 1987 amendments to the NWPA specified that Yucca Mountain (NV) was to be the site for the nation's single prospective geologic repository and the ultimate destination for these highly-toxic and long-lived materials.

Less clear since 1987 has been the strategy for managing waste until the time that the permanent repository is available. Should it continue to be stored at its current "temporary" locations, and shipped to the permanent repository when it is available? If so, federal government acceptance could be delayed 10, 20 or even more years beyond the 1998 acceptance date promised in 1982. Should it be transported to a centralized above-ground storage facility (which under current law cannot be in the same state as the permanent repository) to await a second shipment to the geologic disposal site? If so, the federal government would have to find a suitable site outside Nevada, and persuade its stakeholders that centralized storage would not become de facto a permanent above-ground repository.

Legislation proposed in the 104th Congress* would deal with these questions by shipping waste early and to Nevada. The legislation directs DOE to accept spent nuclear fuel at specified annual rates beginning not later than November 1999 for transport to a specified destination—a centralized above-ground storage facility on the Nevada Test Site, adjacent to Yucca Mountain. A viability assessment completed in 1998 is intended to provide some assurance that the wastes shipped to Nevada for above-ground storage could ultimately be disposed at a Yucca Mountain geologic repository, and that a second shipment to another interim or permanent site will not be necessary.

Neither Congress nor DOE has developed a plan for implementing the transportation and storage provisions of the proposed legislation. It is uncertain, for example, when shipments would begin, how rapidly they would proceed, what shipment priorities might be, what transportation/storage casks might be available, how utilities would choose among available casks, what routes would prove most acceptable, etc. How would these questions be resolved, and who would be involved in their resolution, at what stage and with what authority, responsibility and capability? How will the risks, "real" and "perceived," be addressed, assessed, and effectively managed? Even the role and accountability of DOE is uncertain, given its recent initiative to privatize the entire civilian spent fuel transportation system, leaving decisions about shipping containers, modes and routes largely up to private contractors.

Though occasional shipments of spent fuel and other highly-radioactive materials (e.g., cesium, naval reactor fuel) have been safely conducted and effectively managed, no land-based shipment campaign of the scale implied by proposed legislation has been conducted in the U.S. or elsewhere. How best to plan for and effectively manage such a campaign in our participatory federal system of governance of the 1990's has not been decided. It is generally assumed that such a campaign would require the coordinated participation of several federal and many state, local, and private agencies—each responsive to its own constituencies. It is acknowledged that these agencies would need to participate in an extensive array of

* Senate bill 1936 (S. 1936), a substitute for the earlier Senate bill 1271. A companion bill (H.R. 1020) is under consideration in the House of Representatives.

activities over many months, years, even decades. It is generally acknowledged that a detailed description of the national shipment campaign, including an inventory of key local conditions potentially affected, is required as the basis for coordinated planning and management. But, though proposed legislation would make an unprecedented national shipment campaign a near-term prospect, such a detailed description is not available as a resource for the many parties which would expect to participate in its coordinated planning and management.

One way to reduce uncertainty is to develop scenarios which reflect specific assumptions regarding relevant factors, and which then provide detailed information (e.g., shipments by cask type, origin, route segment, and year) needed as the basis for planning and management. One purpose of this report is to describe several possible scenarios for the shipment campaign in prospect under S. 1936, and the direct consequences of these scenarios—prospective cask shipments of particular types on particular rail and highway routes in particular years. In the process, the report identifies the several factors and assumptions that underlie any scenario for a national campaign for shipment of SNF and HLW. These factors, combined in an integrated assessment process, suggest the type of information base needed in the planning and management of national shipment campaign—the inputs needed for analysis of risks and impacts, and for identification and resolution of issues ranging from overall campaign efficiency, to regional routing options, to issues specific to particular communities or route segments.

This study applied an integrated assessment system to develop scenarios considering three sets of potential utility transportation choices, two alternative routing strategies and two alternative truck cask options. It will be apparent in review of the factors and assumptions that many other scenarios for the prospective shipment campaign are possible. The integrated assessment process supports the consistent development of alternative scenarios with comparable outputs at the national, regional, and route-segment level.

As introduction to the scenarios, this section discusses the *activities* involved in planning and managing a national shipment campaign, the *agencies* which must coordinate to conduct these activities, the *information* needed as a basis for coordinated planning and management, and the *factors* that must be considered in generating this information.

Activities

To identify the range of activities involved in planning and managing a national shipment campaign, one might consider DOE's May 10, 1996 notice of proposed policies and procedures for implementing section 180(c) of the Nuclear Waste Policy Act regarding training for safe routine transportation and emergency response training.[1] A review of this notice, which summarizes and responds to previous stakeholder comments on the subject, provides a useful list of the activities which will be involved in the transportation of SNF and HLW from about 80 origin sites across the country, along numerous highway and rail routes, across many jurisdictions and communities, over a 30-year period to an interim or permanent storage site in Nevada. The list of activities, only a few of which DOE proposes to support with 180(c) funds, includes:

- route selection
- alternative route analysis
- route risk analysis
- route inspection (highway and rail)
- contingency routing plans
- transportation infrastructure improvements

- shipment notification
- shipment tracking
- shipment escorting
- provision of public information on routing and shipments
- preparation and enforcement of transportation operations protocols
- carrier and shipper compliance reviews
- assessment of state and local capabilities regarding safe routine transport and emergency response
- enhancement and maintenance of state and local emergency preparedness
- enhancement and maintenance of emergency response and recovery capabilities
- awareness training for first-on-scene and first responder personnel
- specialized training for emergency management and recovery personnel
- public information training for route community liaison personnel
- training for hospital personnel, if and as necessary
- waste acceptance scheduling (start date and annual rate)
- waste acceptance prioritization
- transportation cask design, certification, production, and delivery
- cask loading (wet or dry)
- accident notification
- safe parking designation and procedures
- provision of equipment for emergency response, inspection, first response personnel

Agencies

If the activities involved in nuclear waste transportation are numerous and varied, the actors are numerous and varied as well—adding to the need for federal agencies as well as potentially affected states and local governments to have a sound description of and an effective role in planning the shipment campaign in prospect. The actors, whose respective roles and responsibilities have been much discussed but not decided, include federal, state, local agencies as well as utility shippers, contract carriers, and others.

- Federal agencies include:

  — DOE/OCRWM (Office of Civilian Radioactive Waste Management) . . . manager of the Nuclear Waste Fund and responsible for high-level waste management strategy.

  — DOE/EM (Environmental Management) . . . responsible for HLW in the DOE complex, and for the Nevada Test Site Area 25, designated as the site for centralized above-ground storage in proposed legislation.

  — DOT/RSPA (Research and Special Programs Administration) . . . responsible for implementation guidelines for HMTUSA (the Hazardous Materials Transportation Uniform Safety Act).

  — DOT/FHWA (Federal Highway Administration) . . . responsible for implementation of HM164, and for inspection of highway shipments.

  — DOT/FRA (Federal Railroad Administration) . . . responsible for rail inspections and regulation, and for special studies regarding rail shipments.

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— NRC (Nuclear Regulatory Commission) . . . responsible for certification of storage and transportation canisters and casks.

— FEMA (Federal Emergency Management Agency) . . . responsible for emergency management and response in transport of radiological materials.

— Coast Guard/Corps of Engineers . . . responsible for regulation of barge shipments and intermodal transfer at barge terminals.

- State agencies include state police and highway patrols, emergency management agencies, utility regulatory commissions, agencies responsible for route designation, radiological health agencies, environmental regulation agencies, etc.

- State agencies need to coordinate with their counterparts in adjacent states and with Indian tribes, perhaps via regional groups.

- State agencies also need to coordinate with local jurisdictions (especially police, fire, and transportation departments) and with utility (and DOE) shippers and their selected carriers.

- Operating under federal and state guidelines, various private organizations are likely to be directly responsible for cask fabrication, truck transport, and/or rail transport. Furthermore, DOE could convey to private industry contractors broad responsibility for planning and managing campaigns for transporting high-level nuclear waste from various sections of the country. A May 28, 1996 notice in the Federal Register[2] indicates that DOE/OCRWM anticipates contracting with private industry for:

  — virtually all aspects of spent fuel acceptance
  — supplying transportation (and storage) casks
  — transportation to a designated storage facility
  — any required intermodal transport or heavy-haul
  — handling uncanistered spent fuel, as necessary.

  Under such contracts—DOE anticipates two or more contractors serving four regions—the private companies would be permitted to:

  — alter the order of spent fuel acceptance (presumably in consultation with utilities) and/or
  — recommend preferred transportation routes (presumably in consultation with states).

Assessment and Management Information Needs

However roles and responsibilities are decided, any federal, state, local agency or contractor will need certain information as a basis for planning, coordination, and management:

— how many cask shipments are expected?
— containing what types of SNF or HLW?
— in what types of casks?
— in which acceptance year?
— from which storage locations?
— by what mode? (rail, highway, barge)
— on which rail or highway route segments?

In sum, though they may focus on topics or geographic areas of particular relevance to their own responsibilities or contributions, any participating agency will need to plan and manage with reference to a detailed description of the shipment campaign, consistently developed at national, regional, and community levels.

Assessment System Factors

To generate such information for a transportation scenario, however, requires an assessment system in which explicit assumptions are made and information systematically generated regarding at least the following factors:

- Waste origins and storage locations (section 1)
- Current and projected inventory (section 2)
- Waste acceptance startup and rate (section 3)
- Priorities for waste acceptance and pickup (section 4)
- Waste shipment groups (section 5)
- Cask options (section 6)
- Transportation choices and choice factors (sections 7 through 11)
- Annual cask shipments (section 12)
- Routing criteria, mapping, and segmentation (sections 13 and 14)
- Routing options: origin-destination pairs (section 15)

Combined in an integrated assessment system, these factors generate information regarding:

- Routes and cask shipments over the 30-year (life of operations) national campaign (section 16).
- Routes and cask shipments at the Nevada destination—the end of the funnel (section 17).
- Regional routing alternatives and consequences for particular routes in various states (section 18).
- Annual cask shipments and the routes involved in various phases of the campaign (section 19).
- Transportation operations requirements—cask shipment miles, cask shipment miles per MTU shipped, cask shipments per route mile affected (section 20).

Assessment of risks, impacts, and policy options requires systematically-assembled information on key features along affected routes, as illustrated in section 21.

Scenarios Considered in this Study

Using an integrated assessment system, this study describes the national shipment campaign for scenarios which differ in utility transportation choices (three alternative sets), routing strategy (a base case and a consolidated southern routing strategy across central and western states) and cask options (two rail casks, plus one of two legal-weight truck casks). Figure 1 summarizes the factors varied and held constant in these scenarios, providing references to relevant sections of the report.

The integrated assessment system can be used to describe in similar dimensions and detail any national shipment campaign which could emerge—e.g., scenarios reflecting a different current or projected inventory, different acceptance rates or priorities for pickup, alternative cask options, different utility transportation choices and/or alternative routing criteria.

Figure I-1. The Transportation of SNF and HLW: Key Assess System Factors and Variables

	SPENT NUCLEAR FUEL	HIGH-LEVEL WASTE
1.WASTE ORIGINS	124 commercial reactors in 34 states Spent fuel from research reactors: General Atomics.... priority ranking DOE: 8 sites Domestic non-DOE: 8 sites Foreign: 3 temp storage sites in US	4 major DOE sites: Hanford (WA) Idaho Nat Eng Lab (ID) Savannah River (SC) West Valley Demo Proj (NY)
STORAGE LOCATIONS	82 pools assoc with individual reactors 20 pools joined by transfer canals 11 pools shared by two reactors 7 pools at offsite locations (3 DOE) 14 onsite dry strg facil (ex & planned)	Same 4 major DOE sites
SHIPMENT SITES	83 sites (4 DOE) in 36 states	Same 4 major DOE sites
2.INVENTORY	Nov'94: 10809 MTU in 59418 BWR assemblies 19149 MTU in 44602 PWR assemblies 86 MTU in HTG, RSC, MSC SNF 30044 MTU total Cumul: 30,682 MTU in 169,675 BWR assemblies 55,931 MTU in 129,517 PWR assemblies 86 MTU in HTG, RSC, MSC, SNF 86,699 MTU total	13789-28372 canisters of vitrified HLW Hanford: 7067-15000 canisters INEL: 704-8500 canisters SRS: 5717-4572 canisters WVDP: 300 canisters
3.ACCEPTANCE START	Annual estimates, w/o specified start yr	Year 15: ie 2015 if 2000 start yr
ACCEPTANCE RATE	Years 1- 5: 9100 MTU Years 6-10: 15000 MTU Years 11-15: 15000 MTU	Years 15-20: 4000 canisters Years 21-25: 4500 canisters Years 26-30: 5000 canisters
4.ACCEPTANCE PRIORITY	Oldest fuel (current & projected) first No within utility reallocations No among utility trades	Generally: 1. WVDP 2. SRS 3. HANF 4. INEL
5.SHIPMENT GROUPS	Among acceptance years? No Among assembly types? Yes Among reactor types? No Among waste origins? No	Not applicable (canistered waste)
6.CASK OPTIONS	R125: similar to DOE's 125-ton MPC R75: similar to DOE's 75-ton MPC LWT: legal-weight truck cask T4/9: the GA-4/9 cask, used if available T1/2: similar to the NAC LWT	R100: an adaption of DOE's 125-ton MPC
7.CASK LOADING FACTORS	Design crane capacity (tons) Operating crane capacity (tons) Cask set-down area (max cask option) Cask length requirement (max cask option)	Assume adequate to load R100
8.NEAR-SITE INFRASRUC	Onsite rail ? Operating onsite rail ? Onsite rail upgrade cost Distance to offsite railhead	Assume adequate to ship R100
9.OTHER TRANSPORTATION CHOICE FACTORS	Federal policies Utility choice criteria Changes at or near utility sites	DOE policy Changes at or near DOE sites
10.TRANSP CHOICE DECISION	Four case examples: Monticello Big Rock Point Point Beach Salem/Hope Creek Enrico Fermi	Factors 6-8 determine

Figure I-1 (Cont)

	SPENT NUCLEAR FUEL	HIGH-LEVEL WASTE
11.TRANSP CHOICE SCENARIOS	Current capabilities MPC base case Maximum rail	All rail shipment, using R100
12.CASK SHIPMENTS	BWR/PWR assemblies in shipment group/ cask capacity (partially-filled cask=1) Non-BWR/PWR MTU in shipment group/ MTU per cask (BWR/PWR)	Canisters in shipment group/ 5 canisters per cask (partially-filled cask=1)
13.ROUTING CRITERIA Default route/ highway:	HM 164; max use of interstate hwys; Min transit time; two drivers; Pop centers not avoided.	NA
Default route/ rail:	Nearest railhead or designated barge; Min carrier transfer; min transit time; Pop centers not avoided	Same as SNF
Consolidated southern route/ Highway	Uses Interstate 40 west of Okla City, Interstate 15 north to Las V & Yucca Mtn	NA
Consolidated southern route/ rail:	Uses Sante Fe lines west of Kansas City, Union Pacific north to intermodal transfer	Same as SNF
14.ROUTE IDENTIFICATION & MAPPING	Locate designated route segments Identify on base highway/rail maps Route segmentation	Same as SNF
15.ROUTING CASE EXAMPLES	Oyster Creek (NJ) to Yucca Mtn (NV) Fermi (MI) to Yucca Mtn (NV) Browns Ferry (AL) to Yucca Mtn (NV) Cooper Station (NE) to Yucca Mtn (NV) Grand Gulf (MS) to Yucca Mtn (NV) Diablo Canyon (CA) to Yucca Mtn (NV)	NA
16. NATIONAL SHIPMENT CAMPAIGN	Life of Operations Cask Shipments Default routing 3 transportation choice scenarios	Year 15-30 cask shipments Sames as SNF
17. NEVADA IMPLICATIONS	Life of operations cask shipments Default routing Nevada route segments 3 transportation choice scenarios	Year 15-30 cask shipments Same as SNF Same as SNF
18. REGIONAL ROUTING OPTIONS	Life of operations cask shipments Default and So consol routing Selected route segments in: Wyoming (UP and I-80) Colorado (SP and I-70) New Mexico (SF and I-40) Nevada (UP and I-15) 3 transportation choice scenarios	Year 15-30 cask shipments Same as SNF
19.NATL SHIPMENT CAMPAIGN: ANNUAL SHIPMENTS	Current capabil choices/default routing Year 1 cask shipments by origin: Year 2 cask shipments by origin: Year 3 cask shipments by origin: Year 20 cask shipments by origin: Maximum rail choices/default routing Year 20 cask shipments by origin:	All rail shipment/default routing: Year 1 cask shipments by origin: Year 2 cask shipments by origin: Year 3 cask shipments by origin: Year 20 cask shipments by origin:

Figure I-1 (Cont).

20. TRANSP OPER REQUIREMENTS	Life of operations and years 1-3	Year 15-30 cask shipments
	Cask shipment miles (total and per MTU)	Cask shipments miles (total)
	Cask shipments per route mile	Same as SNF
	2 transportation choice scenarios	Same as SNF
21.ROUTE FEATURES	Illustrative:	Same as SNF
	Key route characteristics	
	Route conditions	
	Key facilities alongside	
	Administrative boundaries	
	Segment-specific management policies	

1. WASTE ORIGINS, STORAGE LOCATIONS AND SHIPMENT SITES

In common practice, a reactor name may be used to refer to any of several facilities at a site, or to the site itself. Thus, the term "Calvert Cliffs" may be used to refer to either or both of Baltimore Gas and Electric's two nuclear powerplants, to the joined spent fuel pools at those reactors, to the site's concrete module dry storage facility, or the site itself on the Patuxent River near Lusby in Calvert County. In assessment, however, it is useful to maintain a distinction between the facilities which generate spent fuel, the facilities where this waste is temporarily stored, and the sites from which such waste may be shipped to a centralized or permanent storage facility. The same applies to high-level waste at DOE's defense sites and to other nuclear waste requiring geologic disposal.

Spent Fuel Origins and Storage Locations

In its Acceptance Priority Ranking reports,[3] DOE identifies SNF by the reactor from which it was discharged and by its current storage location. For example:

- The 136 BWR assemblies discharged from the Oyster Creek reactor in Ocean County, New Jersey on May 1, 1972 are now stored at Oyster Creek—meaning the spent fuel pool associated with the Oyster Creek reactor.

- The 85 BWR assemblies discharged from the Quad Cities 2 reactor in Rock Island County, Illinois on December 22, 1974 are now stored at Quad Cities 1—meaning the joined spent fuel storage pools for Quad Cities reactors 1 and 2.

- The 509 BWR assemblies discharged from the Dresden 2 reactor near Morris, Illinois on February 19, 1972 are now stored at Morris—meaning that they have been moved to the nearby General Electric spent fuel storage facility.

- The 102 PWR assemblies discharged from the Robinson 2 reactor in Hartsville, South Carolina on May 4, 1974 are now stored at the Brunswick 1 PWR pool—meaning that they have been transported to Southport, North Carolina for storage in the portion of the Brunswick 1 spent fuel pool designed for BWR assemblies.

Thus, there is a distinction between spent fuel origins and storage locations. Origins are nuclear reactors. Storage locations are spent fuel pools which are sometimes shared among two reactors, or joined by a transfer canal, or, increasingly, on-site dry storage facilities such as those at Surry or Calvert Cliffs, or off-site pools such as those are Morris, or the Idaho National Engineering Lab (INEL). Tables 1-1 and 1-2 present the list of spent fuel origins and storage locations used in this assessment.

In aggregate, DOE's listing of spent fuel discharges describes where spent fuel from particular reactors is now stored, and where spent fuel at particular storage locations came from. For example:

- The 2,200 BWR assemblies discharged through November 1994 from the Peachbottom 3 reactor near York, Pennsylvania are all stored at the Peachbottom 3 spent fuel pool, which has capacity to store 3,814 BWR assemblies.

- Of the 808 PWR assemblies discharged through November 1994 from the Oconee 3 reactor in the western corner of South Carolina, 444 (55 percent) are now stored at the Oconee 3 spent fuel pool, 244 (30.2 percent) are in dry storage facilities at the Oconee site, 58 (7.2 percent) are stored at the Oconee 1 spent fuel pool shared by the Oconee 1 and Oconee 2 reactors, and 62 (7.7 percent) are stored at the McGuire 2 spent fuel pool in North Carolina.

- Of the 3,217 spent fuel assemblies stored at GE's Morris facility in Gundy County, Illinois in November 1994, 1,054 (32.8 percent) are BWR assemblies discharged from the Copper Station reactor in Nebraska, 1,058 (32.9 percent) are BWR assemblies discharged from the Monticello reactor in Minnesota, 753 (23.4 percent) are BWR assemblies from the nearby Dresden 2 reactor, 270 (8.4 percent) are PWR assemblies from the San Onofre 1 reactor in California, and 82 (2.5 percent) are PWR assemblies from the Haddam Neck reactor in Connecticut.

- Of the 1,018 spent fuel assemblies stored at INEL in November 1994, 744 (73.1 percent) are HTG assemblies from Fort St. Vrain in Colorado, 177 are PWR assemblies from the damaged Three Mile Island 2 reactor in Pennsylvania, 69 (6.8 percent) are PWR assemblies from the Surry 1 and 2 reactors in Virginia, 18 (1.8 percent) are PWR assemblies from the Turkey Point 3 reactor in Florida, 6 (0.6 percent) are PWR assemblies from the Point Beach 1 reactor in Wisconsin, and 4 are BWR assemblies from Dresden 1 in Illinois and Peachbottom 2 in Pennsylvania.

Waste Origin and Storage Location Assumptions

- **The Current Inventory of Spent Nuclear Fuel**

  As mentioned, spent fuel discharges through November 1994 are identified in DOE Acceptance Priority Ranking reports by the reactor from which the fuel was discharged and by the current storage location. In this assessment, the 30,044 MTU discharged through November 1994 are assumed to remain at their November 1994 storage location until accepted by DOE for transport to an interim or permanent storage facility. We have not attempted to project future transfers of spent fuel among storage locations.

- **Projected Inventory of Spent Nuclear Fuel**

  For the no-new-reactor-orders case in which nuclear reactors are assumed to operate at an assumed percentage of capacity through their NRC license term, DOE forecasts annual discharges through 2042 by the reactor from which the fuel is discharged.[4] In this assessment, we have identified the pool location to which the fuel would be discharged. For example, projected discharges from the Point Beach 2 reactor near Two Creeks, Wisconsin would go to the Point Beach 1 pool shared by Point Beach reactors 1 and 2, while projected discharges from the Comanche Peak 2 reactor near Glen Rose, Texas would go to the Comanche Peak 1 and 2 pools which are connected by a transfer canal. However, we have not attempted to project future transfers of this fuel either to onsite dry storage facilities or to pools at other sites owned by the same utility, or to pools at sites such as Morris or INEL.

- **High-Level Waste Origins and Storage Locations**

  For HLW generated at defense sites, DOE forecasts the projected number of canisters (containing vitrified HLW) which will require disposal in a geologic repository.[5] In this assessment, we assume that the HLW is vitrified, canistered, and stored until pick up at the site at which it was generated.

Shipment Sites

Route analysis requires the identification of a point of origin for each shipment—the place from which the legal-weight truck, heavy-haul truck, rail or barge shipment begins. This assessment associates each storage location with a shipment origin (Table 1-3). For example, spent fuel stored at the separate pools at Arkansas Nuclear's reactors 1 and 2 or at the Arkansas Nuclear dry storage facility all have the same shipment origin. Similarly, spent fuel stored at the connected pools at Calvert Cliffs reactors 1 and 2 or at the Calvert Cliffs dry storage facility all have the same shipment origin.

As will be discussed in Sections 7 and 8, transportation choices are keyed both to the facilities at the storage location (e.g., the characteristics of the separate, shared or joined spent fuel pools, or of the dry storage facility) *and* to the characteristics of near-site infrastructure (e.g., the availability of onsite rail, the distance to an offsite railhead, and the characteristics of the community along the heavy-haul route).

Table 1-1. Originators of Spent Nuclear Fuel or High-Level Waste

#	WASTE ORIGINS:	COMPANY:	STATE	WASTE TYPE	WASTE TYPE	DESIGN CAPAC (MWE)	UTIL STRTUP YEAR	UTIL SHUTD YEAR
1	ARKANSAS NUCLEAR 1	ARKANSAS POWER & LIGHT	AK	PWR	COMM	850	1974	2014
2	ARKANSAS NUCLEAR 2	ARKANSAS POWER & LIGHT	AK	PWR	COMM	912	1978	2018
3	BEAVER VALLEY 1	DUQUESNE LIGHT COMPANY	PA	PWR	COMM	835	1976	2016
4	BEAVER VALLEY 2	DUQUESNE LIGHT COMPANY	PA	PWR	COMM	857	1987	2027
5	BELLEFONTE 1	TENNESSEE VALLEY AUTHORITY	AL	PWR	COMM	1235	????	????
6	BELLEFONTE 2	TENNESSEE VALLEY AUTHORITY	AL	PWR	COMM	1235	????	????
7	BIG ROCK 1	CONSUMERS POWER COMPANY	MI	BWR	COMM	72	1962	2000
8	BRAIDWOOD 1	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1175	1987	2026
9	BRAIDWOOD 2	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1175	1988	2027
10	BROWNS FERRY 1	TENNESSEE VALLEY AUTHORITY	AL	BWR	COMM	1065	1973	2013
11	BROWNS FERRY 2	TENNESSEE VALLEY AUTHORITY	AL	BWR	COMM	1065	1974	2014
12	BROWNS FERRY 3	TENNESSEE VALLEY AUTHORITY	AL	BWR	COMM	1065	1977	2016
13	BRUNSWICK 1	CAROLINA POWER & LIGHT	NC	BWR	COMM	821	1976	2016
14	BRUNSWICK 2	CAROLINA POWER & LIGHT	NC	BWR	COMM	821	1974	2014
15	BYRON 1	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1120	1985	2024
16	BYRON 2	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1120	1987	2026
17	CALLAWAY 1	UNION ELECTRIC CO.	MO	PWR	COMM	1171	1984	2024
18	CALVERT CLIFFS 1	BALTIMORE GAS & ELECTRIC CO.	MD	PWR	COMM	845	1975	2014
19	CALVERT CLIFFS 2	BALTIMORE GAS & ELECTRIC CO.	MD	PWR	COMM	845	1976	2016
20	CATAWBA 1	DUKE POWER COMPANY	SC	PWR	COMM	1145	1985	2024
21	CATAWBA 2	DUKE POWER COMPANY	SC	PWR	COMM	1145	1986	2026
22	CLINTON 1	ILLINOIS POWER CO.	IL	BWR	COMM	933	1987	2026
23	COMANCHE PEAK 1	TEXAS UTILITIES ELECTRIC CO.	TX	PWR	COMM	1150	1990	2030
24	COMANCHE PEAK 2	TEXAS UTILITIES ELECTRIC CO.	TX	PWR	COMM	1150	1993	2033
25	COOK 1	INDIANA MICHIGAN POWER CO.	MI	PWR	COMM	1030	1975	2014
26	COOK 2	INDIANA MICHIGAN POWER CO.	MI	PWR	COMM	1100	1978	2017
27	COOPER STATION	NEERASKA PUBLIC POWER DISTRICT	NB	BWR	COMM	778	1974	2014
28	CRYSTAL RIVER 3	FLORIDA POWER CORPORATION	FL	PWR	COMM	825	1977	2016
29	DAVIS-BESSE 1	TOLEDO EDISON CO.	OH	PWR	COMM	906	1977	2017
30	DIABLO CANYON 1	PACIFIC GAS & ELECTRIC CO.	CA	PWR	COMM	1086	1984	2008
31	DIABLO CANYON 2	PACIFIC GAS & ELECTRIC CO.	CA	PWR	COMM	1119	1985	2010
32	DRESDEN 1	COMMONWEALTH EDISON CO.	IL	BWR	COMM	200	1960	1978
33	DRESDEN 2	COMMONWEALTH EDISON CO.	IL	BWR	COMM	794	1970	2006
34	DRESDEN 3	COMMONWEALTH EDISON CO.	IL	BWR	COMM	794	1971	2011
35	DUANE ARNOLD	IOWA ELEC LGT & PWR (IES UTIL)	IO	BWR	COMM	538	1974	2014
36	ENRICO FERMI 2	DETROIT EDISON CO.	MI	BWR	COMM	1093	1985	2025
37	FARLEY 1	ALABAMA POWER & LIGHT	AL	PWR	COMM	829	1977	2017
38	FARLEY 2	ALABAMA POWER & LIGHT	AL	PWR	COMM	829	1981	2021
39	FITZPATRICK	POWER AUTHORITY OF NEW YORK STATE	NY	BWR	COMM	821	1975	2014
40	FORT CALHOUN	OMAHA PUBLIC POWER DISTRICT	NB	PWR	COMM	486	1973	2008
41	FORT ST VRAIN	PUBLIC SERVICE CO. OF COLORADO	CO	HTG	COMM	330	1979	1989
42	GINNA	ROCHESTER GAS & ELECTRIC	NY	PWR	COMM	490	1969	2009
43	GRAND GULF 1	SYSTEM ENERGY RESOURCES	MS	BWR	COMM	1250	1984	2022
44	HADDAM NECK	CONNECTICUTT YANKEE ATOMIC POWER	CT	PWR	COMM	582	1967	2007
45	HARRIS 1	CAROLINA POWER & LIGHT	NC	PWR	COMM	940	1987	2026
46	HATCH 1	GEORGIA POWER COMPANY	GA	BWR	COMM	777	1974	2014
47	HATCH 2	GEORGIA POWER COMPANY	GA	BWR	COMM	784	1978	2018
48	HOPE CREEK	PUBLIC SERVICE ELECTRIC & GAS CO	NJ	BWR	COMM	1118	1986	2026
49	HUMBOLDT BAY	PACIFIC GAS & ELECTRIC CO.	CA	BWR	COMM	65	1963	1976
50	INDIAN POINT 1	CONSOLIDATED EDISON OF NY	NY	PWR	COMM	265	1962	1980
51	INDIAN POINT 2	CONSOLIDATED EDISON OF NY	NY	PWR	COMM	873	1973	2013
52	INDIAN POINT 3	PORT AUTHORITY OF NEW YORK	NY	PWR	COMM	965	1976	2015
53	KEWAUNEE	WISCONSIN PUBLIC SERVICE CO.	WI	PWR	COMM	535	1974	2013
54	LACROSSE	DAIRYLAND POWER COOP.	WI	BWR	COMM	50	1968	1987
55	LASALLE 1	COMMONWEALTH EDISON CO.	IL	BWR	COMM	1122	1982	2022
56	LASALLE 2	COMMONWEALTH EDISON CO.	IL	BWR	COMM	1122	1984	2023
57	LIMERICK 1	PHILADELPHIA ELECTRIC CO.	PA	BWR	COMM	1055	1985	2024
58	LIMERICK 2	PHILADELPHIA ELECTRIC CO.	PA	BWR	COMM	1055	1989	2029
59	MAINE YANKEE	MAINE YANKEE ATOMIC	ME	PWR	COMM	825	1972	2008
60	MCGUIRE 1	DUKE POWER COMPANY	NC	PWR	COMM	1180	1981	2021
61	MCGUIRE 2	DUKE POWER COMPANY	NC	PWR	COMM	1180	1983	2023
62	MILLSTONE 1	NORTHEAST UTILITY SVC CO.	CT	BWR	COMM	660	1970	2010
63	MILLSTONE 2	NORTHEAST UTILITY SVC CO.	CT	PWR	COMM	870	1975	2015
64	MILLSTONE 3	NORTHEAST UTILITY SVC CO.	CT	PWR	COMM	1150	1986	2025
65	MONTICELLO	NORTHERN STATES POWER CO.	MN	BWR	COMM	545	1971	2010
66	NINE MILE POINT 1	NIAGRA MOHAWK POWER CO.	NY	BWR	COMM	620	1969	2009
67	NINE MILE POINT 2	NIAGRA MOHAWK POWER CO.	NY	BWR	COMM	1080	1987	2025
68	NORTH ANNA 1	VIRGINIA POWER	VA	PWR	COMM	907	1978	2018
69	NORTH ANNA 2	VIRGINIA POWER	VA	PWR	COMM	907	1980	2020
70	OCONEE 1	DUKE POWER COMPANY	SC	PWR	COMM	887	1973	2013
71	OCONEE 2	DUKE POWER COMPANY	SC	PWR	COMM	887	1973	2013
72	OCONEE 3	DUKE POWER COMPANY	SC	PWR	COMM	886	1974	2014

Source: Spent Fuel Storage Requirements: 1994-2042 (DOE/RW-0431-Rev.1: June 1995)

Table 1-1 (Cont).

#	WASTE ORIGINS:	COMPANY:	STATE	WASTE TYPE	WASTE TYPE	DESIGN CAPAC (MWE)	UTIL STRTUP YEAR	UTIL SHUTD YEAR
73	OYSTER CREEK 1	GPU NUCLEAR CORP	NJ	BWR	COMM	650	1969	2009
74	PALISADES	CONSUMERS POWER CO.	MI	PWR	COMM	805	1971	2007
75	PALO VERDE 1	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	COMM	1270	1985	2024
76	PALO VERDE 2	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	COMM	1270	1986	2025
77	PALO VERDE 3	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	COMM	1270	1987	2027
78	PEACHBOTTOM 2	PHILADELPHIA ELECTRIC CO.	PA	BWR	COMM	1065	1974	2008
79	PEACHBOTTOM 3	PHILADELPHIA ELECTRIC CO.	PA	BWR	COMM	1065	1974	2008
80	PERRY 1	CLEVELAND ELEC ILLUMINATING CO.	OH	BWR	COMM	1265	1986	2026
81	PILGRIM 1	BOSTON EDISON CO.	MA	BWR	COMM	655	1972	2012
82	POINT BEACH 1	WISCONSIN ELECTRIC POWER CO.	WI	PWR	COMM	497	1970	2010
83	POINT BEACH 2	WISCONSIN ELECTRIC POWER CO.	WI	PWR	COMM	497	1972	2013
84	PRAIRIE ISLAND 1	NORTHERN STATES POWER CO.	MN	PWR	COMM	530	1973	2013
85	PRAIRIE ISLAND 2	NORTHERN STATES POWER CO.	MN	PWR	COMM	530	1974	2014
86	QUAD CITIES 1	COMMONWEALTH EDISON CO.	IL	BWR	COMM	789	1972	2012
87	QUAD CITIES 2	COMMONWEALTH EDISON CO.	IL	BWR	COMM	789	1972	2012
88	RANCHO SECO 1	SACRAMENTO MUNICIPAL UTILITY DIST.	CA	PWR	COMM	918	1974	1989
89	RIVER BEND 1	GULF STATES UTILITIES CO.	LA	BWR	COMM	936	1985	2025
90	ROBINSON 2	CAROLINA POWER & LIGHT	SC	PWR	COMM	700	1970	2010
91	SALEM 1	PUBLIC SERVICE ELECTRIC & GAS CO	NJ	PWR	COMM	1115	1976	2016
92	SALEM 2	PUBLIC SERVICE ELECTRIC & GAS CO	NJ	PWR	COMM	1115	1981	2020
93	SAN ONOFRE 1	SOUTHERN CALIF EDISON	CA	PWR	COMM	436	1967	1992
94	SAN ONOFRE 2	SOUTHERN CALIF EDISON	CA	PWR	COMM	1070	1982	2013
95	SAN ONOFRE 3	SOUTHERN CALIF EDISON	CA	PWR	COMM	1080	1983	2013
96	SEABROOK 1	NORTH ATLANTIC ENERGY SERVICE	NH	PWR	COMM	1150	1990	2026
97	SEQUOYAH 1	TENNESSEE VALLEY AUTHORITY	TN	PWR	COMM	1148	1980	2020
98	SEQUOYAH 2	TENNESSEE VALLEY AUTHORITY	TN	PWR	COMM	1148	1981	2021
99	SHOREHAM	LONG ISLAND LIGHTING CO.	NY	BWR	COMM	849	1986	1987
100	SOUTH TEXAS 1	HOUSTON LIGHTING & POWER CO.	TX	PWR	COMM	1250	1988	2027
101	SOUTH TEXAS 2	HOUSTON LIGHTING & POWER CO.	TX	PWR	COMM	1250	1989	2028
102	ST LUCIE 1	FLORIDA POWER & LIGHTING CO.	FL	PWR	COMM	830	1976	2016
103	ST LUCIE 2	FLORIDA POWER & LIGHTING CO.	FL	PWR	COMM	804	1983	2023
104	SUMMER 1	SOUTH CAROLINA ELECTRIC & GAS	SC	PWR	COMM	900	1982	2022
105	SURRY 1	VIRGINIA POWER	VA	PWR	COMM	788	1972	2012
106	SURRY 2	VIRGINIA POWER	VA	PWR	COMM	788	1973	2013
107	SUSQUEHANNA 1	PENNSYLVANIA POWER & LIGHT	PA	BWR	COMM	1065	1982	2022
108	SUSQUEHANNA 2	PENNSYLVANIA POWER & LIGHT	PA	BWR	COMM	1065	1984	2024
109	THREE MILE ISLAND 1	GPU NUCLEAR CORP	PA	PWR	COMM	819	1974	2014
110	TROJAN	PORTLAND GENERAL ELECTRIC CO.	OR	PWR	COMM	1130	1975	1992
111	TURKEY POINT 3	FLORIDA POWER & LIGHTING CO.	FL	PWR	COMM	693	1972	2007
112	TURKEY POINT 4	FLORIDA POWER & LIGHTING CO.	FL	PWR	COMM	693	1973	2007
113	VERMONT YANKEE 1	VERMONT YANKEE NUCLEAR POWER	VT	BWR	COMM	514	1972	2012
114	VOGTLE 1	GEORGIA POWER CO.	GA	PWR	COMM	1069	1987	2027
115	VOGTLE 2	GEORGIA POWER CO.	GA	PWR	COMM	1069	1989	2029
116	WASHINGTON NUCLEAR 2	WASH PUBLIC POWER SUPPLY SYSTEM	WA	BWR	COMM	1100	1984	2023
117	WASHINGTON NUCLEAR 3	WASH PUBLIC POWER SUPPLY SYSTEM	WA	BWR	COMM	1250	????	????
118	WATERFORD 3	LOUISIANNA POWER & LIGHT	LA	PWR	COMM	1104	1985	2024
119	WATTS BAR 1	TENNESSEE VALLEY AUTHORITY	TN	PWR	COMM	1165	????	????
120	WATTS BAR 2	TENNESSEE VALLEY AUTHORITY	TN	PWR	COMM	1165	????	????
121	WOLF CREEK 1	WOLF CREEK NUCLEAR OPERATING CORP.	KS	PWR	COMM	1150	1985	2025
122	YANKEE-ROWE 1	YANKEE ATOMIC ELECTRIC CO.	MA	PWR	COMM	175	1960	1991
123	ZION 1	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1085	1973	2013
124	ZION 2	COMMONWEALTH EDISON CO.	IL	PWR	COMM	1085	1973	2013
125	GENERAL ATOMICS	GENERAL ATOMICS	CA	RSH	DFNS	NA	????	????
126	HANFORD	DOE/HANFORD	WA	HLW	DFNS	NA	????	????
127	INEL	DOE/INEL	ID	HLW	DFNS	NA	????	????
128	SAVANNAH RIVER	DOE/SAVANNAH RIVER	SC	HLW	DFNS	NA	????	????
129	WEST VALLEY	DOE/WEST VALLEY	NY	HLW	DFNS	NA	????	????

Source: Spent Fuel Storage Requirements: 1994-2042 (DOE/RW-0431-Rev.1: June 1995)

Table 1-2. Storage Locations for Spent Nuclear Fuel and High-Level Waste

	STORAGE LOCATIONS:	WASTE TYPE	UTIL STRTUP YEAR	UTIL SHUTD YEAR	STRG CAPAC (ASSEMBLIES) LICEN	MAX	FULL CORE ASMB	NOTES:
1	ARKANSAS NUCLEAR 1	PWR	1974	2014	968	948	177	
2	ARKANSAS NUCLEAR 2	PWR	1978	2018	988	933	177	
3	ARKANSAS NUCLEAR DRY STRG	PWR	1995	2015	192	192	NA	VSC-24 under gnrl lic, starting 1995
4	BEAVER VALLEY 1	PWR	1976	2016	833	1621	157	
5	BEAVER VALLEY 2	PWR	1987	2027	1088	1088	157	
6	BELLEFONTE 1	PWR	????	????	1058	1058	205	
7	BELLEFONTE 2	PWR	????	????	1058	1058	205	
8	BIG ROCK 1	BWR	1962	2000	441	441	84	
9	BRAIDWOOD 1&2	PWR	1987	2027	2870	2834	193	
10	BROWNS FERRY 1-2	BWR	1973	2014	3471	6942	764	
11	BROWNS FERRY 3	BWR	1977	2016	3471	3471	764	
12	BRUNSWICK 1	BWR	1976	2016	1803	1767	560	
13	BRUNSWICK 1 BWR POOL	PWR	1976	2016	NA	160	NA	
14	BRUNSWICK 2	BWR	1974	2014	1839	1767	560	
15	BRUNSWICK 2 BWR POOL	PWR	1974	2014	NA	144	NA	
16	BYRON 1&2	PWR	1985	2026	2870	2824	193	
17	CALLAWAY 1	PWR	1984	2024	1340	1340	193	
18	CALVERT CLIFFS 1-2	PWR	1975	2016	1830	1778	217	
19	CALVERT DRY STORAGE	PWR	1991	2011	1152	1152	NA	NUHOMS-24 under 1992 site specific lic
20	CATAWBA 1	PWR	1985	2024	1419	2615	193	
21	CATAWBA 2	PWR	1986	2026	1418	2615	193	
22	CLINTON 1	BWR	1987	2026	2512	2512	624	
23	COMANCHE PEAK 1-2	PWR	1990	2030	1693	1289	193	
24	COOK 1&2	PWR	1975	2017	2050	3613	193	
25	COOPER STATION	BWR	1974	2014	2366	2366	548	
26	CRYSTAL RIVER 3	PWR	1977	2016	1357	1357	177	
27	DAVIS-BESSE 1	PWR	1977	2017	735	720	177	
28	DAVIS-BESSE DRY STRG	PWR	1995	2015	192	192	NA	NUHOMS-24 under gnrl lic, starting 1995
29	DIABLO CANYON 1	PWR	1984	2010	1324	1324	193	
30	DIABLO CANYON 2	PWR	1985	2010	1324	1317	193	
31	DRESDEN 1	BWR	1960	1978	720	720	464	
32	DRESDEN 2	BWR	1970	2006	3537	3537	724	
33	DRESDEN 3	BWR	1971	2011	3537	3537	724	
34	DUANE ARNOLD	BWR	1974	2014	2050	1898	368	
35	ENRICO FERMI 2	BWR	1985	2025	2383	2383	764	
36	FARLEY 1	PWR	1977	2017	1407	1407	157	
37	FARLEY 2	PWR	1981	2021	1407	1407	157	
38	FITZPATRICK	BWR	1975	2014	2797	2797	560	
39	FORT CALHOUN	PWR	1973	2008	729	1083	133	
40	FORT ST VRAIN	HTG	1979	1989	1482	0	0	
41	FORT ST VRAIN DRY STRG	HTG	1991	2011	1482	1482	NA	Foster Wheeler MVDS under 1991 site specific lic
42	GINNA	PWR	1969	2009	1016	1083	121	
43	GRAND GULF 1	BWR	1984	2022	2324	3872	800	
44	HADDAM NECK	PWR	1967	2007	1172	1167	157	
45	HARRIS 1-2	PWR	1987	2026	4184	1128	157	
46	HARRIS 1-2 BWR POOL	BWR	1987	2026	NA	1573	NA	
47	HATCH 1-2	BWR	1974	2018	3181	5830	560	
48	HOPE CREEK	BWR	1986	2026	4006	3998	764	
49	HUMBOLDT BAY	BWR	1963	1976	486	485	134	
50	INDIAN POINT 1	PWR	1962	1980	756	756	120	
51	INDIAN POINT 2	PWR	1973	2013	1374	1374	193	
52	INDIAN POINT 3	PWR	1976	2015	1345	1340	193	
53	KEWAUNEE	PWR	1974	2013	990	990	121	
54	LACROSSE	BWR	1968	1987	440	440	72	
55	LASALLE 1-2	BWR	1982	2023	5153	7780	764	
56	LIMERICK 1-2	BWR	1985	2029	2040	6798	764	
57	MAINE YANKEE	PWR	1972	2008	1476	1464	217	
58	MCGUIRE 1	PWR	1981	2021	1463	1581	193	
59	MCGUIRE 2	PWR	1983	2023	1463	1460	193	
60	MILLSTONE 1	BWR	1970	2010	3229	3229	580	
61	MILLSTONE 2	PWR	1975	2015	1072	1299	217	
62	MILLSTONE 3	PWR	1986	2025	756	756	193	
63	MONTICELLO	BWR	1971	2010	2237	2229	484	
64	NINE MILE POINT 1	BWR	1969	2009	2776	2560	532	
65	NINE MILE POINT 2	BWR	1987	2026	4049	2528	764	
66	NORTH ANNA 1&2	PWR	1978	2020	1737	1677	157	
67	NORTH ANNA DRY STRG	PWR	1998	2018	256	256	NA	TN-32 under 1998 site specific lic
68	OCONEE 1&2	PWR	1973	2013	1312	1311	177	
69	OCONEE 3	PWR	1974	2014	825	818	177	
70	OCONEE DRY STORAGE	PWR	1990	2010	960	960	NA	NUHOMS-24 under 1990 site specific lic
71	OYSTER CREEK 1	BWR	1969	2009	2600	2600	560	
72	OYSTER CREEK DRY STRG	BWR	1996	2016	416	416	NA	NUHOMS-52 under gnrl lic, starting 1996

Table 1-2 (Cont).

	STORAGE LOCATIONS:	WASTE TYPE	UTIL STRTUP YEAR	UTIL SHUTD YEAR	STRG CAPAC (ASSEMBLIES) LICEN	MAX	FULL CORE ASMB	NOTES:
73	PALISADES	PWR	1971	2007	892	888	204	
74	PALISADES DRY STRG	PWR	1993	2013	48	48	NA	NUHOMS-24 under gnrl lic, starting 1996
75	PALO VERDE 1	PWR	1985	2024	665	1323	241	
76	PALO VERDE 2	PWR	1986	2025	665	1323	241	
77	PALO VERDE 3	PWR	1987	2027	665	1322	241	
78	PEACHBOTTOM 2	BWR	1974	2008	3819	3819	764	
79	PEACHBOTTOM 3	BWR	1974	2008	3819	3814	764	
80	PERRY 1	BWR	1986	2026	4020	4020	748	
81	PILGRIM 1	BWR	1972	2012	2320	2875	580	
82	POINT BEACH 1&2	PWR	1970	2013	1502	1500	121	
83	POINT BEACH DRY STRG	PWR	1995	2015	192	192	NA	VSC-24 under gnrl lic, starting 1995
84	PRAIRIE ISLAND 1&2	PWR	1973	2014	1386	1378	121	
85	PRAIRIE ISLAND DRY STRG	PWR	1993	2013	320	320	NA	TN-40 under 1993 site specific lic
86	QUAD CITIES 1-2	BWR	1972	2012	7554	7533	724	
87	RANCHO SECO 1	PWR	1974	1989	1080	1080	177	
88	RANCHO SECO DRY STRG	PWR	1996	2016	561	561	NA	NUHOMS-MP187 under 1996 site specific lic
89	RIVER BEND 1	BWR	1985	2025	2680	3172	624	
90	ROBINSON 2	PWR	1970	2010	544	537	157	
91	ROBINSON DRY STRG	PWR	1986	2006	56	56	NA	NUHOMS-07 under 1986 site specific lic
92	SALEM 1	PWR	1976	2016	1170	1117	193	
93	SALEM 2	PWR	1981	2020	1170	1139	193	
94	SAN ONOFRE 1	PWR	1967	1992	216	216	157	
95	SAN ONOFRE 2	PWR	1982	2013	1542	1542	217	
96	SAN ONOFRE 3	PWR	1983	2013	1542	1542	0	
97	SEABROOK 1	PWR	1990	2026	1236	1236	193	
98	SEQUOYAH 1&2	PWR	1980	2021	1386	2091	193	
99	SHOREHAM	BWR	1986	1987	2436	2685	560	
100	SOUTH TEXAS 1	PWR	1988	2027	1969	1958	193	
101	SOUTH TEXAS 2	PWR	1989	2028	1969	1958	193	
102	ST LUCIE 1	PWR	1976	2016	1706	1705	217	
103	ST LUCIE 2	PWR	1983	2023	1584	1076	217	
104	SUMMER 1	PWR	1982	2022	1276	1276	157	
105	SURRY 1&2	PWR	1972	2013	1044	1044	157	
106	SURRY DRY STORAGE	PWR	1986	2006	533	533	NA	CASTOR-22 (& other) under 1986 site spec lic
107	SUSQUEHANNA 1-2	BWR	1982	2024	2840	5680	764	
108	SUSQUEHANNA DRY STRG	BWR	1997	2017	416	416	NA	NUHOMS-52 under gnrl lic, starting 1997
109	THREE MILE ISLAND 1	PWR	1974	2014	752	1284	177	
110	TROJAN	PWR	1975	1992	1408	1395	193	
111	TURKEY POINT 3	PWR	1972	2007	1404	1376	157	
112	TURKEY POINT 4	PWR	1973	2007	1404	1376	0	
113	VERMONT YANKEE 1	BWR	1972	2012	2870	2860	368	
114	VOGTLE 1-2	PWR	1987	2029	2386	2283	193	
115	WASHINGTON NUCLEAR 2	BWR	1984	2023	2658	2654	764	
116	WATERFORD 3	PWR	1985	2024	1088	1070	217	
117	WATTS BAR 1&2	PWR	????	????	1312	1294	193	
118	WOLF CREEK 1	PWR	1985	2025	1340	1327	193	
119	YANKEE-ROWE 1	PWR	1960	1991	721	721	76	
120	ZION 1&2	PWR	1973	2013	2112	2929	193	
121	HANFORD SNF STRG	PWR	????	????	????	????	NA	
122	HANFORD SNF STRG	BWR	????	????	????	????	NA	
123	INEL SNF STRG	PWR	????	????	????	????	NA	
124	INEL SNF STRG	BWR	????	????	????	????	NA	
125	INEL SNF STRG	HTG	????	????	????	????	NA	
126	SAVANNAH RIVER SNF STRG	PWR	????	????	????	????	NA	
127	SAVANNAH RIVER SNF STRG	BWR	????	????	????	????	NA	
128	WEST VALLEY SNF STRG	PWR	????	????	????	????	NA	
129	WEST VALLEY SNF STRG	BWR	????	????	????	????	NA	
130	MORRIS OPERATION	PWR	????	2002	????	380	NA	
131	MORRIS OPERATION	BWR	????	2002	????	2928	NA	
132	GENERAL ATOMICS	RSH	????	????	????	????	NA	
	TOTAL							

Source: Spent Fuel Storage Requirements: 1994-2042 (DOE/RL-0431.... June 1995
Spent Nuclear Fuel Discharges From US Reactors: 1994 (SR/CNEAF/96-01..... Feb 1996)
1-2: Joined pools; 1&2: Shared pools.... later shutdown reactor date applies
Max pool capacities: generally from SFSR; SNFD as noted
Dry storage capacities: generally from SFSR; SNFD or PIC as noted

Table 1-3. Spent Nuclear Fuel and High-Level Waste Shipment Sites

SHIPMENT SITE:	WASTE TYPE
1 ARKANSAS NUCLEAR	PWR
2 BEAVER VALLEY	PWR
3 BELLEFONTE	PWR
4 BIG ROCK	BWR
5 BRAIDWOOD	PWR
6 BROWNS FERRY	BWR
7 BRUNSWICK	BWR
	PWR
8 BYRON	PWR
9 CALLAWAY	PWR
10 CALVERT CLIFFS	PWR
11 CATAWBA	PWR
12 CLINTON	BWR
13 COMANCHE PEAK	PWR
14 COOK	PWR
15 COOPER STATION	BWR
16 CRYSTAL RIVER	PWR
17 DAVIS-BESSE	PWR
18 DIABLO CANYON	PWR
19 DRESDEN	BWR
20 DUANE ARNOLD	BWR
21 ENRICO FERMI	BWR
22 FARLEY	PWR
23 FITZPATRICK	BWR
24 FORT CALHOUN	PWR
25 FORT ST VRAIN	HTG
26 GINNA	PWR
27 GRAND GULF	BWR
28 HADDAM NECK	PWR
29 HARRIS	PWR
	BWR
30 HATCH	BWR
31 HOPE CREEK	BWR
32 HUMBOLDT BAY	BWR
33 INDIAN POINT	PWR
34 KEWAUNEE	PWR
35 LACROSSE	BWR
36 LASALLE	BWR
37 LIMERICK	BWR
38 MAINE YANKEE	PWR
39 MCGUIRE	PWR
40 MILLSTONE	BWR
41 MONTICELLO	BWR
42 NINE MILE POINT	BWR
43 NORTH ANNA	PWR
43 NORTH ANNA	PWR
44 OCONEE	PWR
45 OYSTER CREEK	BWR
46 PALISADES	PWR
47 PALO VERDE	PWR

FUEL STRG LOCATIONS	WASTE TYPE
48 PEACHBOTTOM	BWR
49 PERRY	BWR
50 PILGRIM	BWR
51 POINT BEACH	PWR
52 PRAIRIE ISLAND	PWR
53 QUAD CITIES	BWR
54 RANCHO SECO	PWR
55 RIVER BEND	BWR
56 ROBINSON	PWR
57 SALEM	PWR
58 SAN ONOFRE	PWR
59 SEABROOK	PWR
60 SEQUOYAH	PWR
61 SHOREHAM	BWR
62 SOUTH TEXAS	PWR
63 ST LUCIE	PWR
64 SUMMER	PWR
65 SURRY	PWR
67 SUSQUEHANNA	BWR
68 THREE MILE ISLAND	PWR
69 TROJAN	PWR
70 TURKEY POINT	PWR
71 VERMONT YANKEE	BWR
72 VOGTLE	PWR
73 WASH NUCLEAR	BWR
74 WATTS BAR	PWR
75 WATERFORD	PWR
76 WOLF CREEK	PWR
77 YANKEE-ROWE	PWR
78 ZION	PWR
79 HANFORD	PWR
	BWR
	HLW
80 INEL	PWR
	BWR
	HTG
	HLW
	NRF
81 SAVANNAH	PWR
	BWR
	HLW
	FRF
82 WEST VALLEY	BWR
	PWR
	HLW
83 MORRIS	BWR
	PWR
84 GENERAL ATOMICS	RSH
	MSC

Waste Types:

BWR: Assemblies from boiling water reactors
PWR: Assemblies from pressurized water reactors
HTG: Assemblies from high-temp gas reactors
MSC: Miscellaneous spent fuel discharges thru Nov 1994 (@GA)
RSH: Spent fuel for research, thru Nov 1994 (@GA)
NRF: Naval reactor fuel
FRF: Foreign research fuel
HLW: High-level defense waste (not spent fuel)

2. THE INVENTORY OF SPENT NUCLEAR FUEL AND HIGH-LEVEL WASTE

The radioactive wastes which require geologic disposal and which could be shipped to a centralized storage facility at the Nevada Test Site (Area 25) to await permanent disposal are in three broad categories: SNF from commercial power plants, HLW from the nation's defense complex, and other wastes requiring geologic disposal. It is convenient to consider the current and projected inventory of these wastes with reference to their key relevant information sources. This, however, introduces some minor anomalies. For example, a portion of research and miscellaneous spent fuel is included in the current inventory of commercial SNF, since it is included in the key information source (prioritized spent fuel discharges) for this category. Also, the consideration of other wastes requires special attention to avoid double-counting.

2.1 Spent Nuclear Fuel from Commercial Plants

The Current SNF Inventory

Through November 1994, 30,044 metric tons of SNF had been permanently discharged from U.S. reactors, and had received priority ranking for acceptance by DOE (see Table 2-1). Of the November 1994 total,

- About 10,809 MTU (36.0 percent) was in 59,400 assemblies discharged from 41 commercial boiling water reactors. The average BWR assembly weighs .182 tons or 364 pounds.
- About 19,149 MTU (63.7 percent) was in 44,600 assemblies discharged from 78 commercial pressurized water reactors. The average PWR assembly weighs .429 tons or 869 pounds.
- About 86 MTU (0.3 percent) was discharges from the high-temperature gas reactor at Fort St. Vrain, Colorado, or discharges of research or miscellaneous spent fuel.

Ranked spent fuel discharges do not include naval reactor fuel, foreign research fuel, or spent fuel discharged from defense reactors. Nor does it include the HLW that have accumulated at defense sites.

The Future SNF Inventory

DOE has projected annual spent fuel discharges from 1994 through 2042 at commercial reactors,[4] under a case which assumes no-new-reactor orders and operations through the current NRC license term (with no early shut downs and no license extensions). The projected discharges include 56,655 MTU in 19,900 BWR and 36,800 PWR assemblies.

In this assessment, 1994 discharges are the "actuals" reported in DOE's 1995 Acceptance Priority Ranking through November 28, 1994. The differences between the actuals for 1994 and DOE's 1994 projections are included in the projected discharges for 1995, so that the projections for 1994 through 2042 are consistent with DOE's forecast for the no-new-orders, NRC license term case.

DOE's forecast is presented by the reactor from which the assemblies are discharged. This assessment identifies the pool location (separate, shared, or joined) to which the fuel would be discharged, but does not attempt to project future transfers of spent fuel to onsite dry storage facilities or to pools at other sites owned by the same utility or others.

The Total SNF Inventory

Combining projected spent fuel discharges with those through November 28, 1994, the total inventory includes 86,699 MTU in 30,700 BWR and 55,900 PWR assemblies. This total, however, does not include projections of spent fuel from research reactors, or projected naval reactor fuel, foreign research fuel, or HLW from defense facilities.

Alternative Inventory Projections

Alternative projections of waste requiring geologic disposal could be considered in alternative scenarios. Some of the contingencies that might be considered in alternative scenarios are briefly discussed below:

- **Reactors licensed for startup after 1993.**

  DOE's forecast for the no-new-orders, NRC license term case includes discharges for five reactors scheduled for startup after 1993, the base year for the DOE forecast:

  — Bellefonte 1, projected to discharge 2,193 PWR assemblies and 913 MTU between 2000 and 2039.

  — Bellefonte 2, projected to discharge 2,076 PWR assemblies and 864 MTU between 2003 and 2042.

  — Comanche Peak 2, projected to discharge 2,081 PWR assemblies and 856 MTU between 1994 and 2033.

  — Watts Bar 1, projected to discharge 1,725 PWR assemblies and 800 MTU between 1996 and 2035.

  — Watts Bar 2, projected to discharge 1,648 PWR assemblies and 763 MTU between 1998 and 2037.

  It is possible, even likely, that the above plants, though licensed, will never operate. In this case, projected discharges would be reduced by 9,723 PWR assemblies or 4,196 MTU, about 17.4 percent of the total inventory of 55,900 PWR assemblies in the no-new-orders case, and about 4.8 percent of total projected MTU.

- **Reactors shut down before their NRC license term**

  The economics of generating nuclear power in increasingly competitive electric power markets, as well as the cost of dealing with aging nuclear reactors[6] and/or problems in providing onsite storage capacity, could persuade utilities to shut down some reactors before their NRC license

term. The transportation effects of such decisions, which would reduce the revenue base for the nuclear waste fund, and complicate the financing of plant decommissioning, could be considered in an alternative inventory scenario.

- **Reactor license extensions**

  Extension of operating licenses beyond the standard 40-year term has been periodically considered by the NRC and utilities. Extensions would be contingent on the solution of problems associated with aging reactors and onsite storage, but could augment the nuclear waste fund as well as funds for decommissioning. The transportation effects of possible license extensions could be considered in an alternative inventory scenario.

2.2 High-Level Wastes from the Defense Complex

High-level waste is generated by the chemical reprocessing of spent research and production reactor fuel, irradiated targets and naval propulsion fuel. It exists in a variety of physical or chemical forms, all of which must be stored behind heavy shielding and usually in underground tanks or bins. Since DOE decided in 1992 to phase out the domestic reprocessing of irradiated nuclear fuel for the recovery of enriched uranium or plutonium, little additional generation of HLW is expected.

Current DOE plans are to immobilize HLW through a vitrification process, and to package it in canisters for storage at the four sites where it was produced (Hanford, INEL, Savannah River, West Valley) and for shipment to the geologic repository for disposal. The canisters are expected to be about 2 feet in diameter and from 10 to 15 feet in length. However, since pretreatment and waste minimization processes at the INEL and Hanford sites have not yet been finalized, the dimensions and number of canisters to be produced from those sites is less certain than at Savannah River and West Valley.

DOE's Integrated Data Base Report[5] (the source for the above summary) provides a projection of the number of canisters of HLW expected to be produced at each of the four sites, noting that "projected inventories. . .(are) based on certain assumptions, and therefore should be considered only as current best estimates." An alternative projection, with substantially higher production estimates for Hanford and INEL, is provided in DOE's Waste Management Programmatic EIS.[7] This assessment combines the canister production rate from the first source with the canister production totals from the second (Figure 2-1). It is assumed that the canisters would be stored at the sites where they are produced, awaiting shipment to a centralized storage or permanent disposal facility.

2.3 Other Wastes Requiring Geologic Disposal

A variety of other radioactive wastes require permanent geologic disposal. Under DOE waste management plans or DOE agreements with states such as Idaho, these wastes could be shipped to a centralized above-ground facility for storage while awaiting permanent disposal. A recent DOE document[8] provides the best available information on the inventory of such wastes, which could total about 2,700 MTU, about 9.0 percent of the commercial spent fuel discharged through November 1994. This section briefly discusses the categories and projected inventory of "other wastes requiring geologic disposal," but the schedule, packages, and routes by which they would be shipped to Nevada are not included in this assessment.

- **Naval Reactor Fuel**

  Spent fuel from the power plants of the Navy's submarines and aircraft carriers is being shipped to INEL for storage, but, under an October 1995 agreement with the State of Idaho, must be removed from the state by 2035. The current inventory of such fuel at INEL is about 10.23 MTU, and an additional 55 tons may be accumulated.

- **Defense Production Reactor Fuel**

  About 2,100 MTU of SNF has been generated at Hanford's weapons production reactors (reactors N and K) and about 150 MTU at Savannah River. Prior to DOE's 1992 decision, this spent fuel would have been reprocessed—producing enriched uranium or plutonium as well as HLW. Under the 1992 decision, however, it will be packaged for shipment to a permanent geologic repository, perhaps via a centralized above-ground storage facility.

- **Spent Fuel from Research Reactors: DOE**

  Spent fuel has been discharged from research reactors at INEL (about 263.9 MTU), Savannah River (about 56.3 MTU), Hanford (about 32.4 MTU), Oak Ridge (about 1.8 MTU), and elsewhere (Battelle, Sandia, Los Alamos, Argonne-East: about 2.3 MTU). This material, which is in assemblies generally about one-quarter of the size of BWR assemblies will require geologic disposal.

- **Spent Fuel from Research Reactors: Non-DOE**

  About 5.5 MTU from non-DOE research reactors (about 90 percent from research reactors at universities, about 10 percent from research reactors at other federal agencies or commercial sites) will require geologic disposal. This total does not include the 3.2 MTU of spent fuel from the General Atomics research reactor near San Diego, which has acceptance priority under the standard contract.

- **Spent Fuel from Research Reactors: Foreign**

  About 21.7 MTU of spent fuel provided for research in foreign countries is being returned to the U.S. (arriving at various ports of entry) for management and disposal at a geologic repository. The fuel may be shipped for storage at DOE facilities (e.g., Hanford, INEL, Savannah River) pending subsequent transportation to a centralized storage or disposal site.

Table 2-1. Spent Nuclear Fuel: Discharges, Assemblies, MTIHM
Current Inventory: Discharges Through November 28, 1994
Future Additions: Discharges 1995 through 2042

	DISCHG	ASSMBL	MTU	MTU/A	LBS/A	A/DSCHG	MTU/D
CURRENT:							
BWR	411	59418	10809	0.182	364	145	26
PWR	843	44602	19149	0.429	859	53	23
HTG	6	2208	24	0.011	22	368	4
RSC	32	72	3	0.044	89	2	0
MSC	3	0	59	NA	0	0	NA
SUM	1295	106300	30044	0.283	565	82	23
FUTURE:							
BWR	1872	110257	19873	0.180	360	59	11
PWR	3552	84915	36782	0.433	866	24	10
HTG	0	0	0	NA	0	NA	NA
RSC	0	0	0	NA	0	NA	NA
MSC	0	0	0	NA	0	NA	NA
SUM	5424	195172	56655	0.290	581	36	10
TOTAL:							
BWR	2283	169675	30682	0.181	362	74	13
PWR	4395	129517	55931	0.432	864	29	13
HTG	6	2208	24	0.011	22	368	4
RSC	32	72	3	0.044	89	2	0
MSC	3	0	59	NA	0	0	NA
SUM	6719	301472	86699	0.288	575	45	13

	DISCHG	ASSMBL	MTU	MTU/A	LBS/A	A/DSCHG	MTU/D
BWR: Current	411	59418	10809	0.182	364	145	26
Future	1872	110257	19873	0.180	360	59	11
Total	2283	169675	30682	0.181	362	74	13
PWR: Current	843	44602	19149	0.429	859	53	23
Future	3552	84915	36782	0.433	866	24	10
Total	4395	129517	55931	0.432	864	29	13
HTG: Current	6	2208	24	0.011	22	368	4
Future	0	0	0	NA	0	NA	NA
Total	6	2208	24	0.011	22	368	4
RSC: Current	32	72	3	0.044	89	2	0
Future	0	0	0	NA	0	NA	NA
Total	32	72	3	0.044	89	2	0
MSC: Current	3	0	59	NA	0	0	NA
Future	0	0	0	NA	0	NA	NA
Total	3	0	59	NA	0	0	NA
SUM: Current	1295	106300	30044	0.283	565	82	23
Future	5424	195172	56655	0.290	581	36	10
Total	6719	301472	86699	0.288	575	45	13

Source: DOE Acceptance Priority Ranking: Nov 28, 1994
Spent Fuel Storage Req: 1994-2042 (Tables 8.1a & 1b),
via PIC: DISCHG, ACCPT94V, ACCPT95X

Figure 2-1a. Cumulative Projected Production of HLW Canisters at West Valley, Savannah River, Hanford, and Idaho National Engineering Lab

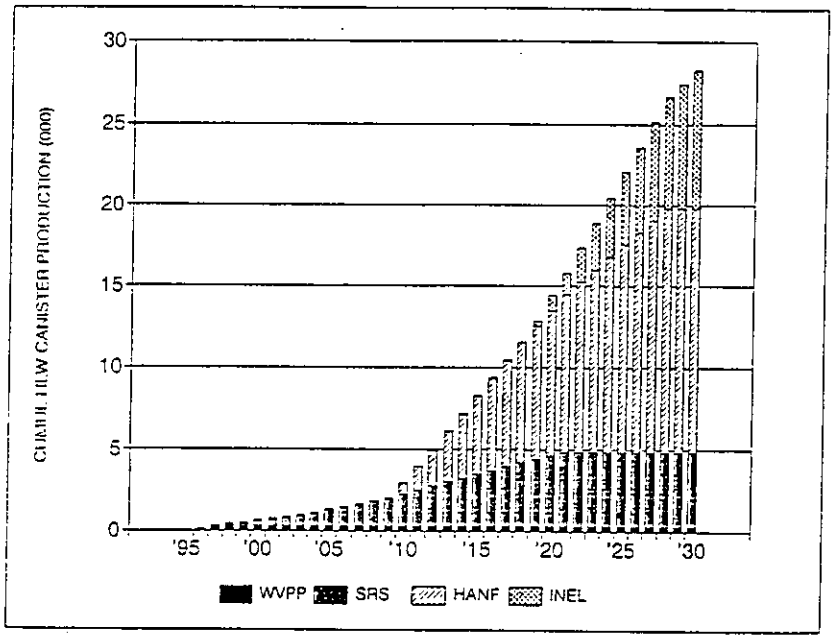
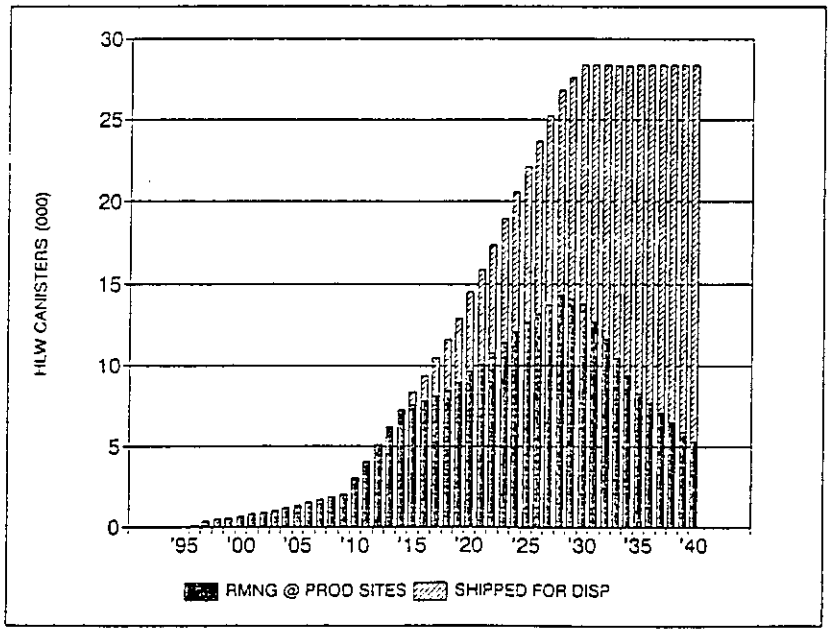


Figure. 2-1b. Cumulative Projected HLW Canisters—Shipped and Remaining at Production Sites



3. ACCEPTANCE STARTUP AND RATE

When the federal government is obligated to take title to SNF, and the annual rate at which it must pick up waste for transportation to and management at a federally-licensed facility are matters of current legal and legislative controversy:

Acceptance Startup Year

DOE has argued that acceptance would begin when a federally-licensed facility is available.[9] Since current legislation does not authorize construction of a centralized above-ground storage facility in Nevada, and since the suitability of Yucca Mountain as a permanent disposal site is uncertain, a date at which acceptance would begin cannot be specified.

Industry, on the other hand, has argued that the standard contract established by the NWPA requires the federal government to begin acceptance in 1998, in return for payments to the nuclear waste fund of 1 mill per kilowatt hour of nuclear generated electricity.[10]

This assessment does not specify the acceptance start year; acceptance begins in "year 1" and extends through "year 31". Assuming a 1998 startup year, and the acceptance rate specified in proposed legislation (see below), at least 84,100 MTU of SNF would be accepted by the end of the year 2027 (the 30th acceptance year)—reducing spent fuel in temporary storage to about 850 MTU. This spent fuel, plus about 1,610 MTU generated between 2027 and 2042 (under DOE's no-new-orders, NRC license term forecast[4]) is included in the "31st acceptance year," though in fact the fuel would be accepted in small quantities over a 22-year period between 2028 and 2050.

Changing the startup year to 2003, 84,100 MTU of SNF would not be accepted until the end of the year 2032 (the 30th acceptance year)—at which point the SNF in temporary storage would be about 1,715 MTU. This spent fuel, plus about 750 MTU generated between 2032 and 2042, is included in the "31st acceptance year", though in fact the fuel would be accepted in small quantities over a 17-year period between 2033 and 2050.

Acceptance Rate

DOE has suggested[11] that spent fuel would be accepted at a rate of 400 MTU in the first acceptance year, 600 MTU in the second, and 900 MTU in years three through ten. Only after year 10, other DOE reports[12] suggest, would acceptance and pick up increase to 3,000 MTU annually.

By contrast, proposed legislation would require acceptance of at least 1,200 MTU in the first and second acceptance years, 2,000 MTU in the third and fourth acceptance years, 2,700 MTU in the fifth acceptance year, and 3,000 MTU in the sixth and subsequent acceptance years.

This assessment uses the acceptance rate required by proposed legislation. The implication is that at least 9,100 MTU would be accepted for pickup and transport to a centralized storage facility over the first five acceptance years, and 15,000 MTU over each subsequent five-year period. Compared with acceptance rates implied by DOE reports, proposed legislation (e.g., S-1936) would increase pick up by

5,400 MTU over the first five years, by 10,500 MTU over the second five years, and by 3,000 MTU over the third five years.

SNF Acceptance and Pick Up (MTU)

	DOE	S-1936	Difference
Years 1 - 5	3,700	9,100	5,400
Years 6 - 10	4,500	15,000	10,500
Years 11 - 15	12,000	15,000	3,000
Years 16 - 20	15,000	15,000	0
Years 1 - 15	20,200	39,100	18,900

Shipment of High-Level Wastes

This assessment assumes that the start date for shipment of canisters of vitrified high-level waste from DOE defense sites in year 15—that is, 15 years after the start date for spent fuel shipments, or 2015 assuming that spent fuel shipments begin in the year 2000. Once begun, this assessment assumes that HLW canisters would be shipped at an annual rate of 800 in the first five years, 900 in the second five, and 600 in subsequent years. At these rates, shipments would continue through 2049, roughly 20 years beyond the conclusion of SNF shipments.

Would a permanent geologic repository be available in year 15 (i.e., in 2015 if SNF shipments begin in the year 2000, in 2025 if SNF shipments begin in 2010), and could or would HLW be shipped to Nevada for centralized above-ground storage while awaiting permanent disposal? The answer is uncertain. The October 1995 settlement agreement between the State of Idaho and the DOE suggests (Section C3) that all HLW as well as naval reactor fuel and foreign research reactor fuel must be moved out of Idaho (i.e., to Nevada) by January 2035, and a possible interpretation of proposed legislation would allow shipment of HLW for centralized above-ground storage if a geologic repository is unavailable. As mentioned, this assessment assumes HLW shipments begin year 15 after the start of SNF shipments, whether the Nevada destination is a centralized storage facility or a permanent repository.

4. ACCEPTANCE PRIORITY

Spent Fuel Discharges and Prioritization

The first spent fuel permanently discharged from a commercial nuclear plant occurred on June 21, 1968 and included five assemblies from the Big Rock Point boiling water reactor in northern Michigan. These assemblies, plus 80 others discharged from Big Rock in the late 1960s and early 1970s, are now stored at West Valley, in western New York State. The next spent fuel discharge from a commercial nuclear plant occurred on September 6, 1969 and included 94 assemblies from the Dresden 1 boiling water reactor in northeastern Illinois. These assemblies have been transferred for storage in the Dresden 2 and 3 spent fuel pools. The most recent spent fuel discharge in the current listing occurred on November 28, 1994 and included 204 assemblies from the Fitzpatrick boiling water reactor, north of Syracuse, New York, near the southeast corner of Lake Ontario.

Overall, there have been 1,108 discharges from commercial nuclear reactors through November 28, 1994—each of which is ranked for acceptance by year, month and day, and many of which have been subsequently separated into portions stored at various temporary locations. Assuming that DOE accepts "oldest-fuel-first," spent fuel would be picked up in the order in which it was discharged. This is the assumption in this assessment, though utilities are free to apply priorities to other fuel in their system, or to sell or auction priorities to other utilities. Also, proposed legislation might give priority to fuel at shut down reactors, which might help certain utilities to shut down their spent fuel pools earlier, and avoid the significant expense of continued pool operations at shut-down plants.

The Use of Spent Fuel Priorities

Though difficult to predict, some examples illustrate how utilities might use the priorities of spent fuel in their system:

- Pacific Gas and Electric has 29.2 MTU in BWR assemblies stored at Humboldt Bay, whose reactor was shut down in 1976, and 427.7 MTU in PWR assemblies stored at Diablo Canyon, whose reactors are scheduled for shut down in 2008 and 2010. The spent fuel at Humboldt Bay was discharged in the early and mid-1970's, giving it priority for pickup in the first two acceptance years, while that at Diablo Canyon was discharged after 1985, giving it priority for pickup in years 7 to 12.

  Pacific Gas and Electric could use the priority of its fuel at Humboldt Bay to empty and shut down the Humboldt Bay pool, thus avoiding the expense of its continued operation. Or, it could use the priority of its fuel at Humboldt Bay to ship from Diablo Canyon, thus providing additional pool capacity at the still-operating Diablo Canyon plants.

- Consumers Power Company has 44.7 MTU in BWR assemblies stored at Big Rock (whose reactor is scheduled for shut down in the year 2000), and 316.8 MTU in PWR assemblies stored at Palisades (whose reactor is scheduled for shut down in 2007). While Consumers Power has 181.1 MTU of spent fuel with rankings which qualify for pickup in the first five acceptance years, almost all (91.9 percent) is stored at Palisades rather than at the Big Rock spent fuel pool.

Consumers Power could choose to use the priority of fuel in its system to empty the Big Rock pool after the Big Rock reactor shuts down in 2000, thus eliminating the expense of its continued operation. The Palisades dry storage facility would be required to enable its reactor to continue operation through its NRC license term.

- Northern States Power has 198.7 MTU in BWR assemblies stored at Morris, 147.5 MTU in BWR assemblies stored at Monticello (whose plant is scheduled for shut down in 2010), and 502.0 MTU stored at Prairie Island, whose plants are scheduled for shut down in 2013 and 2014, but which has very limited onsite storage capacity (wet or dry) to support continued plant operations. While Northern States Power has 191.8 MTU of spent fuel with rankings which qualify for pickup in the first three acceptance years, over half is stored at Morris (46.9 percent) or Monticello (5.0 percent) rather than at Prairie Island.

  Northern States could choose to use the priority of its spent fuel at Morris and Monticello to ship from Prairie Island, making additional storage capacity available there. While the capacity limitations at the Monticello spent fuel pool are much less severe than those at Prairie Island, the dimensions of the pool at Monticello (which was designed for BWR assemblies) preclude the transfer of PWR assemblies from Prairie Island. With confidence regarding an acceptance/shipment start date, Northern States might choose to purchase priority positions from one or more utilities with more sufficient onsite storage capacity.

5. SHIPMENT GROUPS

Spent Fuel Forms and Ages

Spent fuel discharged from boiling water reactors is in 52 different types of assemblies.[13] As of July 1, 1996, 8.6 percent of the MTU discharged from boiling water reactors is over 20 years old, 41.4 percent is between 10 and 20 years old, and 50.0 percent is less than 10 years old.

Spent fuel discharged from pressurized water reactors is in 54 different types of assemblies. As of July 1, 1996, 5.3 percent of the MTU discharged from boiling water reactors is over 20 years old, 37.4 percent is between 10 and 20 years old, and 57.3 percent is less than 10 years old.

Under an oldest-fuel-first acceptance prioritization, spent fuel which is over 20 years old on July 1, 1996 would be picked up in the first and second acceptance years. Spent fuel which is between 10 and 20 years old would be picked up in the second through seventh acceptance years, while fuel less than 10 years old would be picked up in the seventh through twelfth acceptance years. If acceptance begins in January 1998, the 40 PWR assemblies discharged from the Trojan plant in May 1986 would be picked up in 2005—meaning that Portland General Electric will have stored these assemblies in an operating spent fuel pool for 19 years, and for 13 years after the Trojan plant shut down in 1992.

Criteria for Cask Loading

How would the discharges at various storage locations be grouped for loading into transportation casks for shipment in a particular acceptance year?

- Would discharges whose priority ranking places them in different acceptance years be mixed in the same transportation cask? Under an oldest-fuel-first acceptance prioritization, the assumption in this assessment is "no."

- Would BWR or PWR discharges of different assembly types be mixed in the same transportation cask? The assumption in this assessment is "yes, as necessary." Thus, for example, the 335 assemblies at Big Rock, which include seven BWR assembly types fabricated by three companies (General Electric, Siemens and Nuclear Fuel Services), could be mixed in the same transportation cask if they fall into the same acceptance year.

- Would BWR and PWR assemblies be mixed in the same transportation cask? The question arises at storage locations such as Brunswick and Harris, whose pools have sections for storage of BWR and PWR assemblies, and at locations such as Morris, West Valley, and INEL, where BWR, PWR, and (in the case of INEL) HTG assemblies have been shipped for temporary storage. The assumption in this assessment is "no"—BWR and PWR assemblies would not be mixed in the same transportation cask.

- Would BWR or PWR assemblies discharged from different reactors be mixed in the same transportation cask? The question arises at Morris, which stores BWR assemblies discharged from Cooper Station and Dresden 2, or at McGuire 2, which stores PWR assemblies discharged

from the three Oconee reactors as well as the McGuire 2 reactor, or at INEL, which stores PWR assemblies discharged at TMI 2, Surry 1 and 2, Turkey Point 3, and Point Beach. The assumption in this assessment is "no"—BWR or PWR assemblies discharged from different reactors would not be mixed in the same transportation cask.

Among the four shipment grouping criteria discussed above, the last may be considered too restrictive in its application in certain cases. An example is the BWR assemblies stored in the joined Hatch 1 and 2 spent fuel pools, near the Altamaha River about 75 miles west of Savannah, Georgia. These pools contain about 900 BWR assemblies of the 8G5 type, about 750 of the 8GP type, and about 1,450 of the 8GB type,[13] each of which has been discharged in substantial numbers from both the Hatch 1 and Hatch 2 reactors. There may be no impediment in mixing such assemblies in the same transportation cask, if they fall into the same acceptance year.

While shipment grouping is considered in this assessment, it is a factor which as a limited effect on the number of transportation casks shipped from a particular site in a particular acceptance year. More elaborate grouping criteria sometimes result in a few additional one or two partially-filled casks shipped from a particular site in a particular acceptance year.

6. CASK OPTIONS

Rail Transport Casks

Several casks are potentially available for rail shipment of SNF or HLW, some of which may also be used for above-ground storage of these materials:

- The NAC STC cask, designed by Nuclear Assurance Corporation, would have a capacity of 26 PWR assemblies at least 6½ years old, or 57 BWR assemblies at least eight years old. The cask would weigh at least 125 tons loaded. The PWR version has been certified by NRC for storage and transport, while the BWR version was scheduled for license submission in the fall of 1995. No NAC STC casks have been fabricated and none are currently available for delivery to storage or shipment sites. It is estimated that fabrication and delivery would take about two years after the order for a certified cask is made.

- The IF-300 cask, designed by General Electric, has a capacity of 7 PWR or 18 BWR assemblies. The cask weighs about 70 tons loaded. Four such casks have been fabricated. Two have been used by Carolina Power and Light for transfer of PWR and BWR assemblies among their Robinson, Brunswick, and Harris facilities. Two are owned by Vectra Technologies, formerly Pacific Nuclear Corporation. The IF-300 is certified for transport only, and no new fabrication is permitted under its current NRC certificate of compliance, which expired in May 1995.

- The TN-8 and TN-9 casks, designed by Transnuclear Inc., have capacities for 3 PWR or 7 BWR assemblies. Assemblies transported in TN-8/9 casks are uncanistered—meaning that, on arrival at its destination, the transportation cask must be moved to a spent fuel pool, where bare fuel assemblies are removed for pool storage or canistering. Though four such casks are available, they are not currently certified for use in the U.S. The TN-8 and TN-9 casks weigh just under 40 tons loaded. They are designed for transport only, not for storage, and the current certificate of compliance expired in May 1996.

- The Hi-Star 100 cask, designed by Holtec International, has a capacity of 24 PWR and 68 BWR assemblies. It is designed for storage as well as transport. None are currently available, as its NRC license application is currently under review. The cask weight, empty or loaded, is currently considered proprietary.

- The Vectra MP-187 cask, designed by Vectra Technologies for storage as well as transport, would have a capacity of 24 PWR assemblies. Its NRC license application is currently under review. The cask is intended for storage and transport of spent fuel at the Rancho Seco plant (near Sacramento, California) which was shut down in 1989.

- The small MPC (multiple-purpose canister) cask, designed by Westinghouse Electric for transport, storage, and (possibly) permanent disposal, would have a capacity of 12 PWR or 24 BWR assemblies. The large MPC cask, also designed by Westinghouse Electric for transport, storage, and (possibly) permanent disposal, would have a capacity of 21 PWR or 40 BWR assemblies.

Through FY 1995, MPC cask design and licensing was supported by DOE via the Nuclear Waste Fund, but this support was not continued in appropriations for FY 1995. While the U.S. Navy is considering an adaptation of the MPC design for the transport and storage of naval reactor fuel, the schedule for its design and licensing for use with SNF is uncertain. It appears unlikely that such casks could be delivered for a 1998 acceptance date.

- DOE has expressed its intention to adapt the MPC design for transport and storage of five canisters of vitrified HLW, each of which would be about 2 feet in diameter and 10 to 15 feet in length.[14] (The 48" diameter cavity of the MPC-75 might accommodate four two-foot diameter canisters, while the 58" diameter cavity of the MPC-125 might accommodate six two-foot diameter canisters.)[15] DOE has not begun detailed design or licensing of such a cask, however.

Dry Storage of Canistered Spent Fuel

Several designs for dry storage of canistered spent fuel have been approved by NRC. In these designs, spent fuel canisters are loaded and sealed in an operating spent fuel pool, then inserted into a nearby concrete or metal facility for onsite storage. The Electric Power Research Institute is currently developing a "dry transfer" facility, by which the sealed canisters could be transferred to a transport cask without return to a spent fuel pool. If successful, dry transfer could enable certain spent fuel pools to be shut down, even while spent fuel remains onsite in dry storage. Dry storage designs include:

- The NUHOMS concrete modules, designed by Vectra Technologies for storage of canistered PWR or BWR assemblies. The NUHOMS-7 design was licensed in 1986 and has a capacity of 7 PWR assemblies, while the NUHOMS-24P design was licensed in 1989 for storage of 24 PWR assemblies. A standardized version of the NUHOMS-24P and NUHOMS-52B (for 52 BWR assemblies) received an NRC certificate of compliance in January 1995.[16] The NUHOMS-7 design is in use at Robinson 2, while the NUHOMS-24P design is in use at Oconee, Calvert Cliffs, and Rancho Seco.

- The VSC-24 ventilated cask, designed by Pacific Sierra Nuclear for storage of 24 PWR assemblies. The design received its NRC certificate of compliance in 1993 and is in use at the Palisades nuclear plant, about 40 miles west of Kalamazoo near the eastern shore of Lake Michigan.

Legal-Weight Truck Transport Casks

Several designs are potentially available for legal-weight truck shipment of SNF and HLW. In contrast to dry storage casks and recently-designed rail casks, legal-weight truck casks are designed to transport uncanistered assemblies—meaning that, on its arrival at its destination, the cask must be placed in a spent fuel pool or hot cell, where the assemblies are removed for pool storage or canistered for dry storage.

- The GA-4 and GA-9 casks, designed by General Atomics, would have capacity for four PWR or nine BWR assemblies. The design is currently in review by NRC. The cask would weigh 27 tons, loaded. Adding the truck and transportation tackle, shipments would barely meet legal highway weight (80,000 lbs.).

There is some question whether General Atomics would find it advantageous to produce the GA-4/9 casks for a shipment campaign which emphasizes rail transport and reduces the inventory shipped by truck. Ironically, the number of smaller capacity truck shipments in a shipment campaign emphasizing rail transport could be as large or larger than the number truck shipments in a campaign which uses the higher capacity GA-4/9 casks combined with less rail transport.

- The NLI-1/2 cask designed by National Lead Industries, but not currently certified for domestic use, and the NAC-LWT cask designed by Nuclear Assurance Corporation have capacity to transport a single 860 pound PWR assembly or two 360 pound BWR assemblies. Such casks have been used in most spent fuel transport to date. These casks weigh 24 to 26 tons loaded.

Transport Cask Options: This Assessment

This assessment limits the array of transport cask options to essentially four:

- A 75-ton rail transport and storage cask similar to the MPC-75 design.
- A 125-ton rail transport and storage cask similar to the MPC-125 design.
- A high-capacity legal-weight truck transport cask similar to the GA-4/9 designs.
- A standard legal-weight truck transport cask similar to the NLI-1/2 or NAC-LWT designs.
- In addition, we have included a 100+ ton rail transport and storage cask for canisters of vitrified HLW—an adaption of the MPC-75/125 designs.

Note that, with the exception of the standard legal-weight truck transport casks, none of the above cask options are licensed by NRC, in production, or currently-available for delivery and use. The GA-4/9 cask design is in review in NRC, but, even if it is licensed, its production is uncertain. Despite considerable DOE investment in the 1990's, the designs for the MPC-75 and 125 casks are conceptual, and have not yet been submitted to NRC for licensing.

This assessment considers the high-capacity and standard capacity truck casks as alternatives for legal-weight truck transport. We estimate truck shipments using either cask, but do not attempt to estimate the mix of high and standard capacity casks that could be used in legal-weight truck shipments.*

* Map presentation of annual cask shipments (Sections 16-20) assume the use of standard capacity legal-weight truck casks in the "current capabilities" scenario, and the high-capacity, legal-weight truck cask in the "MPC base case" and "maximum rail" transportation choice scenarios.

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7. CASK LOADING

Key Factors in Cask Loading

The facilities at each storage location must be able to load the cask option selected. The key requirements include:

- A crane at the spent fuel pool with operating capacity to safely lift the loaded cask.
- A cask loading area in the spent fuel pool of sufficient dimension to accommodate the upended cask and with a floor capable of supporting the cask during loading.
- A pool depth sufficient to maintain necessary water coverage while assemblies are moved over the upended cask during loading.
- A receiving area of sufficient dimension to accommodate the loading of the upended cask onto the rail car or truck, and a receiving area door of sufficient height to accommodate the rail car or truck along with its horizontally-positioned transport cask.
- In addition, sites with canistered spent fuel stored in concrete modules or vaults (e.g., Robinson, Oconee, Calvert Cliffs, Palisades, Rancho Seco) must have facilities necessary to remove the canisters and load them (wet or dry) into the selected transport cask.

DOE's "FICA" Database

DOE's "Facility Interface Capability Assessment (FICA)" project[17] assessed the capability of each commercial SNF storage facility to handle shipping casks. The assessment, which was conducted in the late 1980s and has not been systematically updated, found one or more limitations at many storage locations (particularly in handling larger and heavier rail casks). Some limitations, however, might be overcome by modifications to facility licenses, administrative controls or physical aspects of the facility.

Application of FICA Data in this Assessment

This assessment has reviewed the FICA data to consider the capability of each storage location to handle the cask options selected (Table 7-1). The key considerations were operating crane capacity, cask loading area dimensions, and pool depth. The assessment recognizes that facilities at some locations have been upgraded since the FICA assessment—particularly with regard to operating crane capacity at sites where onsite dry storage has been developed. The assessment also recognizes that facility limitations are often not absolute; current limitations may be eliminated or reduced through modification of facility licenses, administrative controls or physical aspects of the cask-handling building.

At the same time, the utility must decide that it is advantageous to invest in the changes necessary to enable their facilities to handle cask option "A" rather than cask options "B," or cask option "B" rather than cask options "C" or "D." These decisions "at the margin" will be made in the context of other factors (near-site rail infrastructure, site community characteristics, utility choice criteria) which are discussed in the following sections.

Table 7-1. Cask Loading Factors: by Storage Location

	FUEL STRG LOCATION:	CASK LOADG FACTOR: CRD	CRO	CDI	CLG
1	ARKANSAS NUCLEAR 1	100	100	R125	R125
2	ARKANSAS NUCLEAR 2	100	100	R125	R125
3	ARKANSAS NUCLEAR DRY STRG	NA	NA	NA	NA
4	BEAVER VALLEY 1	125	60	R125	R125
5	BEAVER VALLEY 2	125	100	R125	R125
6	BELLEFONTE 1	ND	ND	ND	ND
7	BELLEFONTE 2	ND	ND	ND	ND
8	BIG ROCK 1	75	24	LWT	LWT
9	BRAIDWOOD 1	125	110	R125	R125
10	BROWNS FERRY 1-2	125	106	R75	LWT
11	BROWNS FERRY 3	125	106	R75	LWT
12	BRUNSWICK 1	125	75	R125	R125
13	BRUNSWICK 1 PWR POOL	125	75	R125	R125
14	BRUNSWICK 2	125	75	R125	R125
15	BRUNSWICK 2 PWR POOL	125	75	R125	R125
16	BYRON 1	125	110	R125	R125
17	CALLAWAY 1	150	125	R125	R125
18	CALVERT CLIFFS 1-2	150	25	R125	R75
19	CALVERT DRY STORAGE	NA	NA	NA	NA
20	CATAWBA 1	125	125	R125	R125
21	CATAWBA 2	125	125	R125	R125
22	CLINTON 1	125	100	R125	R125
23	COMANCHE PEAK 1	130	130	R125	R125
24	COOK 1	150	60	R125	R125
25	COOPER STATION	100	100	LWT	LWT
26	CRYSTAL RIVER 3	120	72	R125	R125
27	DAVIS-BESSE 1	140	125	R125	R125
28	DAVIS-BESSE DRY STRG	NA	NA	NA	NA
29	DIABLO CANYON 1	125	67	R125	R125
30	DIABLO CANYON 2	125	67	R125	R125
31	DRESDEN 1	75	24	LWT	R125
32	DRESDEN 2	75	75	LWT	LWT
33	DRESDEN 3	75	75	LWT	LWT
34	DUANE ARNOLD	100	85	R125	R75
35	ENRICO FERMI 2	125	100	R125	LWT
36	FARLEY 1	125	125	R125	R125
37	FARLEY 2	125	125	R125	R125
38	FITZPATRICK	125	52	R125	R75
39	FORT CALHOUN	75	40	R125	R125
40	FORT ST VRAIN	50	50	LWT	R125
41	FORT ST VRAIN DRY STRG	NA	NA	NA	NA
42	GINNA	40	30	R125	LWT
43	GRAND GULF 1	150	125	R125	R125
44	HADDAM NECK	100	100	R75	LWT
45	HARRIS 1	150	75	R125	R125
46	HARRIS 1 BWR POOL	150	97	LWT	LWT
47	HATCH 1-2	125	125	R125	LWT
48	HOPE CREEK	150	130	R125	R125
49	HUMBOLDT BAY	75	60	R125	R125
50	INDIAN POINT 1	75	60	LWT	LWT
51	INDIAN POINT 2	40	32	R75	LWT
52	INDIAN POINT 3	75	40	R75	LWT
53	KEWAUNEE	125	120	LWT	LWT
54	LACROSSE	50	36	LWT	LWT
55	LASALLE 1-2	125	100	R125	R125
56	LIMERICK 1-2	125	110	R125	R125
57	MAINE YANKEE	125	125	R125	R125
58	MCGUIRE 1	125	100	LWT	R125
59	MCGUIRE 2	125	100	LWT	R125
60	MILLSTONE 1	110	110	LWT	R125
61	MILLSTONE 2	100	100	R125	R125
62	MILLSTONE 3	125	125	R125	R125
63	MONTICELLO	85	85	LWT	LWT
64	NINE MILE POINT 1	125	100	R125	LWT
65	NINE MILE POINT 2	125	100	R125	LWT
66	NORTH ANNA 1&2	125	105	R125	R125
67	NORTH ANNA DRY STRG	NA	NA	NA	NA
68	OCONEE 1&2	100	100	LWT	R125
69	OCONEE 3	100	100	LWT	R125
70	OCONEE DRY STORAGE	NA	NA	NA	NA
71	OYSTER CREEK 1	100	100	R125	R75
72	OYSTER CREEK DRY STRG	NA	NA	NA	NA
73	PALISADES	100	25	LWT	LWT
74	PALISADES DRY STORAGE	NA	NA	NA	NA
75	PALO VERDE 1	150	150	R125	R125
76	PALO VERDE 2	150	150	R125	R125
77	PALO VERDE 3	150	150	R125	R125
78	PEACHBOTTOM 2	125	100	R75	LWT
79	PEACHBOTTOM 3	125	100	R75	LWT
80	PERRY 1	125	125	R125	R125
81	PILGRIM 1	100	26	R75	LWT
82	POINT BEACH 1&2	125	125	R75	R125
83	POINT BEACH DRY STRG	NA	NA	NA	NA
84	PRAIRIE ISLAND 1&2	125	125	R125	R125
85	PRAIRIE ISLAND DRY STRG	NA	NA	NA	NA
86	QUAD CITIES 1	125	75	R125	LWT
87	RANCHO SECO 1	100	97	R125	R125
88	RANCHO SECO DRY STRG	NA	NA	NA	NA
89	RIVER BEND 1	125	125	R125	R125
90	ROBINSON 2	125	77	R75	R125
91	ROBINSON DRY STORAGE	NA	NA	NA	NA
92	SALEM 1	110	110	R125	R125
93	SALEM 2	110	110	R125	R125
94	SAN ONOFRE 1	105	70	R75	LWT
95	SAN ONOFRE 2	125	125	R125	R125
96	SAN ONOFRE 3	125	125	R125	R125
97	SEABROOK 1	125	125	R125	R125
98	SEQUOYAH 1	125	80	R125	R125
99	SHOREHAM	125	123	R75	LWT
100	SOUTH TEXAS 1	150	150	R125	R125
101	SOUTH TEXAS 2	150	150	R125	R125
102	ST LUCIE 1	105	25	R125	R125
103	ST LUCIE 2	150	100	R125	R125
104	SUMMER 1	125	125	R125	R125
105	SURRY 1&2	125	125	R125	R125
106	SURRY DRY STORAGE	NA	NA	NA	NA
107	SUSQUEHANNA 1-2	125	125	R125	R125
108	SUSQUEHANNA DRY STRG	NA	NA	NA	NA
109	THREE MILE ISLAND 1	110	110	R75	R125
110	TROJAN	125	100	R125	R125
111	TURKEY POINT 3	105	25	R125	R75
112	TURKEY POINT 4	105	25	R125	R75
113	VERMONT YANKEE 1	110	110	LWT	LWT
114	VOGTLE 1-2	125	91	R125	R125
115	WASH NUCLEAR 2	125	125	R125	LWT
116	WATTS BAR 1&2	ND	ND	ND	ND
117	WATERFORD 3	125	125	R125	LWT
118	WOLF CREEK 1	150	125	R125	R125
119	YANKEE-ROWE 1	75	37	R75	R125
120	ZION 1&2	125	110	R125	LWT
121	HANFORD SNF STRG	ND	ND	ND	ND
122	HANFORD SNF STRG	ND	ND	ND	ND
123	INEL SNF STRG	ND	ND	ND	ND
124	INEL SNF STRG	ND	ND	ND	ND
125	INEL SNF STRG	ND	ND	ND	ND
126	SAVANNAH RV SNF STRG	ND	ND	ND	ND
127	SAVANNAH RV SNF STRG	ND	ND	ND	ND
128	WEST VALLEY SNF STRG	ND	ND	ND	ND
129	WEST VALLEY SNF STRG	ND	ND	ND	ND
130	MORRIS	125	68	R125	R125
131	MORRIS	125	68	R125	R125
132	GENERAL ATOMICS	ND	ND	ND	ND

Cask Loading Factors:
- CRO: design crane capacity (tons)
- CRO: operating crane capacity (tons)
- CDI: cask set-down (loading) diameter (max cask option)
- CLG: cask length (loading) req (max cask option)

Shipment Cask Options:
- R125: Large MPC for up to 21 PWR or 40 BWR
- R75: Small MPC for up to 12 PWR or 24 BWR
- LWT: Legal-weight truck casks.... GA-4/9 if avail, NLI-1/2 or NAC LWT otherwise

8. NEAR-SITE INFRASTRUCTURE

Sites with Onsite Rail

At many storage locations, a rail line extends to the plant site and to the cask receiving area in the fuel handling building and/or the dry storage facility or barge loading platform. At some such locations, however, the onsite rail line requires upgrading for spent fuel rail shipments.

Sites without Onsite Rail

Locations without onsite rail may choose to transport the rail cask by heavy-haul truck or barge to an offsite railhead where the cask can be loaded onto a rail car for cross-country shipment. Such a decision, however, can introduce complications which could persuade a utility to choose to ship by legal-weight truck, or at least to hesitate before choosing to ship by rail.

- The additional load/unload operation in heavy-haul truck or barge transport is both costly and logistically complex.
- Heavy-haul truck transport involves state regulatory agencies in ways that legal-highway-weight transport does not.
- The communities along the heavy-haul route may object to such shipments.

Branch Rail Line Abandonments

Due to branch rail line abandonments, a number of storage locations which had onsite rail when the reactor was constructed do not have onsite rail now, or may not have onsite rail by the time a national shipment campaign begins. For example:

- The Central Railroad of New Jersey branch rail line, which provided onsite rail access when the Oyster Creek plant was constructed in 1969, has since been abandoned. The nearest currently available railhead is on the Conrail line at Lakehurst, New Jersey, and would be reached via a somewhat circuitous 30-mile heavy-haul truck shipment.
- The Elgin Joliet and Eastern branch rail line which has provided onsite rail access to General Electric's storage facility at Morris, Illinois is being considered for abandonment. The nearest available offsite railhead is on the Santa Fe Railroad at Coal City, and would be reached via a seven-mile heavy-haul truck shipment.

DOE's "NSTI" Database

DOE's Near-Site Transportation Infrastructure (NSTI) project[18] assessed the existing capabilities and upgrade potentials of transportation networks near 76 spent fuel storage sites. The assessment was conducted in 1989, and has not been systematically updated. Also, the NSTI final report makes clear that it does not recommend which transportation mode or shipping route should be used at the 76 sites, or

imply that the utility or plant operator for any facility or transportation system has expressed the intention of completing the upgrades assessed (Table 8-1).

Onsite Rail, Plus Rail Cask Loading

In fact, the utility's transportation choice will not be made on the basis of either near-site transportation or storage facility infrastructure, but on the combination of these factors with other considerations. This assessment generally assumes that a site will ship by rail if onsite rail is available and if the storage location facilities are able to load a 75 or 125-ton rail cask. In other words, it is generally assumed that a utility will find it advantageous to ship by rail if the additional investment required is small. For example,

- Arkansas Nuclear 1 and 2, located near Russellville, Arkansas, about 65 miles northwest of Little Rock, is a site which has operating onsite rail, and two separate pools—each capable of loading casks up to 9'6" in diameter and 19'2" in length, and each with an operating crane capacity of 100 tons. In this case, rail shipment using 75-ton casks would appear to require limited additional investment in pool facilities or near-site infrastructure, and it is assumed that this would be the choice of Arkansas Power and Light.

- Perry, located on the south shore of Lake Erie about 35 miles northeast of Cleveland, has operating onsite rail with modest upgrade requirements and two separate pools—each capable of loading casks up to 10'0" in diameter and 20'11" in length, and each with an operating crane capacity of 125 tons. In this case, rail shipment using 125-ton casks would appear to require limited additional investment in pool facilities or near-site infrastructure, and it is assumed this would be the choice of Cleveland Electric Illuminating Company.

No Onsite Rail or Rail Cask Loading

This assessment generally assumes that a site will ship by truck if on-site rail is not available and if current storage location facilities are unable to load a 75 or 125-ton rail cask. In other words, it is generally assumed that a utility will ship by legal-weight truck if the additional cost (in facility upgrades or logistical complication) to ship by rail is large. For example:

- Indian Point, located on the Hudson River about 35 miles north of Times Square, does not have onsite rail, though an offsite railhead is less than five miles distant. The pool at reactor #1, which was shut down in 1980, is capable of loading casks only 3'1" in diameter and 12'11" in length. The pools at reactors 2 and 3 are capable of loading casks of only 7'6" and 8'0" in diameter and 15'10" to 16'2" in length. The operating capacities of the pool cranes are 40 tons or less. In this case, rail shipment would appear to require substantial investment in pool dimensions, crane capacity and heavy-haul logistics. It is assumed that Consolidated Edison would avoid this investment, and ship by legal-weight truck.

- Ginna, located on Lake Ontario about 15 miles east of Rochester, New York, does not have onsite rail, though an offsite railhead is less than five miles distant. Its pools is capable of loading casks of 8'7" in diameter, but only 16'9" in length, and its operating crane capacity is only 30 tons. In this case, rail shipment would appear to require substantial investment in pool dimensions, crane

capacity and heavy-haul logistics. It is assumed that Rochester Gas and Electric would avoid this investment, and ship by legal-weight truck.

Near-Site Transportation/Cask Loading Combinations

Many sites have combinations of characteristics that complicate the utility's transportation choice:

- Onsite rail is available but pool facilities are unable to load a 75 or 125-ton rail cask.
- Pool facilities are sufficient but onsite rail is unavailable, or, if available, requires expensive upgrading.
- Pool dimensions are sufficient, but operating crane capacity is insufficient to lift a loaded 75- or 125-ton rail cask.
- Crane capacity could be improved, but requires substantial investment in equipment and drop tests.
- An offsite railhead is available but would require an additional loading (to a heavy-haul truck), plus highway travel through nearby communities, plus state heavy-haul permits.

In such circumstances, utilities must choose among available transportation cask options and make the consequent investment in pool facilities or near-site infrastructure to support the choice. DOE/OCRWM, which is responsible for the national shipment campaign, has an interest in and influence on the utility's choice, but cannot force utility investment beyond what the utility considers reasonable and appropriate. Each utility also has an interest in the success of the national shipment campaign—that is, an interest beyond minimizing the cost of moving spent fuel off its particular sites. In sum, choices among available transportation cask options will be made pool by pool and site by site, based on each utility's choice criteria and in the context of federal policy and the various facility, site and transportation network circumstances at the time the choice must be made. For planning purposes, this assessment specifies the available cask options (section 6), and considers three sets of possible utility transportation choices (section 11). Before reviewing the transportation scenarios, we consider several other choice factors—federal policy, utility choice criteria, and changing circumstances.

Table 8-1. Near-Site Infrastructure: by Storage Location

	FUEL STRG LOCATION:	NEAR-SITE FACTOR: OSR	OP?	OS$	OFD
1	ARKANSAS NUCLEAR 1	Y	Y	0	0
2	ARKANSAS NUCLEAR 2	Y	Y	0	0
3	ARKANSAS NUCLEAR DRY STRG	Y	Y	0	0
4	BEAVER VALLEY 1	Y	Y	0	0
5	BEAVER VALLEY 2	Y	Y	0	0
6	BELLEFONTE 1	ND	ND	ND	ND
7	BELLEFONTE 2	ND	ND	ND	ND
8	BIG ROCK 1	N	NA	0	13
9	BRAIDWOOD 1	Y	Y	10	0
10	BROWNS FERRY 1-2	N	NA	20	9
11	BROWNS FERRY 3	N	NA	20	9
12	BRUNSWICK 1	Y	Y	0	0
13	BRUNSWICK 1 PWR POOL	Y	Y	0	0
14	BRUNSWICK 2	Y	Y	0	0
15	BRUNSWICK 2 PWR POOL	Y	Y	0	0
16	BYRON 1	Y	Y	0	0
17	CALLAWAY 1	N	NA	0	15
18	CALVERT CLIFFS 1-2	N	NA	0	37
19	CALVERT DRY STORAGE	N	NA	0	37
20	CATAWBA 1	Y	N	0	0
21	CATAWBA 2	Y	N	0	0
22	CLINTON 1	Y	N	0	0
23	COMANCHE PEAK 1	Y	Y	125	0
24	COOK 1	Y	N	100	0
25	COOPER STATION	Y	Y	0	0
26	CRYSTAL RIVER 3	Y	Y	80	0
27	DAVIS-BESSE 1	Y	Y	0	0
28	DAVIS-BESSE DRY STRG	Y	Y	0	0
29	DIABLO CANYON 1	N	NA	0	19
30	DIABLO CANYON 2	N	NA	0	19
31	DRESDEN 1	Y	Y	25	0
32	DRESDEN 2	Y	Y	25	0
33	DRESDEN 3	Y	Y	25	0
34	DUANE ARNOLD	Y	Y	0	0
35	ENRICO FERMI 2	Y	N	125	0
36	FARLEY 1	Y	Y	45	0
37	FARLEY 2	Y	Y	45	0
38	FITZPATRICK	Y	Y	10	0
39	FORT CALHOUN	N	NA	0	6
40	FORT ST VRAIN	Y	N	100	0
41	FORT ST VRAIN DRY STRG	Y	N	100	0
42	GINNA	N	NA	0	4
43	GRAND GULF 1	N	NA	0	24
44	HADDAM NECK	N	NA	0	14
45	HARRIS 1	Y	Y	0	0
46	HARRIS 1 BWR POOL	Y	Y	0	0
47	HATCH 1-2	Y	Y	0	0
48	HOPE CREEK	N	NA	0	23
49	HUMBOLOT BAY	Y	Y	150	0
50	INDIAN POINT 1	N	NA	0	3
51	INDIAN POINT 2	N	NA	0	3
52	INDIAN POINT 3	N	NA	0	3
53	KEWAUNEE	N	NA	0	10
54	LACROSSE	Y	N	100	0
55	LASALLE 1-2	Y	Y	0	0
56	LIMERICK 1-2	Y	N	50	0
57	MAINE YANKEE	Y	Y	0	0
58	MCGUIRE 1	Y	N	0	0
59	MCGUIRE 2	Y	N	0	0
60	MILLSTONE 1	Y	N	115	0
61	MILLSTONE 2	Y	N	115	0
62	MILLSTONE 3	Y	N	115	0
63	MONTICELLO	Y	Y	0	0
64	NINE MILE POINT 1	Y	Y	125	0
65	NINE MILE POINT 2	Y	Y	125	0
66	NORTH ANNA 1&2	Y	Y	50	0
67	NORTH ANNA DRY STRG	Y	Y	50	0
68	OCONEE 1&2	N	NA	0	35
69	OCONEE 3	N	NA	0	35
70	OCONEE DRY STORAGE	N	NA	0	35
71	OYSTER CREEK 1	N	NA	0	30
72	OYSTER CREEK DRY STRG	N	NA	0	30
73	PALISADES	N	NA	10	13
74	PALISADES DRY STORAGE	N	NA	10	13
75	PALO VERDE 1	Y	Y	0	0
76	PALO VERDE 2	Y	Y	0	0
77	PALO VERDE 3	Y	Y	0	0
78	PEACHBOTTOM 2	N	NA	0	35
79	PEACHBOTTOM 3	N	NA	0	35
80	PERRY 1	Y	Y	40	0
81	PILGRIM 1	N	NA	0	12
82	POINT BEACH 1&2	N	NA	0	16
83	POINT BEACH DRY STRG	N	NA	0	16
84	PRAIRIE ISLAND 1&2	Y	N	25	0
85	PRAIRIE ISLAND DRY STRG	Y	N	25	0
86	QUAD CITIES 1	Y	N	0	0
87	RANCHO SECO 1	Y	N	0	0
88	RANCHO SECO DRY STRG	Y	N	0	0
89	RIVER BEND 1	Y	N	175	0
90	ROBINSON 2	Y	Y	0	0
91	ROBINSON DRY STORAGE	Y	Y	0	0
92	SALEM 1	N	NA	0	23
93	SALEM 2	N	NA	0	23
94	SAN ONOFRE 1	Y	Y	200	0
95	SAN ONOFRE 2	Y	Y	200	0
96	SAN ONOFRE 3	Y	Y	200	0
97	SEABROOK 1	Y	N	135	0
98	SEQUOYAH 1	Y	Y	10	0
99	SHOREHAM	N	NA	0	10
100	SOUTH TEXAS 1	Y	Y	85	0
101	SOUTH TEXAS 2	Y	Y	85	0
102	ST LUCIE 1	N	NA	0	10
103	ST LUCIE 2	N	NA	0	10
104	SUMMER 1	Y	Y	0	0
105	SURRY 1&2	N	NA	0	30
106	SURRY DRY STORAGE	N	NA	0	30
107	SUSQUEHANNA 1-2	Y	Y	0	0
108	SUSQUEHANNA DRY STRG	Y	Y	0	0
109	THREE MILE ISLAND 1	Y	Y	0	0
110	TROJAN	Y	Y	0	0
111	TURKEY POINT 3	N	NA	0	30
112	TURKEY POINT 4	N	NA	0	30
113	VERMONT YANKEE 1	Y	Y	75	0
114	VOGTLE 1-2	Y	N	25	0
115	WASH NUCLEAR 2	Y	Y	0	0
116	WATTS BAR 1&2				
117	WATERFORD 3	Y	Y	25	0
118	WOLF CREEK 1	Y	N	10	0
119	YANKEE-ROWE 1	N	NA	0	7
120	ZION 1&2	Y	Y	0	0
121	HANFORD SNF STRG	ND	ND	ND	ND
122	HANFORD SNF STRG	ND	ND	ND	ND
123	INEL SNF STRG	ND	ND	ND	ND
124	INEL SNF STRG	ND	ND	ND	ND
125	INEL SNF STRG	ND	ND	ND	ND
126	SAVANNAH RV SNF STRG	ND	ND	ND	ND
127	SAVANNAH RV SNF STRG	ND	ND	ND	ND
128	WEST VALLEY SNF STRG	ND	ND	ND	ND
129	WEST VALLEY SNF STRG	ND	ND	ND	ND
130	MORRIS	Y	Y	0	0
131	MORRIS	Y	Y	0	0
132	GENERAL ATOMICS	ND	ND	ND	ND

Near-Site Infrastructure Considerations:
- OSR: onsite rail (yes, no, not applic)
- OP?: onsite rail operating? (yes, no, not applic)
- OS$: onsite rail upgrade cost (000$)
- OFD: distance to offsite rail (miles)

Shipment Cask Options:
- R125: Large MPC for up to 21 PWR or 40 BWR
- R75: Small MPC for up to 12 PWR or 24 BWR
- LWT: Legal-weight truck casks.... GA-4/9 if avail. NLI-1/2 or NAC LWT otherwise

9. OTHER TRANSPORTATION CHOICE FACTORS

Utility transportation choice decisions will reflect factors in addition to current near-site infrastructure and pool capabilities—e.g., federal policy, utility choice criteria, changes in near-site infrastructure cask handling capabilities, or site community characteristics.

Federal Policies

Federal policies affect utility transportation choices. For example,

- Via the nuclear waste fund, DOE has invested in the design of the GA-4/9 cask and the MPC 75 and 125-ton casks, and has set the parameters for these designs. However, as of FY 1996, DOE withdrew its financial support for design, and indicated that it does not intend to support certification or fabrication of these or other transportation or transportation/storage casks.

- Via the nuclear waste fund, DOE could fund modifications to spent fuel pools or near-site infrastructure at origin sites—modifications which would enable these sites to choose transportation options considered more desirable from the perspective of the national shipment campaign. However, in its draft scope for acquisition of transportation services,[2] DOE states that "OCRWM will not fund any on-site infrastructure modifications or improvements to the purchasers' facilities" (page 1).

- In its May 28, 1996 notice,[2] DOE proposes to delegate major responsibilities for waste acceptance, transportation and storage to contractors operating under competitive fixed price contracts. The resulting transportation choices negotiated with utilities could be quite different from those reached under another decision framework.

- DOE intends to provide the final route links to a permanent repository or centralized storage site in Nevada, and has conducted major studies of alternative heavy-haul and rail routes for this link. In the process, DOE would enable origin sites to choose rail over legal-weight truck transport, without, however, providing an incentive for origin sites to ship by rail.

Utility Choice Criteria

Utilities will have different sets of transportation choice criteria, based on their financial positions, their nuclear waste and other transportation experiences, their relationships with nearby communities, etc. Given the same origin site circumstances, utility "A" might choose to upgrade for rail shipment while utility "B," approaching the same decision from a different perspective, might choose to avoid upgrades and ship by truck.

Changes At or Near Origin Sites

Changes at or near origin sites will affect utility transportation choices at the time those choices must be made—generally, five to ten years from now. For example,

- The development of dry storage facilities often involves investment to enable pools to handle sealed spent fuel canisters, if not loaded transportation/storage casks. The resulting capabilities, many of which were not anticipated in DOE's 1989 FICA study, will be available for off-site transportation as well.

- While mainline railroads are receiving increasing freight traffic, branch lines—some serving nuclear plant sites—are being abandoned. For example,

  — The branch line of the Central Railroad which extended along US-9 through the Oyster Creek (New Jersey) site when the plant was constructed in the late 1960s has since been abandoned. Rail casks would now be heavy-hauled to Conrail's railhead in Lakehurst, New Jersey, along a 30-mile route which avoids the towns of Forked River, Tom's River, and Pinewold. Or, rail casks might be heavy-hauled across US-9 for barge shipment to an off-site railhead.

  — Burlington Northern's rail spur to the Cooper Station plant site on the Missouri River about 60 miles south of Omaha may be abandoned when it is no longer needed for shipments to Morris. Rail shipments might be heavy-hauled 30 miles to a Burlington Northern railhead in Nebraska City, or barged down the Missouri River through St. Joseph and Kansas City to a Union Pacific railhead in Boonville, Missouri.

  — The Elgin, Joliet, and Eastern rail spurs to the Morris and Dresden sites about 40 miles southwest of Chicago may be abandoned, as may Conrail's spur to West Valley, about 35 miles south of Buffalo, New York.

- Community conditions (resident population, community character, etc.) in near-site communities may also change, affecting the utility's transportation choice.

10. TRANSPORTATION CHOICES

Given the factors discussed in Sections 6 through 9, how would the transportation choice actually be made? Using Monticello, Big Rock Point, Point Beach, Salem/Hope Creek, and Enrico Fermi as case study sites, this section illustrates the transportation choice decision as it might be addressed by utilities. Section 11 presents three scenarios of transportation choices for all shipment sites. Appendix A compares the three transportation choice scenarios considered in this assessment with two developed by DOE.

Monticello

Given the cask options identified in Section 6, and the factors discussed in Sections 7 through 9, how would Northern States Power (NSP) choose to ship from its Monticello plant, located on the Mississippi River about 35 miles northwest of Minneapolis? Monticello has operating onsite rail which does not require upgrade for shipment of spent nuclear fuel. It has the operating crane capacity (85 tons) but currently has neither the cask set-down diameter (6'4") nor the maximum cask length (16'5") required to load a small MPC.

- Would NSP upgrade its spent fuel pool loading area and depth in order the ship by small MPC using its onsite rail?
- Would NSP avoid upgrade investments and ship by legal-weight truck, probably using Interstate 94 towards Minneapolis and Interstate 494 to circle the city on its western side?

The current capabilities and MPC base case scenarios assume that NSP chooses to ship by legal-weight truck. The maximum rail scenario, as well as scenarios identified by DOE, assume that NSP chooses to upgrade in order to ship by small MPC.

Big Rock Point

Given the cask options identified in Section 6, and the factors discussed in sections 7 through 9, how would Consumers Power Company choose to ship from its Big Rock Point plant, located on the upper reaches of Lake Michigan? Big Rock does not have onsite rail; rail shipments would require heavy-haul to the Tuscola and Saginaw Bay railhead in Petoskey about 13 miles east of the plant site. Neither the operating crane capacity (24 tons) nor cask set-down diameter (5'11") nor maximum cask length (15'11") at Big Rock Point currently meet requirements for loading a small MPC.

- Would Consumer's Power upgrade its crane and spent fuel loading area and depth in order to heavy-haul small rail casks for shipment from Petoskey?
- Would Consumers Power avoid investment in cask handling upgrades and heavy-haul operations, choosing to ship by legal-weight truck, probably south on I-75 to Flint, then southwest on I-69 through Lansing and west on I-95 through Battle Creek and Kalamazoo?

The current capabilities and MPC base case scenarios assume that Consumers Power chooses to ship by legal-weight truck. The maximum rail scenario (as well as DOE's Transportation Strategy Study

2) assumes that Consumers Power will upgrade its facilities and heavy-haul to Petoskey in order to ship small MPCs by rail.

Point Beach

Given the cask options identified in Section 6, and the factors discussed in Sections 7 through 9, how would Wisconsin Electric Power choose to ship from its Point Beach plant site, located on the western shore of Lake Michigan about 85 miles north of Milwaukee? Point Beach does not have onsite rail; rail shipment would require heavy-haul to a railhead, such as the Fox Valley and Western railhead Wisconsin Central in Kewaunee.[19] It has the operating crane capacity (125 tons) and maximum cask length (18'8") but not the cask set-down diameter (7'10") required to load a large MPC.

- Would Wisconsin Electric upgrade the cask set-down area in its spent fuel loading area in order to heavy-haul large rail casks for shipment from Kewaunee?

- Would Wisconsin Electric ship by legal-weight truck in order to avoid the cost of heavy-hauling small MPC casks to the Kewaunee railhead?

The current capabilities scenario assumes that Wisconsin Electric chooses to ship by legal-weight truck, via I-43 from Manitowoc through Sheboygan to Milwaukee. The MPC base case and maximum rail scenarios (as well as scenarios identified by DOE) assume that Wisconsin Electric chooses to upgrade its cask loading area and heavy-haul off site in order to ship large MPCs by rail.

Salem and Hope Creek

Given the cask options identified in Section 6, and the factors discussed in Sections 7 through 9, how would Public Service Gas and Electric (PSG&E) choose to ship from its Salem and Hope Creek plants on the New Jersey side of the Delaware River, about 12 miles south of Wilmington, Delaware? The sites do not have onsite rail; rail shipment would require heavy-haul 23 miles north to a railhead on the West Jersey Railroad in the Town of Salem. Hope Creek has the cask set-down diameter (11'0"), maximum cask length (19'9") and operating crane capacity (130 tons) required to load a large MPC. Salem has the cask set-down diameter (10'0") and maximum cask length (21'4") but insufficient operating crane capacity (110 tons) to load a large MPC.

- Would PSG&E upgrade operating crane capacity at its Salem facilities in order to heavy-haul large rail casks 23 miles for shipment by rail?

- Would PSG&E ship by legal-weight truck in order to avoid the cost of heavy-hauling or barging small MPC casks?

The current capabilities scenario assumes that PSG&E chooses to ship by legal-weight truck from both its Hope Creek and Salem plants. The MPC base case and maximum rail scenarios assume that PSG&E upgrades operating crane capacity at Salem in order to use the large MPC cask, which in the MPC base case would be heavy-hauled 23 miles to the Salem railhead on the West Jersey railroad, and in the maximum rail scenario would be barged up the Delaware River to a Conrail railhead in Wilmington.

Enrico Fermi

Given the cask options identified in Section 6 and the factors discussed in Section 7 through 9, how would Detroit Edison Company choose to ship from its Enrico Fermi plant on the western shore of Lake Erie, about midway between Detroit, Michigan and Toledo, Ohio? The Fermi site has onsite rail which is not operating and would require significant investment to upgrade for shipment of spent nuclear fuel. While its cask set-down diameter (9'0") meets requirements for a large MPC, its operating crane capacity (100 tons) currently meets requirements only for the small MPC, and its maximum cask length (14'9") currently meets requirements for neither the large nor small MPC.

- Would Detroit Edison upgrade the rail spur, the maximum cask length in its spent fuel loading facilities and its operating crane capacity in order to ship large MPC casks by rail?

- Would it ship by legal-weight truck in order to avoid or postpone some or all of these expenses?

The current capabilities scenario assumes that Detroit Edison chooses to ship by legal-weight truck, probably using I-275 to access I-94 for travel across the southern portion of the state. The MPC base case scenario assumes that Detroit Edison upgrades it facilities and rail spur in order to ship large MPCs north to Detroit and west through Lansing and Battle Creek on Grand Trunk Western rail lines. The maximum rail scenario assumes that Detroit Edison upgrades its facilities but not its rail spur at Fermi, choosing to barge rail casks east across Lake Erie to a railhead in Buffalo.

Table 10-1. Transportation Choice Factors and Scenarios: By Storage Location

		CASK LOADG FACTOR:				NEAR-SITE FACTOR:				TRANSP CHOICE:				
FUEL STRG LOCATION:	WASTE TYPE	CRD	CRO	CDI	CLG	OSR	OP?	OS$	OFD	CCP	MPC	MXR	TS2	APD
MONTICELLO	BWR	85	85	LWT	LWT	Y	Y	0	0	LWT	LWT	R75	R75	R75
BIG ROCK 1	BWR	75	24	LWT	LWT	N	NA	0	13	LWT	LWT	R75	R75	LWT
POINT BEACH 1&2	PWR	125	125	R75	R125	N	NA	0	16	LWT	R125	R125	R125	R125
POINT BEACH DRY STRG	PWR	NA	NA	NA	NA	N	NA	0	16	LWT	R125	R125	R125	R125
HOPE CREEK	BWR	150	130	R125	R125	N	NA	0	23	LWT	R125	R125	R125	R125
SALEM 1	PWR	110	110	R125	R125	N	NA	0	23	LWT	R125	R125	R125	R75
SALEM 2	PWR	110	110	R125	R125	N	NA	0	23	LWT	R125	R125	R125	R75
ENRICO FERMI 2	BWR	125	100	R125	LWT	Y	N	125	0	LWT	R125	R125	R125	R125

Site/Facility Charac: CRD: design crane capacity (tons)
CRO: operating crane capacity (tons)
CDI: cask set-down (loading) diameter (max cask option)
CLG: cask length (loading) req (max cask option)

OSR: onsite rail (yes, no, not applic)
OP?: onsite rail operating? (yes, no, not applic)
OS$: onsite rail upgrade cost (000$)
OFD: distance to offsite rail (miles)

Shipment Cask Options: R125: Large MPC for up to 21 PWR or 40 BWR
R75: Small MPC for up to 12 PWR or 24 BWR
LWT: Legal-weight truck casks.... GA-4/9 if avail, NLI-1/2 or NAC LWT otherwise

Transp Choice: MPC: MPC "Base Case" (NWPO: Jan 1994)
CCP: Current Capabilities (NWPO: May 1996)
MXR: Maximum Rail (NWPO: May 1996)

TR2: NV Transp Stategy, Study 2 (DOE: Feb 1996, Table F-3 & PIC)
APD: MPC Prelim Evaluation (DOE: Mar 1993, Appendix O)

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11. TRANSPORTATION MODE AND CASK CHOICES: THREE SCENARIOS

Considering the factors discussed in sections 8, 9, and 10, this assessment identifies three transportation choice scenarios, each specifying the assumed utility choice among available cask options (see Section 7) for each storage location (see Section 2). These scenarios, detailed in Table 11-1, assume that the utility's transportation choice does not change during the shipment campaign.

The MPC Base Case Scenario

The "MPC base case" set of utility transportation choices reflects previous work conducted by the state of Nevada to represent the most likely highway and rail routes for shipments of nuclear waste to Yucca Mountain using DOE's proposed Multi-Purpose Canister system for nuclear waste storage, transportation, and disposal.[20] For this assessment, the previous MPC base case transportation choice assumptions were reviewed; rail shipments by small and large MPC were specified; transportation choices for defense sites (e.g., Hanford, INEL, SRS, West Valley) and certain other storage locations (e.g., General Atomics research fuel) were specified.

In the MPC base case scenario, spent fuel stored at 17 commercial plant sites (listed below) is shipped by legal-weight truck; all other commercial plant sites ship by small or large MPC. If the high-capacity GA-4/9 cask is not available, the scenario assumes that legal-weight truck shipments would use a cask similar in capacity to the NLI-1/2 or NAC LWT.

Big Rock	Haddam Neck	Peachbottom
Crystal River	Humboldt Bay	Pilgrim
Fitzpatrick	Indian Point	St. Lucie
Fort Calhoun	LaCrosse	Vermont Yankee
Fort St. Vrain	Monticello	Yankee Rowe
Ginna	Palisades	

Spent fuel stored at Hanford, INEL, and West Valley, as well as research fuel stored at sites such as General Atomics are shipped by legal-weight truck in the MPC base case scenario. However, HLW vitrified and stored in canisters at Hanford, INEL and Savannah River is shipped by rail in an MPC adapted for this purpose.

The Current Capabilities Scenario

Assuming that utilities may be reluctant to make major investments to upgrade cask loading capabilities or near-site infrastructure, the current capabilities scenario identifies 15 additional commercial sites which could choose to ship by legal-weight truck, and assumes that the high-capacity GA-4/9 cask is not available:

Browns Ferry	Dresden/Morris	Oconee
Calvert Cliffs	Fermi	Oyster Creek
Cook	Grand Gulf	Point Beach
Cooper Station	Hope Creek/Salem	Surry
Diablo Canyon	Kewaunee	Turkey Point

Furthermore, the current capabilities scenario identifies 14 sites which might choose to ship by small MPC, rather than by large MPC as assumed in the MPC base case:

Arkansas Nuclear	Duane Arnold	Nine Mile Point
Beaver Valley	Harris	North Anna
Braidwood	La Salle	Rancho Seco
Byron	Limerick	Zion
Clinton	McGuire	

Obviously, the current capabilities scenario generates a larger number of shipments with greater highway impacts than does the MPC base case.

The Maximum Rail Scenario

Considering the upgrade potentials at each storage location, and assuming effective incentives for utilities to make the upgrades, the "maximum rail scenario" identifies 14 commercial sites (of the 17 which ship by truck in the MPC base case) which might ship by rail:

Big Rock	LaCrosse	Fitzpatrick
Crystal River	Monticello	Palisades
Fort Calhoun	Pilgrim	Peachbottom
Haddam Neck	Vermont Yankee	St. Lucie
Humboldt Bay	Yankee Rowe	

The sites in columns 1 and 2 above are assumed to upgrade for shipment by small MPC, while those in column 3 are assumed to upgrade for shipment by large MPC. The upgrades reduce the number of commercial sites which ship by truck to three: Ginna, Indian Point, Fort St. Vrain—all of which are assumed to use the high-capac[illegible]-4/9 cask.

In addition, the maximum rail scenario assumes that Three Mile Island upgrades for shipment by large MPC, rather than by small MPC as in the MPC base case.

DOE's Transportation Choice Assumptions

While DOE has not estimated annual shipments by route segment, several DOE studies consider transportation choices on a site-by-site basis: a 1996 "preliminary transportation strategy study for a potential Nevada repository",[21] and a 1993 evaluation of the use of MPCs in DOE's waste management system.[22] Appendix A reviews the transportation choice assumptions in these DOE studies, comparing them with the transportation choice scenarios outlined above.

Table 11-1. Utility Transportation Choice Scenarios: by Storage Location

	FUEL STRG LOCATION:	TRANSP CHOICE: CCP	MPC	MXR
1	ARKANSAS NUCLEAR 1	R75	R125	R125
2	ARKANSAS NUCLEAR 2	R75	R125	R125
3	ARKANSAS NUCLEAR DRY STRG	R75	R125	R125
4	BEAVER VALLEY 1	R75	R125	R125
5	BEAVER VALLEY 2	R75	R125	R125
6	BELLEFONTE 1	R125	R125	R125
7	BELLEFONTE 2	R125	R125	R125
8	BIG ROCK 1	LWT	LWT	R75
9	BRAIDWOOD 1	R75	R125	R125
10	BROWNS FERRY 1-2	LWT	R125	R125
11	BROWNS FERRY 3	LWT	R125	R125
12	BRUNSWICK 1	R75	R75	R75
13	BRUNSWICK 1 PWR POOL	R75	R75	R75
14	BRUNSWICK 2	R75	R75	R75
15	BRUNSWICK 2 PWR POOL	R75	R75	R75
16	BYRON 1	R75	R125	R125
17	CALLAWAY 1	LWT	R125	R125
18	CALVERT CLIFFS 1-2	LWT	R125	R125
19	CALVERT DRY STORAGE	LWT	R125	R125
20	CATAWBA 1	R125	R125	R125
21	CATAWBA 2	R125	R125	R125
22	CLINTON 1	R75	R125	R125
23	COMANCHE PEAK 1	R125	R125	R125
24	COOK 1	LWT	R125	R125
25	COOPER STATION	LWT	R75	R75
26	CRYSTAL RIVER 3	LWT	LWT	R75
27	DAVIS-BESSE 1	R125	R125	R125
28	DAVIS-BESSE DRY STRG	R125	R125	R125
29	DIABLO CANYON 1	LWT	R125	R125
30	DIABLO CANYON 2	LWT	R125	R125
31	DRESDEN 1	LWT	R75	R75
32	DRESDEN 2	LWT	R75	R75
33	DRESDEN 3	LWT	R75	R75
34	DUANE ARNOLD	R75	R125	R125
35	ENRICO FERMI 2	LWT	R125	R125
36	FARLEY 1	R125	R125	R125
37	FARLEY 2	R125	R125	R125
38	FITZPATRICK	LWT	LWT	R125
39	FORT CALHOUN	LWT	LWT	R75
40	FORT ST VRAIN	LWT	LWT	LWT
41	FORT ST VRAIN DRY STRG	LWT	LWT	LWT
42	GINNA	LWT	LWT	LWT
43	GRAND GULF 1	LWT	R125	R125
44	HADDAM NECK	LWT	LWT	R75
45	HARRIS 1	R75	R125	R125
46	HARRIS 1 BWR POOL	R75	R125	R125
47	HATCH 1-2	R125	R125	R125
48	HOPE CREEK	LWT	R125	R125
49	HUMBOLDT BAY	LWT	LWT	R75
50	INDIAN POINT 1	LWT	LWT	LWT
51	INDIAN POINT 2	LWT	LWT	LWT
52	INDIAN POINT 3	LWT	LWT	LWT
53	KEWAUNEE	LWT	R125	R125
54	LACROSSE	LWT	LWT	R75
55	LASALLE 1-2	R75	R125	R125
56	LIMERICK 1-2	R75	R125	R125
57	MAINE YANKEE	R125	R125	R125
58	MCGUIRE 1	R75	R125	R125
59	MCGUIRE 2	R75	R125	R125
60	MILLSTONE 1	R75	R75	R75
61	MILLSTONE 2	R75	R75	R75
62	MILLSTONE 3	R75	R75	R75
63	MONTICELLO	LWT	LWT	R75
64	NINE MILE POINT 1	R75	R125	R125
65	NINE MILE POINT 2	R75	R125	R125
66	NORTH ANNA 1&2	R75	R125	R125
67	NORTH ANNA DRY STRG	R75	R125	R125
68	OCONEE 1&2	LWT	R125	R125
69	OCONEE 3	LWT	R125	R125
70	OCONEE DRY STORAGE	LWT	R125	R125
71	OYSTER CREEK 1	LWT	R125	R125
72	OYSTER CREEK DRY STRG	LWT	R125	R125
73	PALISADES	LWT	LWT	R125
74	PALISADES DRY STORAGE	LWT	LWT	R125
75	PALO VERDE 1	R125	R125	R125
76	PALO VERDE 2	R125	R125	R125
77	PALO VERDE 3	R125	R125	R125
78	PEACHBOTTOM 2	LWT	LWT	R125
79	PEACHBOTTOM 3	LWT	LWT	R125
80	PERRY 1	R125	R125	R125
81	PILGRIM 1	LWT	LWT	R75
82	POINT BEACH 1&2	LWT	R125	R125
83	POINT BEACH DRY STRG	LWT	R125	R125
84	PRAIRIE ISLAND 1&2	R125	R125	R125
85	PRAIRIE ISLAND DRY STRG	R125	R125	R125
86	QUAD CITIES 1	R75	R75	R75
87	RANCHO SECO 1	R75	R125	R125
88	RANCHO SECO DRY STRG	R75	R125	R125
89	RIVER BEND 1	R125	R125	R125
90	ROBINSON 2	R75	R75	R75
91	ROBINSON DRY STORAGE	R75	R75	R75
92	SALEM 1	LWT	R125	R125
93	SALEM 2	LWT	R125	R125
94	SAN ONOFRE 1	R125	R125	R125
95	SAN ONOFRE 2	R125	R125	R125
96	SAN ONOFRE 3	R125	R125	R125
97	SEABROOK 1	R125	R125	R125
98	SEQUOYAH 1	R125	R125	R125
99	SHOREHAM	NA	NA	NA
100	SOUTH TEXAS 1	R125	R125	R125
101	SOUTH TEXAS 2	R125	R125	R125
102	ST LUCIE 1	LWT	LWT	R125
103	ST LUCIE 2	LWT	LWT	R125
104	SUMMER 1	R125	R125	R125
105	SURRY 1&2	LWT	R125	R125
106	SURRY DRY STORAGE	LWT	R125	R125
107	SUSQUEHANNA 1-2	R125	R125	R125
108	SUSQUEHANNA DRY STRG	R125	R125	R125
109	THREE MILE ISLAND 1	R75	R75	R125
110	TROJAN	R125	R125	R125
111	TURKEY POINT 3	LWT	R125	R125
112	TURKEY POINT 4	LWT	R125	R125
113	VERMONT YANKEE 1	LWT	LWT	R75
114	VOGTLE 1-2	R75	R75	R75
115	WASH NUCLEAR 2	R125	R125	R125
116	WATTS BAR 1&2	R125	R125	R125
117	WATERFORD 3	R125	R125	R125
118	WOLF CREEK 1	R125	R125	R125
119	YANKEE-ROWE 1	LWT	LWT	R75
120	ZION 1&2	R75	R125	R125
121	HANFORD SNF STRG	LWT	LWT	LWT
122	HANFORD SNF STRG	LWT	LWT	LWT
123	INEL SNF STRG	LWT	LWT	LWT
124	INEL SNF STRG	LWT	LWT	LWT
125	INEL SNF STRG	LWT	LWT	LWT
126	SAVANNAH RV SNF STRG	LWT	LWT	LWT
127	SAVANNAH RV SNF STRG	LWT	LWT	LWT
128	WEST VALLEY SNF STRG	LWT	LWT	R125
129	WEST VALLEY SNF STRG	LWT	LWT	R125
130	MORRIS	LWT	R125	R125
131	MORRIS	LWT	R125	R125
132	GENERAL ATOMICS	LWT	LWT	LWT

Transp Choice: CCP: Current Capabilities (NWPO: May 1996)
MPC: MPC "Base Case" (NWPO: Jan 1994)
MXR: Maximum Rail (NWPO: May 1996)

Shipment Cask Options: R125: Large MPC for up to 21 PWR or 40 BWR
R75: Small MPC for up to 12 PWR or 24 BWR
LWT: Legal-weight truck casks.... GA-4/9 if avail
NLI-1/2 or NAC LWT otherwise

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12. CASK SHIPMENTS

The assessment of shipment groups (section 5) determines the assemblies and MTU to be picked up for shipment from a particular storage location in a particular acceptance year. The identification of cask options (section 6) determines the transportation casks available under the particular scenario, and the transportation choice assessment (sections 7 through 11) determines the cask option selected for shipment from each storage location.

The next step in the assessment process is to determine the number of cask shipments from each storage location in each acceptance/pickup year.

- Cask shipments of spent fuel from BWR or PWR reactors are estimated by dividing the number of assemblies in the shipment group by the assembly capacity of the selected cask—rounding up to accommodate any fractions required to ship all assemblies in the group.

- Cask shipments of other spent fuel (e.g., spent fuel from research reactors or HTG assemblies from the Fort St. Vrain reactor) are estimated by dividing the MTU in the shipment group by the average MTU per cask for BWR and PWR assemblies shipped during the same period—generally about .40 MTU per T-1/2 cask, 1.655 MTU per T-4/9 cask, 4.28 MTU per R75 cask and 7.41 MTU per R125 cask. In effect, the assumption is that casks for HTG, research and other wastes will be as efficient as those designed for transport of BWR and PWR assemblies.

- Cask shipments for HLW assume that an MPC-like cask to accommodate five two-foot diameter canisters will be designed and certified for transport of HLW. The estimated shipments of HLW canisters from a particular site is thus divided by five—rounding up to accommodate any remaining canisters in the shipment group.

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13. ROUTING CRITERIA

Having determined the number of shipments of a particular cask type from each site each acceptance year, we must then determine the highway or rail shipment route. Aggregating shipments from each origin site, a community along a particular route segment in Pennsylvania, or in Indiana or Missouri could then understand, for example, that in the second acceptance year it should expect "x" shipments of certain cask types originating from certain storage locations, while in the fifth acceptance year it should expect "y" shipments from a somewhat different set of storage locations. This information should help state and local agencies conduct their planning in the context of the national shipment campaign.

In most cases, the routing decision will be made by the carrier, under certain constraints. Most notable is the requirement (based on 49 CFR§397.101(a), referred to as HM 164), that in transporting radioactive waste by truck, drivers must reduce transit time by using interstate highways or state-designated alternative routes.

In addition to the HM 164 requirement, we also assume that certain routing practices will be followed by shippers and carriers. For example, we assume that shippers will generally choose the closest Class I (highest volume) rail carrier, and that rail carriers will prefer Class A (highest volume) mainline rail segments.

Default (Quickest) Routes

To assist in identifying possible routes for waste shipments, DOE (through the Oak Ridge National Laboratory) has developed and made available two computer-assisted models, HIGHWAY and INTERLINE. In determining the truck shipment routes for this study, the HIGHWAY model[23] was used to calculate the "quickest route" (minimizing travel time) subject to HM 164 requirements. In determining the rail shipment routes, the INTERLINE model[24] was used to calculate the quickest route. In both cases, the models were run without other special limitations, such as avoidance of population centers and recognition of the BN/Santa Fe merger or the anticipated UP/SP merger.*

Consolidated Southern Routes

A second alternative for each route scenario was also developed to consolidate the rail and highway shipments into fewer routes, both to minimize the number of affected communities and to avoid certain seasonal weather conditions or problematic highway segments (e.g., the Eisenhower Tunnel and Glenwood Canyon on I-70 west of Denver). The consolidated route orients truck shipments from the Northeast, Southeast, and Midwest to I-40 in Oklahoma City, generally avoiding I-70 west of Kansas City and I-80 west of Omaha. Compared to their roles under the default routing criteria, I-44 between St. Louis and Oklahoma and I-70 east of St. Louis play more significant roles as a feeders to the consolidated southern route across the western states.

* BN: Burlington Northern; UP: Union Pacific; SP: Southern Pacific

The consolidated route orients rail shipments from the Northeast, Southeast, and Midwest to the Santa Fe rail lines extending southwest from Kansas City through Amarillo and across New Mexico, and Arizona to Daggett in southeastern California. It thereby avoids the UP and SP lines west of Kansas City and Omaha. The route increases feeder shipments along the Burlington Northern lines between Chicago and Kansas City, and on the Norfolk Southern lines between Cleveland and Kansas City, but reduces shipments on the Chicago and North Western lines between Chicago and Omaha. Otherwise, it has limited effects on routing patterns east of the Missouri River.

14. ROUTE IDENTIFICATION AND MAPPING

As currently developed, the HIGHWAY and INTERLINE models describe, but do not map, shipment routes. Figure 14-1 presents the HIGHWAY description of a cross-country truck shipment route to Yucca Mountain, using Oyster Creek (NJ) as the trip origin for illustration purposes:

- The first line of the output shows the origin ("OYSTER CREEK NP, NJ") and the departure date and time.

- The second line shows (reading from left to right):
  — the distance to the nearest "node" or intersection (12.0 miles);
  — the route to that intersection (U.S. Highway 9, or "U9");
  — the name of the node ("TOMS RIVER" at the intersection of "TGSP," or the Garden State Parkway, and "X82," or exit 82, in "NJ");
  — the cumulative distance from the origin (12.0 miles);
  — the cumulative time required to complete travel from the origin to this node ("0:16"); and
  — the date and time of arrival at the node ("2/01 @ 16:19").

- Each line thereafter includes similar information for subsequent links in the route from Oyster Creek to Yucca Mountain.

- According to the model output, the 2,688-mile route from eastern New Jersey to southern Nevada would pass through Pennsylvania, Ohio, Indiana, Illinois, Iowa, Nebraska, Colorado, and Utah; travel time at an average speed of 53.4 miles per hour would be just over 2 days (50.4 hours).

Figure 14-2 presents the INTERLINE description of a cross-country rail route to Yucca Mountain, again using Oyster Creek (NJ) as the trip origin for illustration purposes:

- For each node along the route, the listing indicates the rail carrier, the node number and name, the state in which the node is located, and the cumulative route distance.

- According to the model output, the default rail route under the MPC base case from Oyster Creek to Yucca Mountain would use Conrail lines to travel to Chicago where shipments would be transferred to the Chicago and North Western to Fremont, Nebraska, and from there on the UP to Caliente or Valley. The total travel distance, excluding new rail construction* or heavy-haul segments at either end, is 2,847 miles.

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* Note that INTERLINE assumes construction of a rail spur from Valley to Yucca Mountain, operated by the U.S. government (USG). In this analysis, we assume construction and use of an intermodal transfer facility and a heavy-haul route for all rail shipments.

Mapping HIGHWAY or INTERLINE Route Descriptions

In route mapping, each segment in the model output is identified on a master map of the nation's major highways or railroads. The mapped route can then be shown in relation to state boundaries, county boundaries, or other more detailed information. Mapped routes for all shipment origins reveal combined shipment impacts for each route segment (see Figure 14-1).

Figure 14-1. HIGHWAY Model Output (Oyster Creek to Yucca Mountain: LWT Truck Base Case Route)

Routing through:

0.0			OYSTER CREEK	NP			NJ	0.0	0:00	2/01 @	16:03
12.0	U9		TOMS RIVER	NW	TGSP	X82	NJ	12.0	0:16	2/01 @	16:19
2.0	TGSP		PLEASANT PLNS	S	TGSP	X83	NJ	14.0	0:18	2/01 @	16:21
12.0	TGSPS		GLENDOLA	SW	TGSP	I195	NJ	26.0	0:31	2/01 @	16:34
32.0	I195		ALLENTOWN	NW	TNJT	I195	NJ	56.0	1:04	2/01 @	17:07
10.0	INJTS		HEDDING	SE	TNJT	I276	NJ	66.0	1:15	2/01 @	17:17
7.0	I276#		BRISTOL	N	I276	X29	PA	73.0	1:23	2/01 @	17:25
31.0	I276S		PORT KENNEDY	SE	I276	I76	PA	104.0	1:56	2/01 @	17:59
166.0	I76 S		BREEZEWOOD	SW	I70	I76	PA	270.0	5:27	2/01 @	21:30
86.0	I70 S	I76 S	YOUNGWOOD	SW	I70	I76	PA	356.0	7:01	2/01 @	23:04
39.0	I70		LABORATORY	NE	I70	I79	PA	395.0	7:44	2/01 @	23:46
3.0	I70	I79	WASHINGTON	N	I70	I79	PA	398.0	7:47	2/01 @	23:49
27.0	I70		WHEELING	SE	I470	I70	WV	425.0	8:17	2/02 @	0:19
12.0	I470		ST CLAIRSVILLE	E	I470	I70	OH	437.0	8:30	2/02 @	0:32
116.0	I70		COLUMBUS	E	I270	I70	OH	553.0	11:06	2/02 @	3:08
21.0	I270		COLUMBUS	W	I270	I70	OH	574.0	11:29	2/02 @	3:31
157.0	I70		INDIANAPOLIS	E	I465	I70	IN	731.0	14:50	2/02 @	6:52
5.0	I465		INDIANAPOLIS	SE	I465	I74	IN	736.0	14:56	2/02 @	6:58
13.0	I465	I74	INDIANAPOLIS	SW	I465	I70	IN	749.0	15:10	2/02 @	7:12
132.0	I70		TEUTOPOLIS	NW	I57	I70	IL	881.0	17:34	2/02 @	10:36
6.0	I57	I70	EFFINGHAM	SW	I57	I70	IL	887.0	18:11	2/02 @	11:12
78.0	I70		EDWARDSVILLE	SE	I270	I55	IL	965.0	19:36	2/02 @	12:37
29.0	I270		ST LOUIS	NW	I270	I70	MO	994.0	20:07	2/02 @	13:09
227.0	I70		KANSAS CITY	SE	I435	I70	MO	1221.0	24:45	2/02 @	17:47
33.0	I435		KANSAS CITY	W	I435	I70	KS	1254.0	25:21	2/02 @	18:22
47.0	I70 S	TKSTS	TOPEKA	E	I470	I70	KS	1301.0	26:12	2/02 @	19:14
5.0	I470S	TKSTS	TOPEKA	S	I335	I470	KS	1306.0	26:18	2/02 @	19:19
7.0	I470		TOPEKA	W	I470	I70	KS	1313.0	26:25	2/02 @	19:27
1049.0	I70		COVE FORT	W	I15	I70	UT	2362.0	48:53	2/03 @	16:54
242.0	I15		LAS VEGAS				NV	2604.0	54:17	2/03 @	21:18
86.0	U95		AMARGOSA VALLY		U95	S373	NV	2690.0	55:59	2/03 @	23:00

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Figure 14-2. INTERLINE Model Output, Rail Base Case, Oyster Cr to Yucca Mtn.

RR	NODE	STATE	DIST	
CR	1275-TOMS RIVER	NJ	0.	
CR	1337-TRENTON	NJ	83.	
CR	1454-CONSHOHOCKEN	PA	116.	
CR	1525-READING	PA	160.	
CR	2350-HARRISBURG	PA	213.	
CR	2291-ALTOONA	PA	355.	
CR	2254-JOHNSTOWN	PA	391.	
CR	2066-BESSEMER	PA	458.	
CR	2124-PITTSBURGH	PA	471.	
CR	2125-ROCHESTER	PA	497.	
CR	2798-ALLIANCE	OH	553.	
CR	2763-RAVENNA	OH	570.	
CR	2728-CLEVELAND	OH	611.	
CR	2633-ELYRIA	OH	638.	
CR	3442-TOLEDO	OH	717.	
CR	3526-GOSHEN	IN	839.	
CR	3525-ELKHART	IN	849.	
CR	4022-SOUTH BEND	IN	864.	
CR	4067-PORTER	IN	909.	
CR	4070-GARY	IN	925.	
CR	4073-CLARKE	IN	929.	
CR	4074-INDIANA HARBOR	IN	932.	
CR	4232-SOUTH CHICAGO	IL	939.	
CR	4217-CHICAGO	IL	952.	
				TRANSFER
CNW	4217-CHICAGO	IL	952.	
CNW	4234-PROVISO	IL	966.	
CNW	4311-DE KALB	IL	1008.	
CNW	4324-NELSON	IL	1053.	
CNW	10304-CLINTON	IA	1086.	
CNW	10289-CEDAR RAPIDS	IA	1167.	
CNW	10265-MARSHALLTOWN	IA	1234.	
CNW	10246-NEVADA	IA	1261.	
CNW	10271-AMES	IA	1272.	
CNW	10176-MISSOURI VALLEY	IA	1405.	
CNW	10198-CALIFORNIA JCT	IA	1411.	
CNW	11340-FREMONT	NE	1439.	
				TRANSFER
UP	11340-FREMONT	NE	1439.	
UP	11406-GRAND ISLAND	NE	1548.	
UP	11410-GIBBON	NE	1574.	
UP	11352-NORTH PLATTE	NE	1652.	
UP	11358-O FALLONS	NE	1701.	
UP	13703-JULESBURG	CO	1769.	
UP	13465-CHEYENNE	WY	1915.	
UP	13462-LARAMIE	WY	1967.	
UP	13494-GRANGER	WY	2243.	
UP	13568-OGDEN	UT	2382.	
UP	13595-SALT LAKE CITY	UT	2417.	
UP	13630-LYNNDYL	UT	2530.	
UP	14766-VALLEY	NV	2847.	
				TRANSFER
USG	14766-VALLEY	NV	2847.	
USG	16333-YUCCA MOUNTAIN	NV	2946.	

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15. SIX ROUTING CASE EXAMPLES

This section describes possible routes to Yucca Mountain from six shipment origin sites. The level of description may be termed "regional" rather than "national" or "local." Key routes, rail carriers, and urban centers are identified, but local features are not. The sites selected are among those which are assumed to make different transportation choices under the current capabilities and maximum rail scenarios, and/or different near-site options for accessing a railhead under the MPC base case and maximum rail scenarios. The description focuses on the possible route, not on the cask options, the transportation choice or the routing criteria. The question of the number and type of prospective shipments along particular route segments is addressed in sections 17 and 18.

Oyster Creek (NJ) to Yucca Mountain (NV)

How might shipments from the Oyster Creek (NJ) nuclear plant, located in Ocean County near Barnegat Bay about 55 miles due east of Philadelphia, travel to Yucca Mountain? Under the "current capabilities" scenario, the transportation choice of GPU Nuclear for shipments from Oyster Creek is legal-weight truck—using the high-capacity GA-9 cask if available, or a transportation cask for two BWR assemblies otherwise:

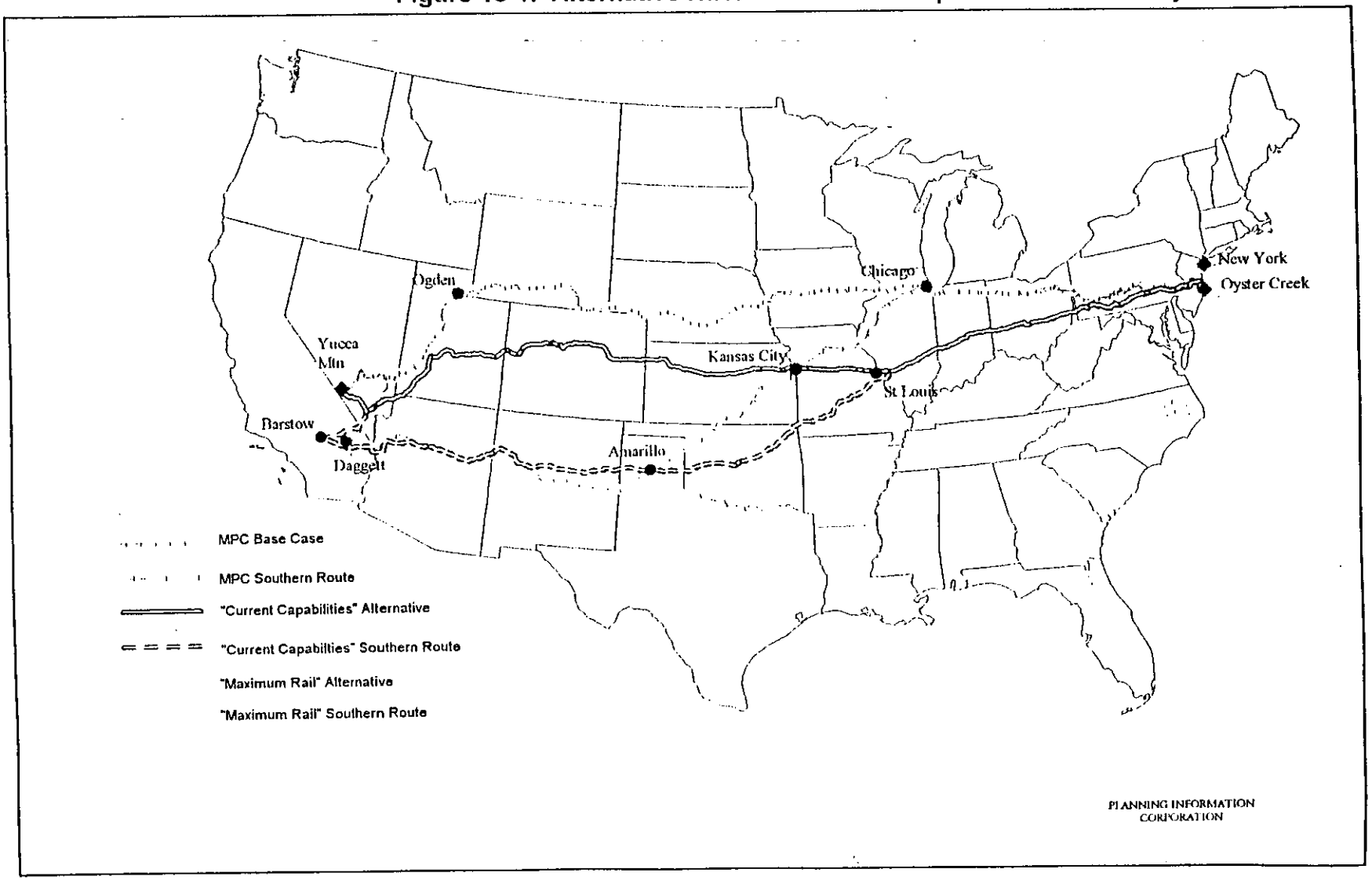
- The "default route" for truck shipments from Oyster Creek would use US 9 and SR-539 to access the Garden State Parkway (a state highway, constructed to interstate standards) northbound at Forked River. The route then continues to I-195 north of Allenwood, to the New Jersey Turnpike and I-276 north of Philadelphia, and to the Pennsylvania Turnpike (I-70 and I-76) through Pennsylvania. From Youngwood in western Pennsylvania, the route continues on I-70 (except for bypasses around major cities) to I-15 in Utah, then through Las Vegas to US 95 and Yucca Mountain.

  The "consolidated southern" option for truck shipments from Oyster Creek would depart from the default route east of St. Louis, continuing on I-70/255 (rather than the I-270 bypass) through East St. Louis, then via I-44 through Tulsa, Oklahoma. From there, the route would follow I-35 to Oklahoma City, I-40 to Barstow, California and I-15 to Las Vegas, US 95 and Yucca Mountain.

Under the "MPC base case" and "maximum rail" scenarios, GPU Nuclear's transportation choice for shipments from Oyster Creek is a large rail cask similar to DOE's 125-ton MPC, containing up to 40 BWR assemblies. However, while the MPC base case assumes heavy-haul transport to the Conrail railhead at Toms River (NJ), the maximum rail scenario would involve barge shipment to Conrail facilities in New York City.[19]

- The "default route" for rail shipments uses different Conrail lines from Toms River (NJ) or New York City to Trenton (NJ).

Figure 15-1. Alternative Nuclear Waste Transportation Routes: Oyster Creek NP



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- From Trenton, the default route for rail shipments uses Conrail lines to Chicago (via Conshohocken, PA, Pittsburgh, Cleveland, and Toledo). In Chicago, shipments are transferred to the Chicago and North Western line for travel to Fremont, NB. In Fremont, shipments are transferred to the Union Pacific line for transport (via Grand Island, Cheyenne, Ogden, and Salt Lake City) to an intermodal facility at Caliente or Valley, Nevada.

- The consolidated southern route for rail shipments would depart from the default route in Chicago. In Chicago, shipments would be transferred to the merged Burlington Northern and Southern Pacific lines for travel to Daggett, California (via Kansas City, Amarillo, and Flagstaff). In Daggett, rail shipments would be transferred to the Union Pacific for travel north through Las Vegas to an intermodal transfer facility at Valley or Caliente.

Fermi (MI) to Yucca Mountain (NV)

How might shipments from the Fermi (MI) nuclear plant, located at the western end of Lake Erie, between Toledo and Detroit, travel to Yucca Mountain? Under the "current capabilities" scenario, the transportation choice of Detroit Edison for shipments from Fermi is legal-weight truck—using the high-capacity GA-9 cask if available, or a transportation cask for two BWR assemblies otherwise:

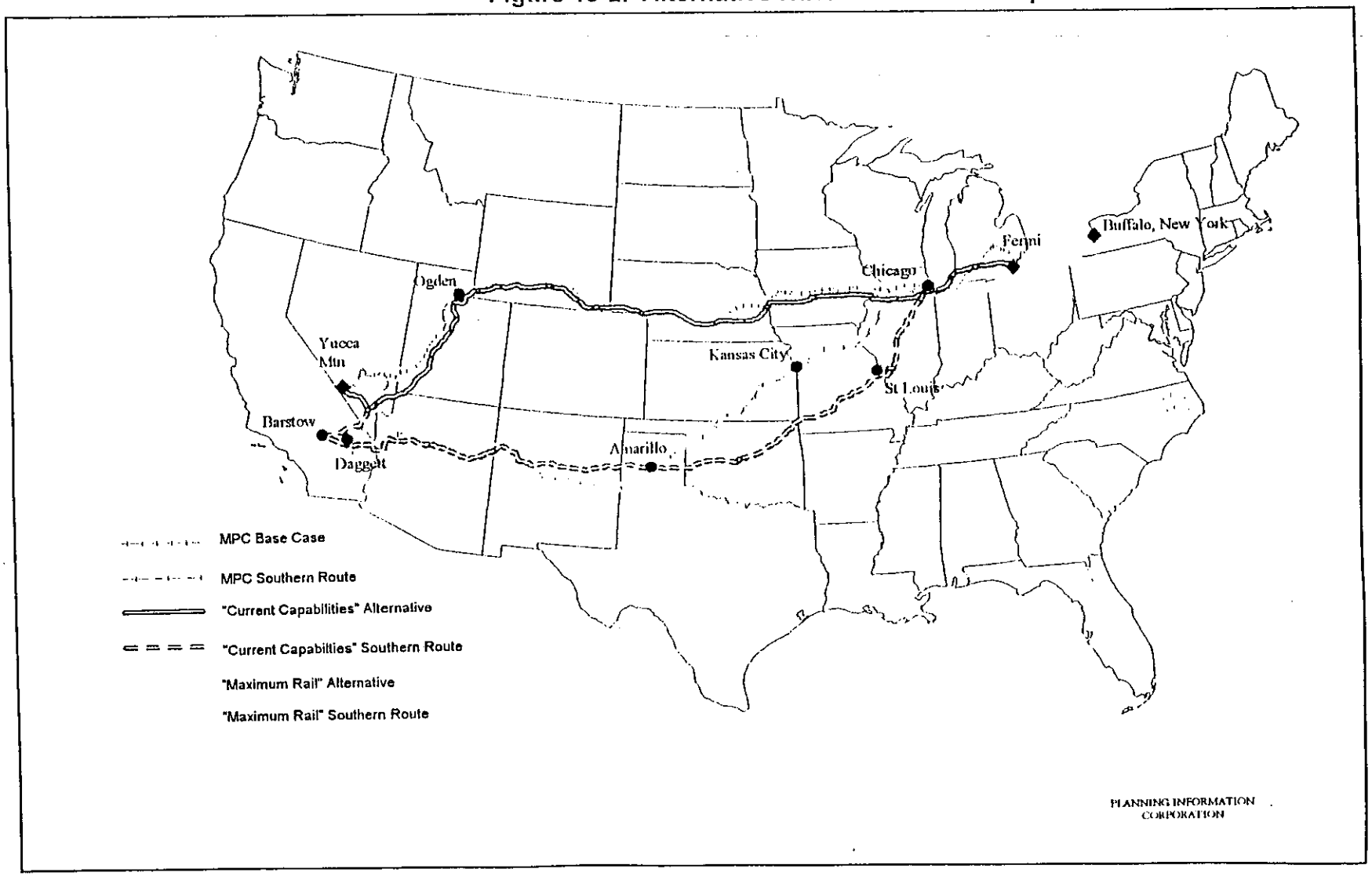
- The "default route" for truck shipments from Fermi would use Interstate 275 (the Detroit metro beltway) to access Interstate 94, which is used to travel across the State of Michigan, passing near Ann Arbor, Jackson, Battle Creek, Kalamazoo, and other cities and towns. The route links with I-80 east of Gary, Indiana, which is used to travel past Chicago and across Iowa, Nebraska, and Wyoming. In Salt Lake City, the default route then links with I-15, which is used for travel south through St. George (UT) and Las Vegas to Yucca Mountain.

- The consolidated southern route for truck shipments from Fermi departs from the default route west of Joliet, Illinois, where, rather than continuing west on I-80, it would access I-55 for travel through Springfield to St. Louis. In St. Louis, the southern route would access I-44 for travel west through Oklahoma City, Amarillo, Albuquerque, and Flagstaff to Barstow, California. In Barstow, the route would access I-15 for travel north to Las Vegas and Yucca Mountain.

Under the "MPC base case" and "maximum rail" scenarios, the transportation choice of Detroit Edison for shipments from Fermi is a large rail cask similar to DOE's 125-ton MPC, containing up to 40 BWR assemblies. However, while the MPC base case assumes use of a substantially upgraded on-site rail spur, the maximum rail scenario would involve barge shipment from the western end of Lake Erie to Conrail facilities in Buffalo (NY) at the eastern end.[19]

- The "default route" for rail shipments from Fermi would use the Grand Trunk Western (GTW) line through Detroit to Blue Island, Illinois where shipments would transfer to the Indiana Harbor Belt line. From Blue Island, the route would travel to the Argo and Proviso yards near Chicago, transferring to the Chicago & North Western (CNW) for transport through Cedar Rapids, Iowa to the UP line at Fremont, Nebraska. From Fremont, Union Pacific lines would be used for travel across Nebraska, Wyoming, and Utah to intermodal facilities at Caliente or Valley.

Figure 15-2. Alternative Nuclear Waste Transportation Routes: Fermi NP



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- The consolidated southern route for rail shipments from Fermi would depart from the default roue at the Argo yards near Chicago, where, rather than transferring to the Chicago and Northwestern line, shipments would be transferred to the consolidated Burlington Northern and Santa Fe lines for travel southwest through Galesburg (IL), Kansas City, Amarillo, and Flagstaff to Daggett (CA). In Daggett, rail shipments would be transferred to the UP for travel north through Las Vegas to an intermodal transfer facility at Valley or Caliente.

- Rail shipments from Buffalo (after barge shipment from Fermi, under the maximum rail scenario) would use Conrail lines for travel along the southern shore of Lake Erie through Erie (PA), Cleveland, and Toledo. Shipments would continue on Conrail through Elkhart and South Bend (IN) to the Argo yards near Chicago, where the route would link with routes for rail shipments directly from Fermi.

Browns Ferry (AL) to Yucca Mountain (NV)

How might shipments from the Browns Ferry plants, located across the Tennessee River from the City of Decatur, travel to Yucca Mountain? Under the 'current capabilities" scenario, the transportation choice of the Tennessee Valley Authority for shipments from Browns Ferry is legal-weight truck—using the high-capacity GA-9 cask if available, or a transportation cask for two BWR assemblies otherwise:

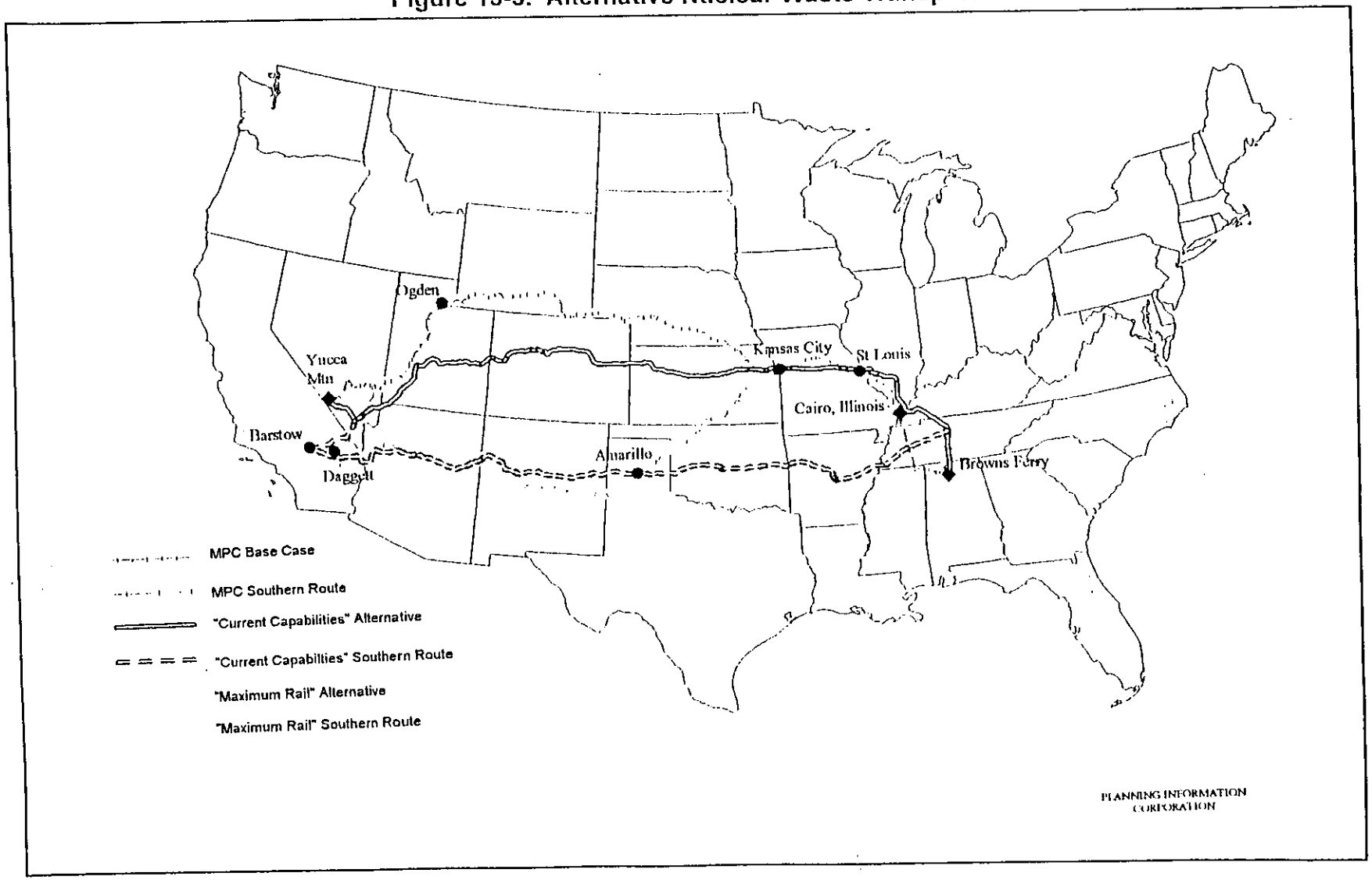
- The "default route" for truck shipments from Browns Ferry would use I-65 to travel north to Nashville, where it would link to I-24 for travel across southwestern Kentucky and southern Illinois to St. Louis. In St. Louis the default route would access I-70 for travel across Missouri to Kansas City, across Kansas and eastern Colorado to Denver, and across western Colorado (through the Eisenhower tunnel and Glenwood Canyon) into Utah. About 160 miles south of Salt Lake City, I-70 links with I-15, which is used for travel south through St. George and Las Vegas to Yucca Mountain.

- The consolidated southern option for truck shipments from Browns Ferry departs from the default route in Nashville, where, rather than continuing west on I-24, it would access I-40 for travel west through Memphis, Little Rock, Oklahoma City, Amarillo, and Albuquerque to Barstow, California. In Barstow, the route would access I-15 for travel north to Las Vegas and Yucca Mountain.

Under the "MPC base case" and "maximum rail" scenarios, the transportation choice of Tennessee Valley Authority for rail shipments from Browns Ferry is a large rail cask similar to DOE's 125-ton MPC, containing up to 40 BWR assemblies. However, while the MPC base case involves heavy-haul transport across the Tennessee River to a Norfolk Southern railhead in Decatur, the maximum rail scenario involves barge shipment down the Tennessee River to Paducah, Kentucky and down the Ohio river to the Illinois Central railhead at Cairo, Illinois:[19]

- The "default route" for rail shipment from Decatur uses Norfolk Southern lines for travel across northern Alabama and Tennessee to Cairo (IL), St. Louis, and Kansas City. In Kansas City, shipments would be transferred to the UP for travel across Nebraska and Wyoming, through Ogden and Salt Lake City (UT) to an intermodal facility at Caliente or Valley.

Figure 15-3. Alternative Nuclear Waste Transportation Routes: Browns Ferry NP



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- The consolidated southern route from Decatur would depart from the default route in Kansas City, where, instead of transferring to the UP, shipments would be transferred to the merged Burlington Northern and Santa Fe lines for travel to Daggett, CA (via Amarillo and Flagstaff). In Daggett, rail shipments would be transferred to the UP for travel north through Las Vegas to an intermodal facility at Valley or Caliente.

- Under the maximum rail scenario, rail shipment on the default or consolidated southern route would begin in Cairo, after barge shipment along the Tennessee and Ohio Rivers.

Cooper Station (NE) to Yucca Mountain (NV)

How might shipments from the Cooper Station site, on the Missouri River about 65 miles south of Omaha, travel to Yucca Mountain? Under "current capabilities" scenario, the transportation choice of Nebraska Public Power for shipments from Cooper Station is legal-weight truck—using the high-capacity GA-9 cask if available, or a transportation cask for two BWR assemblies otherwise:

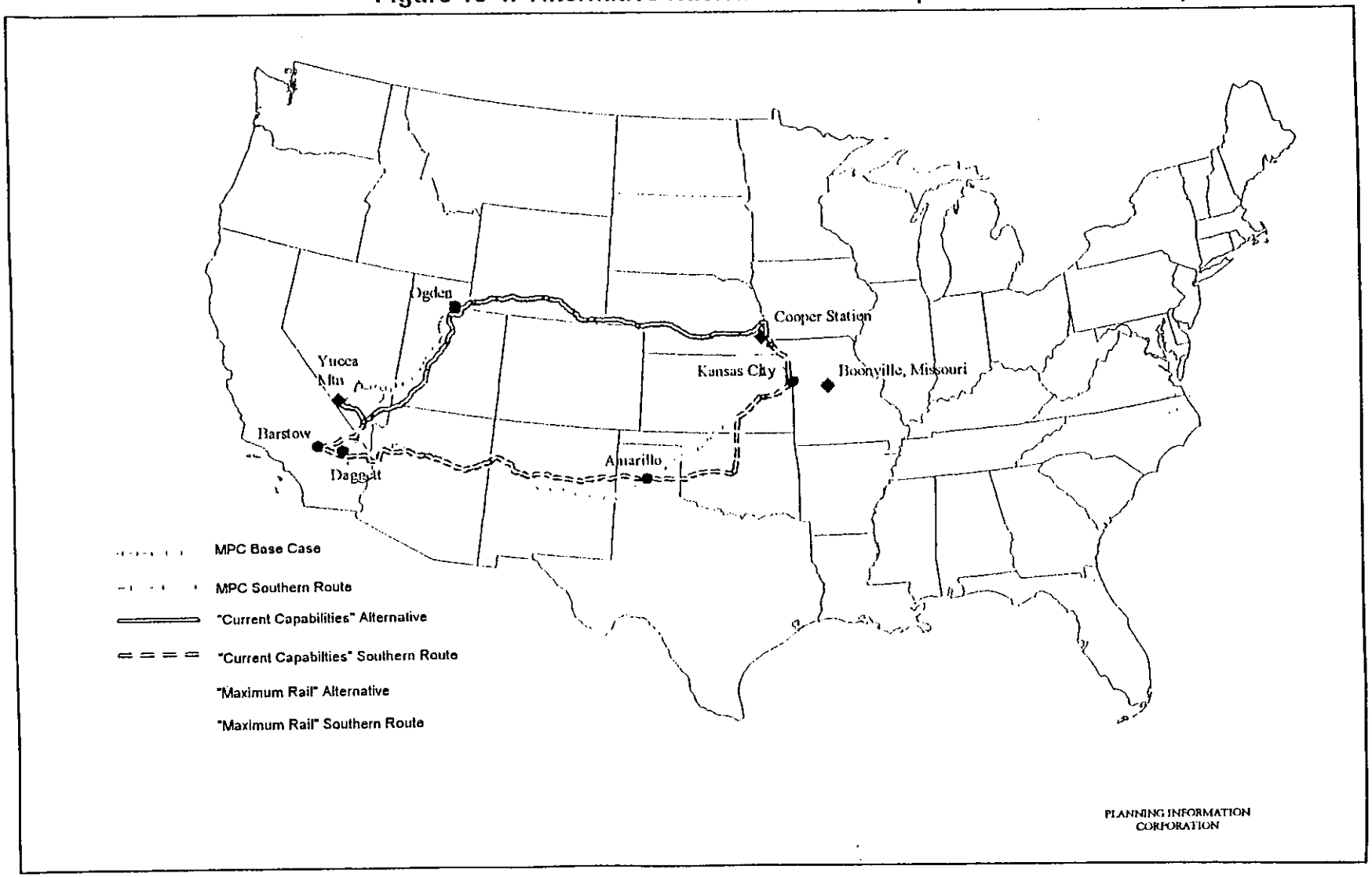
- The "default route" for truck shipments from Cooper Station would follow US 135 west and US 75 north to link with I-80 in Omaha. From Omaha, the route would use I-80 for travel across Nebraska, Wyoming, and Utah, linking with I-15 in Salt Lake City, for travel south through St.. George and Las Vegas to Yucca Mountain.

- The consolidated southern route for truck shipments from Cooper Station would follow US 135 east across the Missouri River, and US 59 south to I-29, continuing south on I-29 through St.. Joseph (MO) to Kansas City. In Kansas City, the southern route would access I-35, which it would follow south through Wichita (KS) to Oklahoma City, where it would access I-40 for continued travel west.

Under the "MPC base case" and "maximum rail" scenarios, Nebraska Public Power's transportation choice for shipments from Cooper Station is a small rail cask similar to DOE's 75-ton MPC, containing up to 24 BWR assemblies. However, while the "MPC base case" assumes heavy-haul transport north to a Burlington Northern railhead in Nebraska City (about 50 miles east of Lincoln), or across the Missouri River and south to a Burlington Northern railhead at Phelps City (MO), the maximum rail scenario assumes barge shipment down the Missouri River to a UP railhead in Boonville, about 120 miles east of Kansas City and about 20 miles west of Columbia (MO):[19]

- The "default route" for rail shipments from Cooper Station involves heavy-haul north to the Burlington Northern railhead at Nebraska City. Burlington Northern lines would be used for travel to Omaha, where shipments would be transferred to the UP railroad for travel west across Nebraska, Wyoming, and Utah, then south through Ogden and Salt Lake City to an intermodal facility at Caliente or Valley.

Figure 15-4. Alternative Nuclear Waste Transportation Routes: Cooper Station NP



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- The consolidated southern route for rail shipments from Cooper Station involves heavy-haul east across the Missouri River to the Burlington Northern railhead at Phelps City (MO). The route uses Burlington Northern lines for travel southeast to Kansas City, and Santa Fe lines (now merged with Burlington Northern) for travel southwest and west to Daggett, California, where shipments would be transferred to the UP for travel north through Las Vegas to an intermodal facility at Valley or Caliente.

- Default route rail shipments from Boonville (after barge shipment from Cooper Station) would use UP lines for travel through Kansas City to Gibbon (NE), about 120 miles west of Lincoln, then west across Nebraska and Wyoming, and south from Ogden (UT) to an intermodal facility at Caliente or Valley.

- Consolidated southern route rail shipments from Boonville would transfer to Santa Fe lines in Kansas City, using these for travel through Amarillo to Daggett, California, where they would transfer back to UP lines for travel north through Las Vegas to an intermodal facility at Valley or Caliente.

Grand Gulf (MS) to Yucca Mountain (NV)

How might shipments from the Grand Gulf (MS) nuclear plant, located on the Mississippi River about 30 miles south of Vicksburg, travel to Yucca Mountain? Under the "current capabilities scenario, the transportation choice of Systems Energy Resources for shipments from Grand Gulf is legal-weight truck—using the high-capacity GA-9 cask if available, or a transportation cask for two BWR assemblies otherwise:

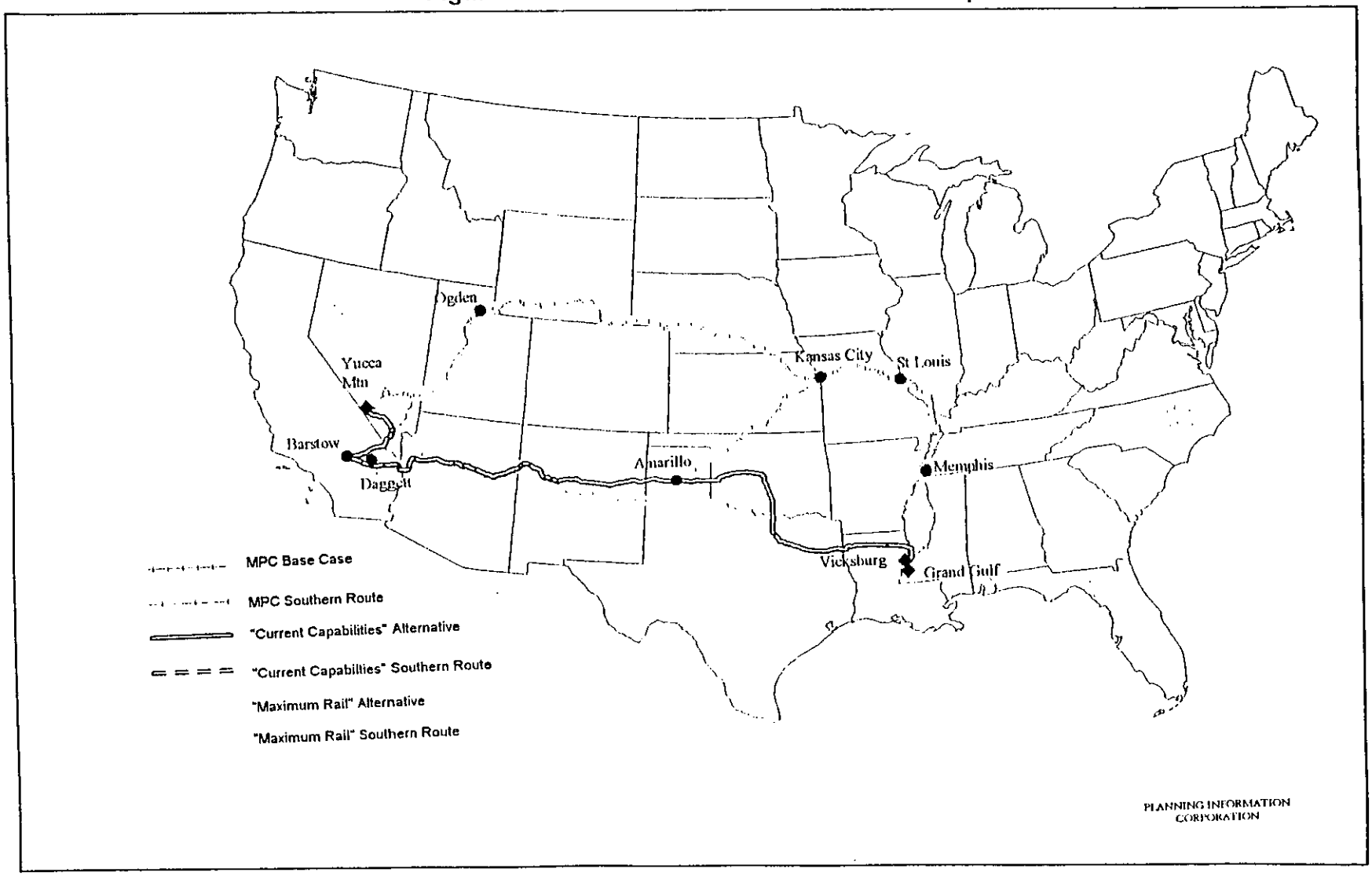
- The default and consolidated southern route for truck shipments from Grand Gulf would follow US 61 north to Vicksburg, where it would link with I-20 for travel west through Shreveport (LA) to Dallas and Fort Worth, where it would access I-35 north to Oklahoma City and I-40 for continued travel west to Barstow, California, where it would access I-15 for travel north through Las Vegas to Yucca Mountain.

Under the MPC base case and maximum rail scenarios, the transportation choice of Systems Energy Resources for shipments from Grand Gulf is a large rail cask similar to DOE's 125-ton MPC, containing up to 40 BWR assemblies:

- The "default route" for rail shipments from Grand Gulf involves heavy-haul north on US 61 and east on I-20 to the Illinois Central railhead at Jackson (MS). The route uses Illinois Central lines for travel north through Memphis to St.. Louis, where shipments would be transferred to UP lines for travel west to Kansas City and across Nebraska, Wyoming, and Utah, then south from Ogden through Salt Lake City to the intermodal facility at Caliente or Valley.

- The consolidated southern route for rail shipments from Grand Gulf departs from the default route in Kansas City where, instead of continuing on the UP, shipments would be transferred to Santa Fe lines for travel southwest to Amarillo and west to Daggett, California, where they would be transferred back to UP lines for travel north through Las Vegas to an intermodal facility at Valley or Caliente.

Figure 15-5. Alternative Nuclear Waste Transportation Routes: Grand Gulf NP



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Diablo Canyon (CA) to Yucca Mountain (NV)

How might shipments from the Diablo Canyon (CA) nuclear plant, located on the Pacific Ocean near San Luis Obispo, about 85 miles northwest of Santa Barbara, travel to Yucca Mountain? Under the "current capabilities" scenario, the transportation choice of Pacific Gas and Electric for shipments from Diablo Canyon is legal-weight truck—using the high-capacity GA-4 cask if available, or a transportation cask for a single PWR assembly otherwise:

- The route for truck shipments from Diablo Canyon would follow US-101 north through San Luis Obispo to Paso Robles, and CA 46 east to access I-5 at Lost Hills. The route would follow I-5 southeast towards Los Angeles, accessing I-210 (Foothill Parkway) for passage across LA's northern suburbs—Burbank, Glendale, Pasadena, Glendora, etc. The route accesses I-10 (San Bernadino Freeway) near Pomona, which is used for travel east through Montclair and Ontario to I-15, which is used for travel north through Las Vegas to Yucca Mountain.

Under the MPC base case and maximum rail scenarios, Pacific Gas and Electric's transportation choice for shipments from Diablo Canyon is a large rail cask similar to DOE's 125-ton MPC, containing up to 21 PWR assemblies. However, while the MPC base case assumes heavy-haul transport to the Southern Pacific railhead in San Luis Obispo, the maximum rail scenario involves a 150-mile barge shipment south to Point Conception and east through the Santa Barbara Channel to the railhead of the Ventura County Railway Company at Port Hueneme near Oxnard:[19]

- Rail shipments from San Luis Obispo would use Santa Fe lines for travel through Santa Barbara, Ventura, Oxnard, Burbank, and east Los Angeles to San Bernadino, where they would be transferred to the UP for travel north through Las Vegas to an intermodal facility at Valley or Caliente.

Figure 15-6. Alternative Nuclear Waste Transportation Routes: Diablo Canyon NP

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16. THE NATIONAL SHIPMENT CAMPAIGN: LIFE OF OPERATIONS

What are the overall effects of the national shipment campaign, aggregated for each origin site and all major rail and highway segments over the entire prospective 30-year shipment campaign? What are the effects under the "current capabilities" scenario of transportation choices, or under the "MPC base case" or "maximum rail" scenarios? What are the effects of using a high capacity cask for legal-weight truck shipments,* rather than the currently-available casks limited to one PWR or 2 BWR assemblies?

This section uses maps to present the rail and highway segments affected, and tables to present the total (life of operations) cask shipments in the 30-year shipment campaign. Both maps and tables reflect factors discussed in previous sections—e.g., the current and projected inventory, the acceptance rate and pickup schedule. Under these assumptions, shipments of HLW from DOE sites begin in year 17 and extend through year 44; only those shipments in years 17 through 31 (54 percent of the total) are included in this summary. Subsequent sections consider implications for Nevada (section 17), regional routing alternatives (section 18), the phasing of shipments during the 30-year campaign (section 19), and transportation operations variables (section 20).

Mapping Routes and Cask Shipments

To visualize the cask shipment findings of a multi-faceted assessment process, this study has developed a map presentation in which route segments are scaled according to the number of projected shipments on each segment over the 30-year shipment campaign. The scale is consistent among cask options and among transportation choice scenarios. That is, in this presentation, 100 prospective cask shipments are shown at the same map scale whether the shipments are truck casks containing 1 PWR or 2 BWR assemblies, high-capacity truck casks containing 4 PWR or 9 BWR assemblies, a small rail cask containing 12 PWR or 24 BWR assemblies or a large rail cask containing 21 PWR or 40 BWR assemblies.** The amount of waste shipped in these casks ranges from about 800 pounds in the case of the small truck cask to about 14,800 pounds in the case of the large rail cask, a factor of 18. Another map presentation might be developed to show the amount of waste shipped, rather than the number of cask shipments.

Rail and Highway Routes Affected

Figure 16-1 shows the rail and highway routes affected by default routing under the current capabilities scenario of transportation choices, scaling the routes according to the number of projected shipments on each segment over the 30-year shipment campaign. Figures 16-2 and 16-3 present similar results for the "MPC base case" and "maximum rail" scenarios of transportation choices. Over the 30-year shipment campaign (and assuming default routing), about 18,800 miles of the nation's railroads carry

* A cask similar to the GA-4/9 cask designed by General Atomics, with capacity for 4 PWR or 9 BWR uncanistered assemblies.

** Also, no attempt has been made to project rail consists. The maps indicate the number of casks shipped on each rail route segment, not the number of trains containing cask shipments.

shipments of SNF or HLW, a figure which increases to 21,200 miles under the MPC base case and to 23,500 under the maximum rail scenario of transportation choices.* Rail rather than highway shipment from certain sites (e.g., Turkey Point, FL, Diablo Canyon, CA, Kewanee, WI) adds significantly to total affected rail route mileage, but from other sites (e.g., Dresden, IL, Browns Ferry, AL) has much less effect.

Over the 30-year shipment campaign (again, assuming default routing) about 13,700 miles of the nation's highways carry shipments of SNF or HLW, a figure which decreases to 10,200 miles under the MPC base case and to 4,200 under the maximum rail scenario of transportation choices. Rail rather than highway shipment from certain sites (e.g., Grand Gulf, MS, Surry, VA, Peachbottom, PA) significantly reduces highway route mileage, but from other sites (e.g., Calvert Cliffs, MD, Salem, NJ) has much less effect.

Total Cask Shipments

Table 16-1 presents total cask shipments over the 30-year campaign, under the current capabilities, MPC base case and maximum rail scenarios. Rail cask shipments of SNF** increase from about 9,900 in the current capabilities scenario of transportation choices to about 11,200 under the MPC base case and 14,100 under the maximum rail scenario. The changes reflect both the number of sites shipping by rail (and their projected inventory) and the type of rail cask used. Compared to the current capabilities scenario, the MPC base case and maximum rail scenarios include more rail shipment sites (*increasing* the number of rail cask shipments) making greater use of the large MPC (*reducing* the number of rail cask shipments). Shipments of uncanistered fuel in currently-available legal-weight truck casks are estimated at 79,300 under the current capabilities scenario of transportation choices, a figure which decreases to 26,100 under the MPC base case and to 4,700 under the maximum rail scenario. The decreases reflect the number of sites shipping by truck rather than by rail, and the projected inventory requiring shipment.

The high-capacity legal-weight truck cask (if available and consistently used throughout the 30-year shipment campaign) dramatically reduces the number of truck cask shipments from 79,300 to 31,400 under the current capabilities scenario, from 26,100 to 6,300 under the MPC base case, and from 4,700 to 1,150 under the maximum rail scenario. Even so, truck cask shipments of SNF would comprise about 71 percent of total cask shipments under the current capabilities scenario, about 31 percent under the MPC base case scenario, and over 6 percent under the maximum rail scenario of transportation choices.

The Use of Affected Rail and Highway Routes

How intensively would the nation's rail and highway networks be used by the national shipment campaign? Over the 30-year campaign, each affected rail route mile would receive an average of about 1,500 cask shipments under the current capabilities scenario, with similar figures for a somewhat more extensive affected rail route network under the MPC base case and maximum rail scenarios. More intensively used rail route segments, however, could receive up to 8.5 times the national average.

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* Route mileage excludes 162 miles of heavy-haul from an intermodal transfer facility at Caliente.

** An additional 2,700 rail cask shipments of HLW are expected between years 17 and 31.

Over the 30-year shipment campaign, each affected rail route mile would receive an average of 13,700 cask shipments under the current capabilities scenario (using currently-available legal-weight truck casks), or about 1,500 shipments (using the high-capacity legal-weight truck cask) under the MPC base case, or about 700 under the maximum rail scenario. Again, more intensively used highway route segments could receive up to six times the national average.

A State-Level Review

Perspectives on nuclear waste transportation are highly correlated with the degree to which waste will be shipped out of, through or to one's own community—that is, the degree to which one's community serves as an origin, corridor or destination for shipments of these highly-toxic and long-lived radioactive materials. Origin communities have lived with nuclear sites for years, even decades, have directly benefited from the electricity and jobs produced, and, with shipment, have the opportunity to rid themselves of the resulting wastes. Corridor communities provide transportation routes for wastes whose origin and destination are elsewhere. Under safe, routine conditions, waste shipments will not linger in corridor communities, but they require attention by public officials and raise anxieties among residents. Destination communities receive the wastes generated elsewhere. In the case of spent nuclear fuel and high-level waste, there is only one prospective destination community, and the waste received, even if safely contained, will remain toxic for centuries.

Under the MPC base case scenario of transportation choices (assuming default routing) only seven states are neither origins, corridors, nor the destination for shipments of SNF or HLW (see Figure 16-4). Together, these jurisdictions comprise 2.4 percent of the nation's population. Another seven states located along the perimeter of the country are origins but not corridors for shipments of SNF and HLW. Together, these states comprise 18 percent of the nation's population. It should be observed, however, that many communities within these states will consider themselves as corridors rather than as origins for shipments of nuclear waste. Still another seven states (three east of the Mississippi River) plus the District of Columbia are corridors but not origins for shipments of SNF and HLW. Together, these states comprise seven percent of the nation's population.

Most states are both origins and corridors for prospective shipments of SNF and HLW under the MPC base case scenario of transportation choices with default routing. Together, these 28 states comprise 71 percent of the nation's population. Five of the 28 are origins for shipments from one (or in the case of Nebraska, two) nuclear site, but are corridors for shipments from 20 sites or more. These states are Iowa, Kansas, Missouri, Nebraska, and Arizona. Together, they comprise 6.2 percent of the nation's population.

Under the MPC base case scenario with default routing, 8 states are corridors for shipments from 25 or more sites. These states, including five with commercial reactors and two east of the Mississippi, comprise 11 percent of the nation's population. Illinois is a corridor state for 47 sites and an origin state for eight sites.

Nevada is the destination state, the end of the funnel for the national shipment campaign and the intended permanent disposal site for the nation's SNF and HLW. Nevada has 0.5 percent of the nation's population. Similar to origin-only states, parts of Nevada are likely to consider themselves more as corridors than as the destination for shipments of SNF and HLW. But these communities are corridors

for all shipment sites, and are in the destination state where the wastes will be permanently stored, not an origin state that has previously chosen to developed nuclear power and is now removing the resulting wastes. Section 17 provides additional detail regarding cask shipments into the destination state.

Table 16-1. Route Miles Affected and Cask Shipments
- **Life of Operations (YR 1-31) . . . Default Routing**
- **Currently-Available and High-Capacity Truck Cask**

	RAIL	HWY:T1/2	TOT:T1/2	HWY:T4/9	TOT:T4/9
ROUTE MILES:					
Current Capabilities	18805	13695	32500	13695	32500
MPC Base Case	21210	10224	31434	10224	31434
Maximum Rail	23507	4178	27685	4178	27685
CASK SHIPMENTS:					
Current Capabilities	12636	79345	91981	31370	44006
MPC Base Case	13916	26093	40009	6322	20238
Maximum Rail	16792	4722	21514	1150	17942
CASK SHIP PER RT-MILE:					
Current Capabilities	1496	13356	6493	3154	2194
MPC Base Case	1463	6505	3103	1536	1487
Maximum Rail	1494	2764	1686	703	1375

Table 16-2. States by Origin/Corridor Status

Neither Origins Nor Corridors	Origin Only States	Corridor Only States	Major Corridor States*	
Rhode Island	Michigan	Indiana	Utah	(65/0)
District of Columbia	Wisconsin	Kentucky	Nebraska	(60/2)
Delaware	Maine	Oklahoma	Wyoming	(58/0)
Alaska	New Jersey	West Virginia	Illinois	(47/8)
Hawaii	Florida	New Mexico	Iowa	(32/1)
Montana	Louisiana	Utah	Kansas	(28/1)
North Dakota	Washington	Wyoming	Missouri	(27/1)
South Dakota			Indiana	(25/0)
Percent of U.S. population:	18 percent	7 percent	11 percent	

* (60/2): corridor for 60 sites, origin for 2.

Figure 16-1. Life of Operations Rail and Highway Cask Shipments Current Capabilities Transportation Choices/Default Routing

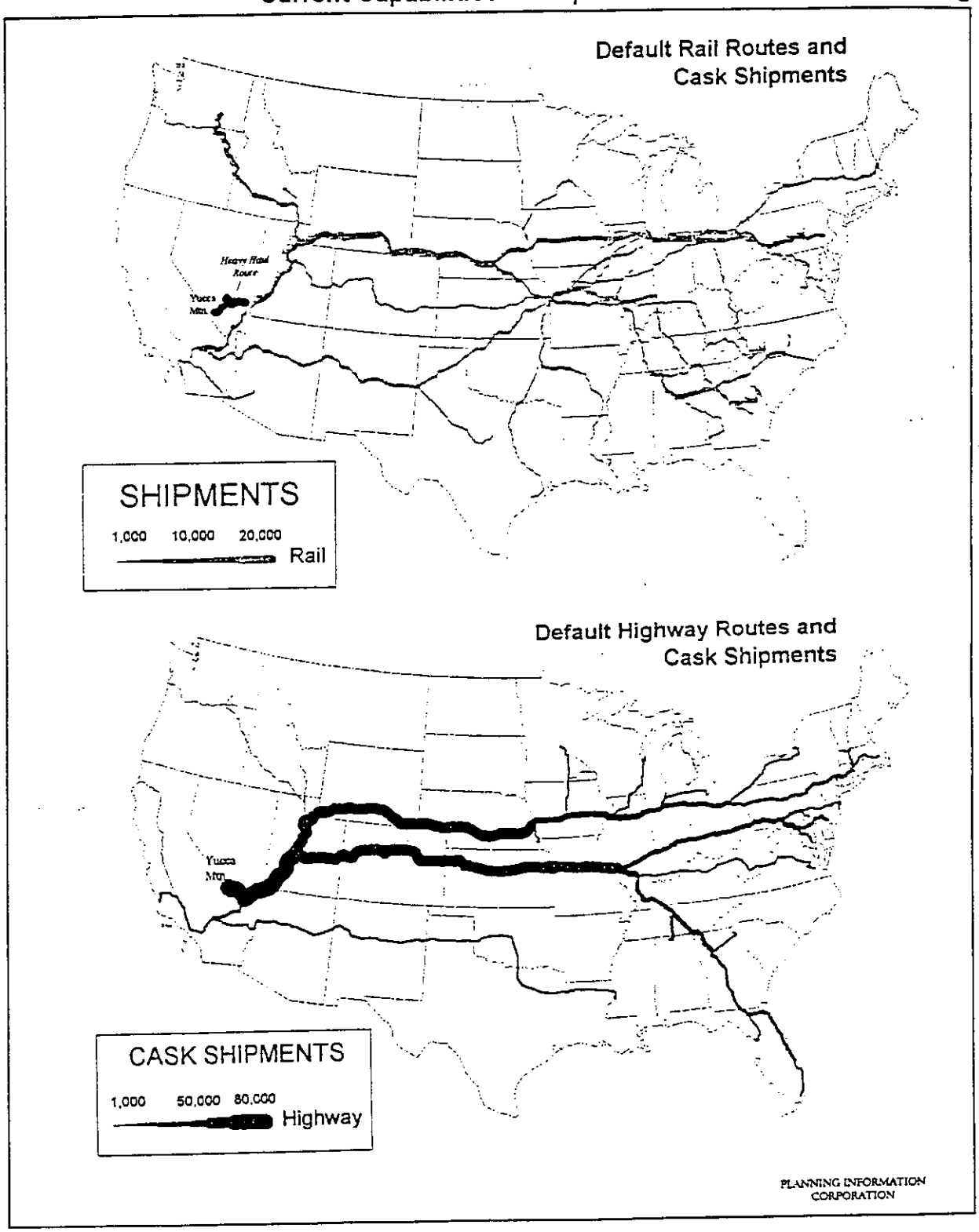


Figure 16-2. Life of Operations Rail and Highway Cask Shipments MPC Base Case Transportation Choices/Default Routing

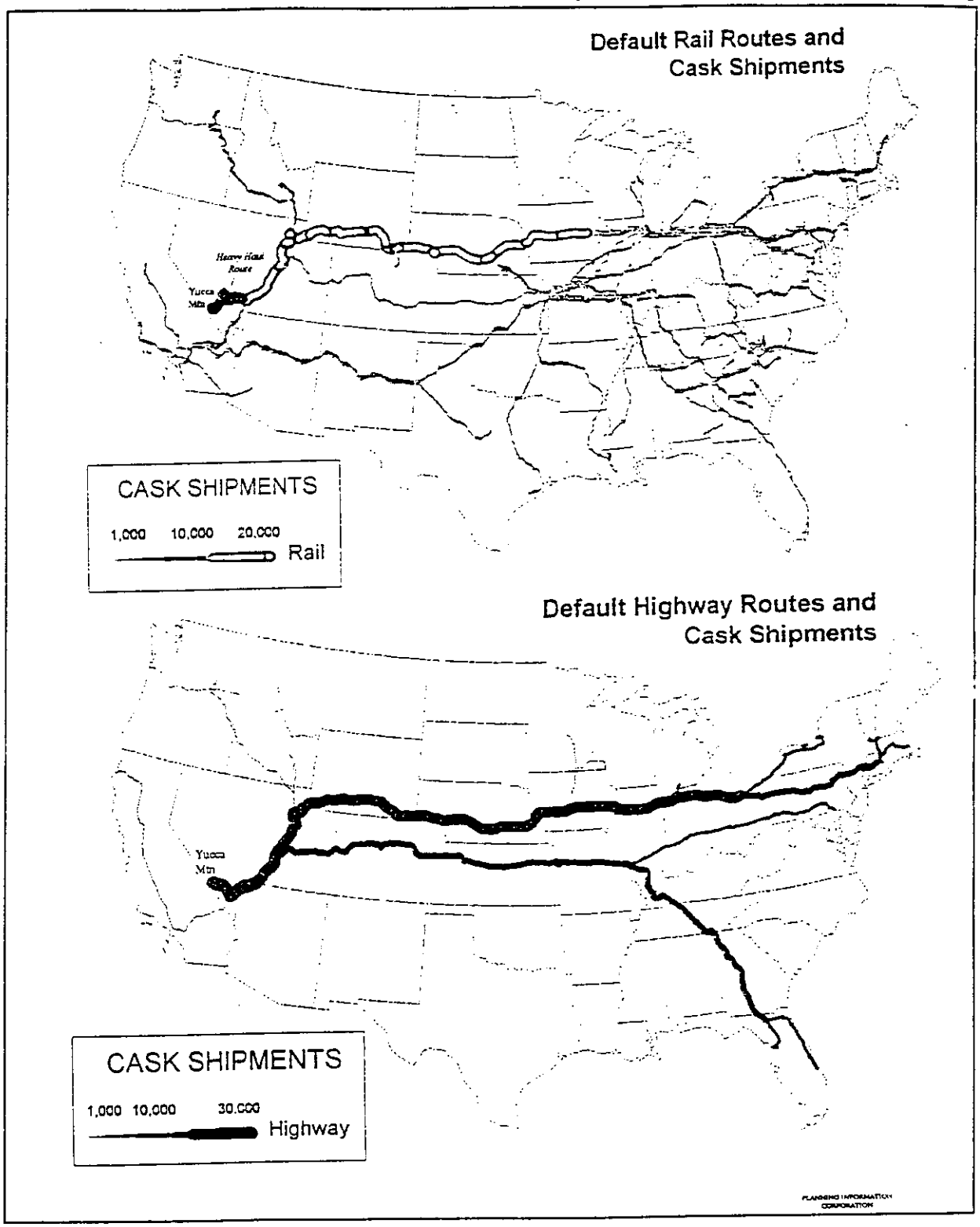
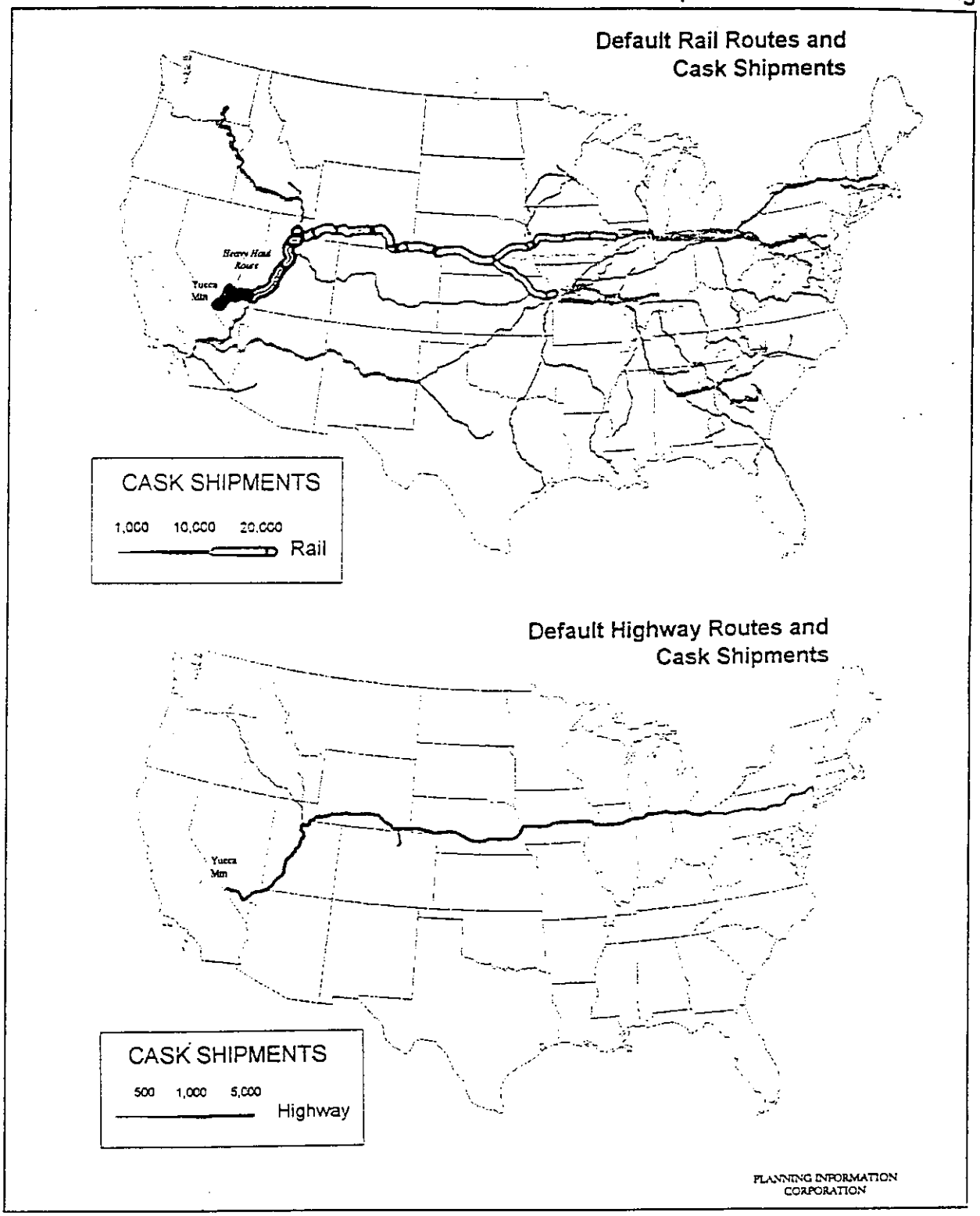


Figure 16-3. Life of Operations Rail and Highway Cask Shipments Maximum Rail Transportation/Default Routing



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17. NEVADA IMPLICATIONS: THE END OF THE FUNNEL

The end of the funnel for the prospective national shipment campaign is Nevada, where rail and truck shipments from 80 sites in 35 states would converge. Under default routing, rail shipments would move on the Union Pacific rail line north from California or south from Utah to an intermodal transfer facility at the Lincoln County community of Caliente. From Caliente, shipments would continue by heavy-haul truck along U.S. highways and state roads, accessing NTS Area 25 via a newly constructed road across a corner of the Nellis Air Force Range, or continuing on public highways along a circuitous route north and west of the Nellis Air Force Range. Truck shipments would move on Interstate 15 north from California or south from Utah and Arizona to a major interchange with US-95/93 in the heart of Las Vegas, locally known as "the Spaghetti Bowl." From the Spaghetti Bowl, truck shipments would continue northwest on US-95, entering the Nevada Test Site at Lathrop Wells in the Nye County community of Amargosa Valley.

Figure 17-1 shows the rail and highway routes affected by default routing under the current capabilities scenario of transportation choices, scaling the routes according to the number of projected shipments on each segment over the 30-year shipment campaign. Figures 17-2 and 17-3 present similar information for the "MPC base case" and "maximum rail" scenarios of transportation choices.

Table 17-1 presents total cask shipments over the 30-year shipment campaign, under the current capabilities, MPC base case and maximum rail scenarios. Under the current capabilities scenario assuming default routing, Nevada would receive about 12,600 rail cask shipments, of which about 9.2 percent would move north from California through Las Vegas. The state would also receive about 79,300 truck shipments (31,300 using the high-capacity T-4/9 cask) of uncanistered fuel, of which about 8.3 percent would move north from California to the Spaghetti Bowl.

Under the MPC base case scenario of transportation choices, rail cask shipments into the state would increase from 12,600 to about 13,900 while truck cask shipments would decrease from 79,300 to 26,100 (from 31,300 to 6,300 using the high-capacity T-4/9 cask). Assuming default routing, the portion of rail and truck shipments moving north into the state from California or south from Utah would change only slightly.

Under the maximum rail scenario of transportation choices, rail cask shipments would increase to 16,800 while truck cask shipments would decrease to 4,700 (to 1,200 using the high-capacity T-4/9 cask). Again, assuming default routing, the portion of rail and truck shipments moving north into the state from California or south from Utah would change only slightly.

Part of a strategy to limit the impacts of transportation shipments in Nevada could involve efforts to avoid Las Vegas, the major urban center of the state. Such a strategy would emphasize rail shipment from the north (where shipments can be intercepted at Caliente) rather than rail shipment from the south or truck shipment on I-15, from the north or south. Among the alternatives considered in this assessment, the maximum rail scenario using default routing (combined with truck shipment using the high-capacity T-4/9 cask) goes the farthest towards this objective. Unfortunately implementation of the maximum rail scenario requires an expensive and not yet devised set of incentives for the choice of rail over truck

shipment, and for large rail over small rail shipment. Furthermore, default routing has implications for corridor communities "upstream" in the route system for shipments of SNF and HLW, which we address in the next section. In addition, even if these arrangements and commitments could be made, it is difficult to envision that they could be implemented in time for a shipment campaign beginning in 1998.

Table 17-1. Life of Operations Rail and Highway Cask Shipments Nevada Rail and Highway Route Segments

	CURRENT CAPABIL	MPC BASE CASE	MAXIMUM RAIL
Rail Segments:			
NV: UP @ UT line	11485	12399	15405
NV: UP @ LV Strip	1151	1517	1387
Hwy Segments:			
NV: I-15 @ Moapa	72768	6277	1150
NV: I-15 @ Strip	6577	45	0

Figure 17-1. Life of Operations Rail & Highway Shipments in Southern NV Region Current Capabilities Transportation Choices/Default Routing

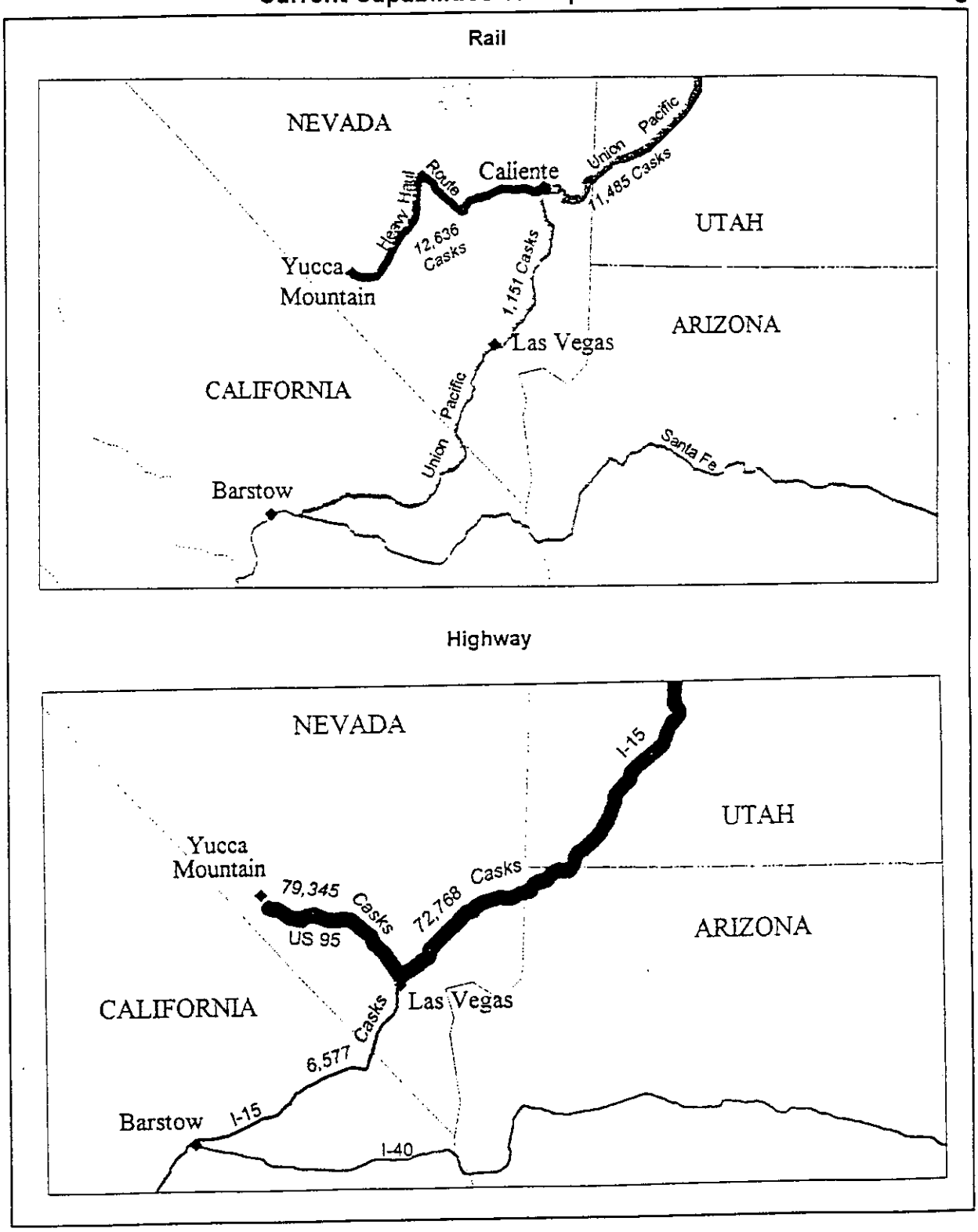


Figure 17-2. Life of Operations Rail & Highway Shipments in Southern NV Region MPC Base Case Choices/Default Routing

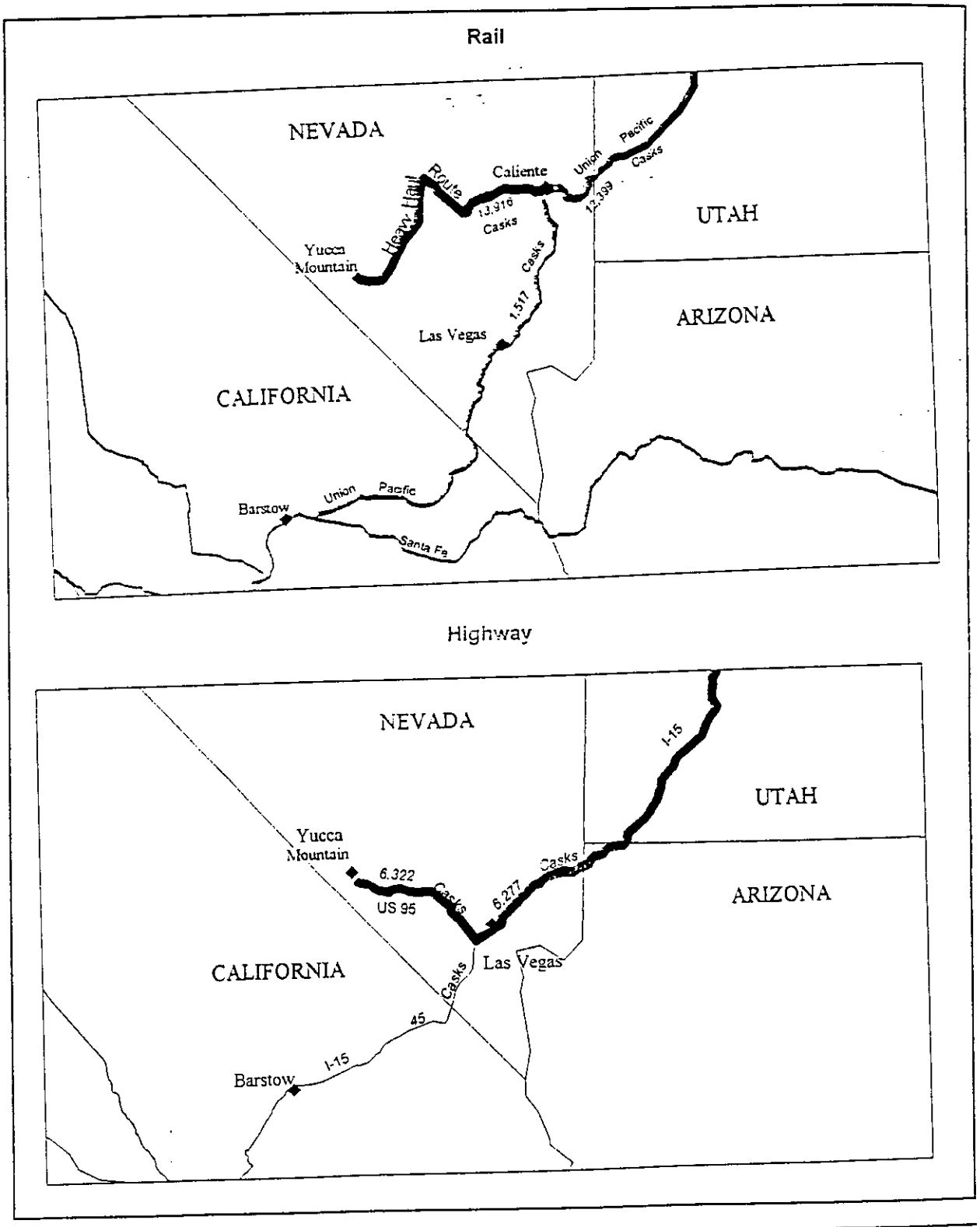
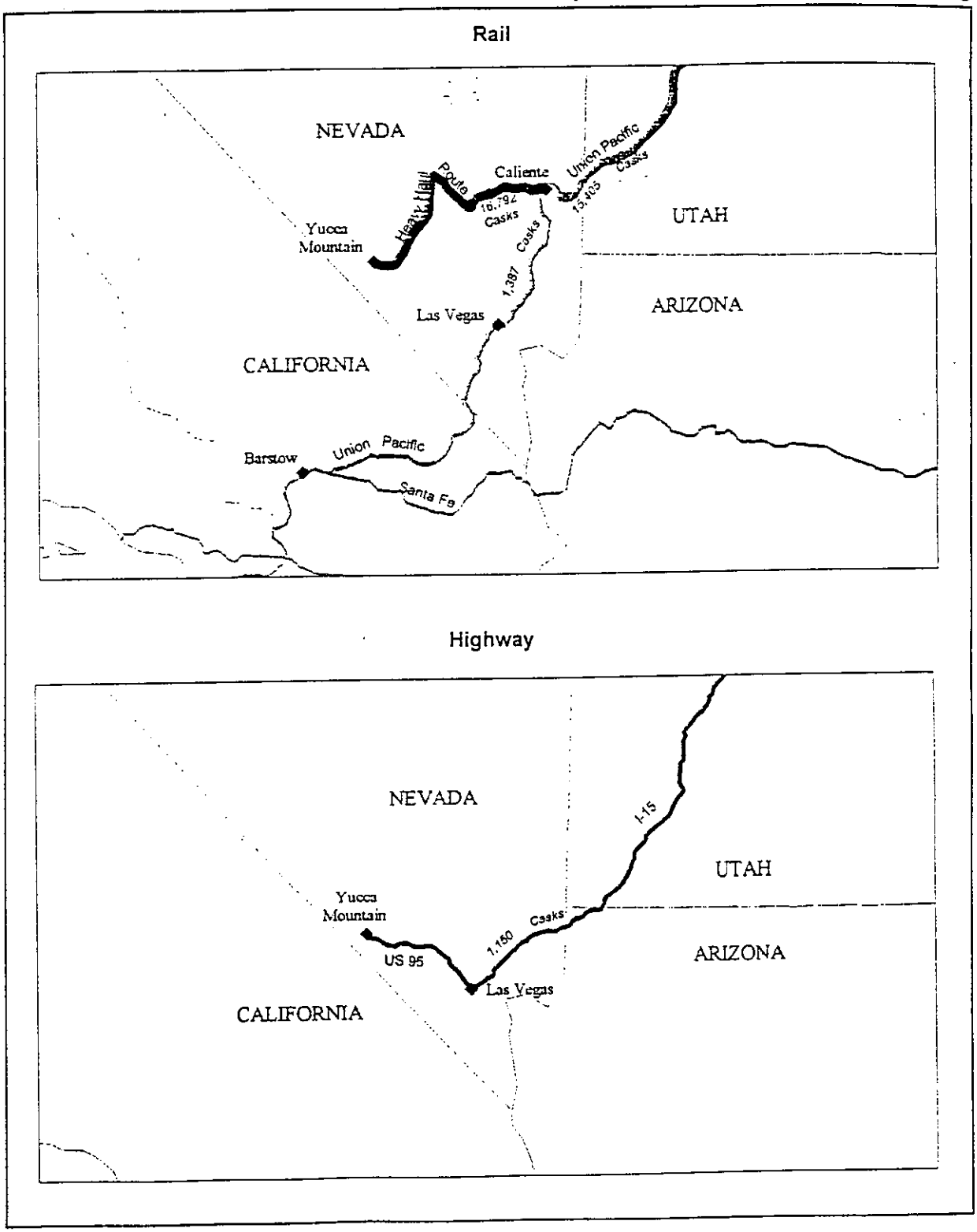


Figure 17-3. Life of Operations Rail & Highway Shipments in Southern NV Region Maximum Rail Transportation Choices/Default Routing



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18. REGIONAL ROUTING ALTERNATIVES

The maps presented in Section 16 can be viewed from many different national, regional, or local perspectives. National perspectives may involve the overall safety or cost efficiency of the national shipment campaign, while regional perspectives may seek to limit impacts on certain centers of population and commerce, and local perspectives may focus on certain facilities (e.g., a hospital or elementary school) or route conditions (e.g., a hazardous interchange) or special events (e.g., the upcoming winter Olympics in Salt Lake City). Under HM164, for example, states may choose to designate alternative routes for shipment of "highway route controlled quantities" of hazardous materials, including SNF and HLW. In a national shipment campaign, such designations have system effects which require coordination with "upstream" and "downstream" states. Rail routes are generally determined by rail carriers, in negotiation with utility shippers and DOE. But the choice to heavy-haul to one railhead rather than another at the origin site, or changes in railroad ownership, can substantially alter a 2,000 mile cross-country route.

The use of Interstate 43, which extends south from Green Bay through Milwaukee and southwest to Beloit, WI provides an example of possible regional perspectives on the routing of SNF shipments. In the current capabilities scenario, I-43 is used to move wastes away from the Kewaunee and Point Beach sites in Wisconsin. In northern Illinois, where the Byron and Zion plants are located, I-43 connects to I-80 via I-39 in Rockford and I-88 in Moline, However, since Byron and Zion ship by rail in the current capabilities scenario, the connecting segments in Illinois are used only by shipments originating in Wisconsin. These circumstances, which are just one example of hundreds involved in a national shipment campaign, could affect the perspective of various state agencies and local communities in Wisconsin and Illinois.

Consolidated Southern Routing

A major alternative to the default routing criteria reflected in the results presented in Sections 16 and 17, is a "consolidated southern" option which would concentrate cross-country rail shipments on the Santa Fe rail line rather than the Union Pacific and Southern Pacific, and concentrate cross-country highway shipments on I-40 rather than I-80 or I-70. To illustrate the effects of regional routing alternatives, we have compared cask shipment estimates under default and consolidated southern routing options for five rail and five highway route segments in four states—Wyoming, Colorado, New Mexico, and Nevada (see Figures 18-1 through 18-3):

- The Wyoming route segments are along the Union Pacific line near Rawlins in south-central Wyoming, and along a nearby segment of I-80.
- The Colorado segments are along the Southern Pacific rail line near Glenwood Springs in western Colorado, and along a nearby segment of I-70.
- The New Mexico segments are along the Santa Fe rail line near Grants in northwestern New Mexico, and along a nearby segment of I-40.

Figure 18-1a. Life of Operations Rail and Highway Cask Shipments Current Capabilities Transportation Choices/Default Routing

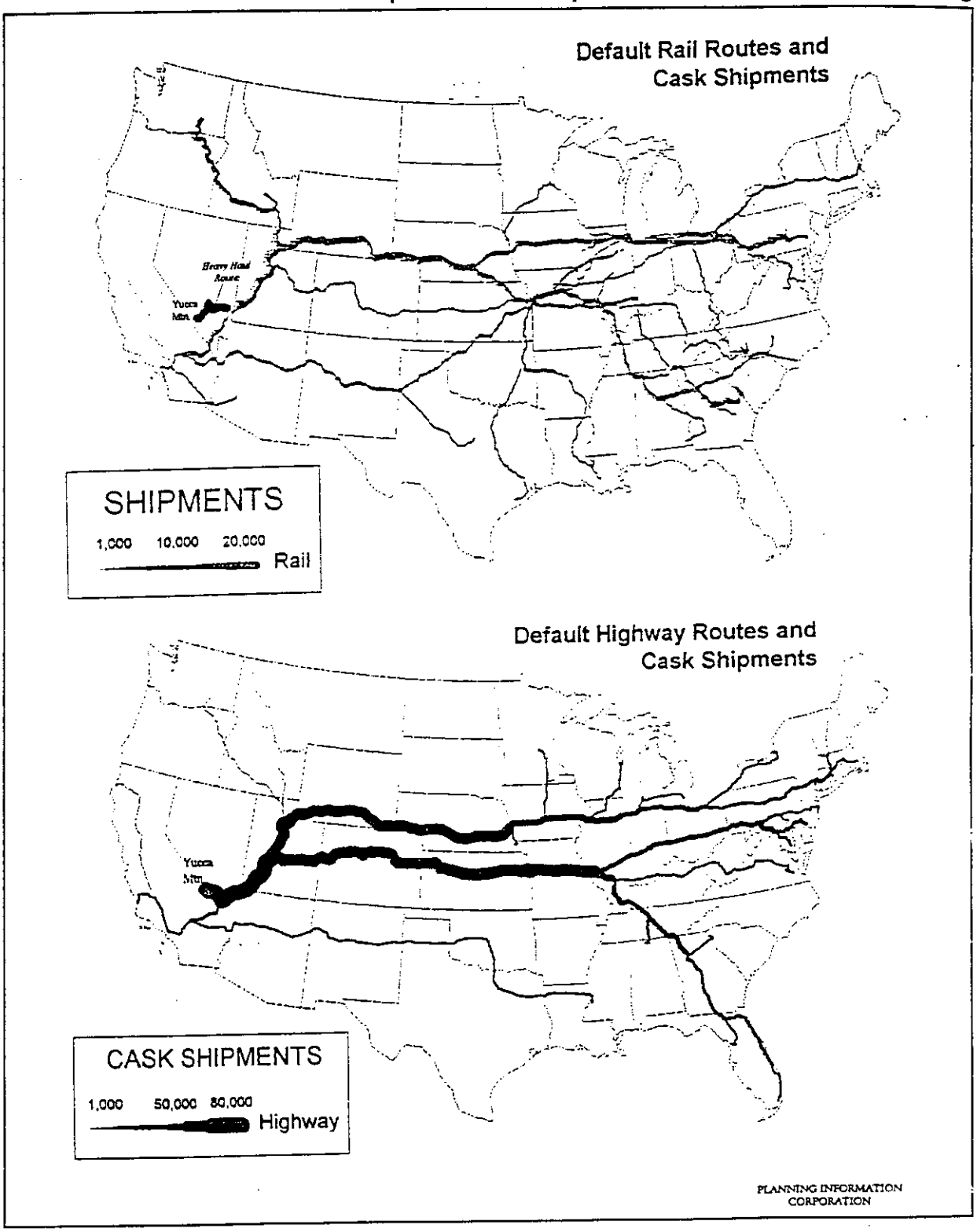


Figure 18-1b. Life of Operations Rail and Highway Cask Shipments Current Capabilities Transportation Choices/Consolidated Southern Routing

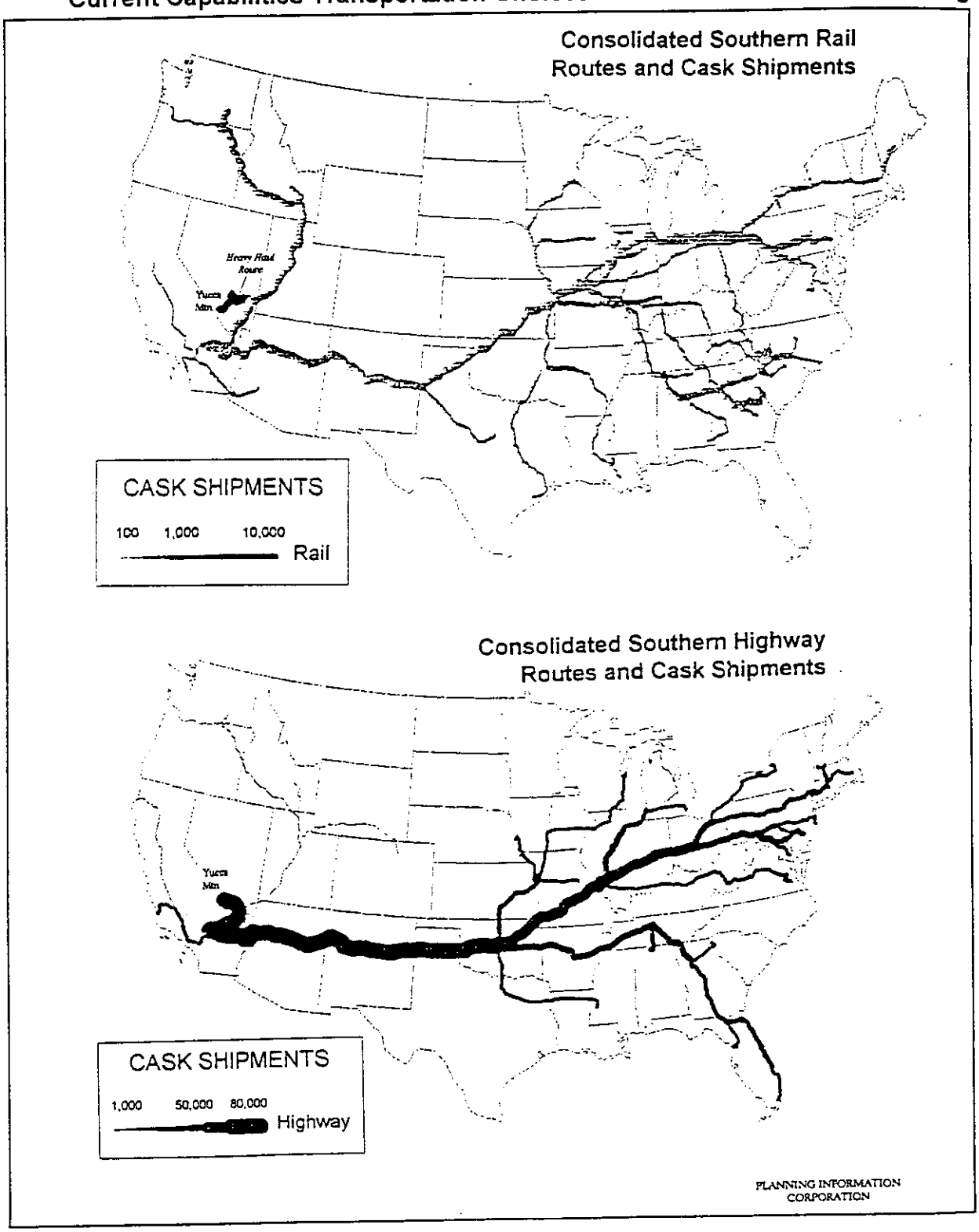


Figure 18-1a (NV). Life of Operations Rail and Highway Cask Shipments in (NV) Current Capabilities Transportation Choices/Default Routing

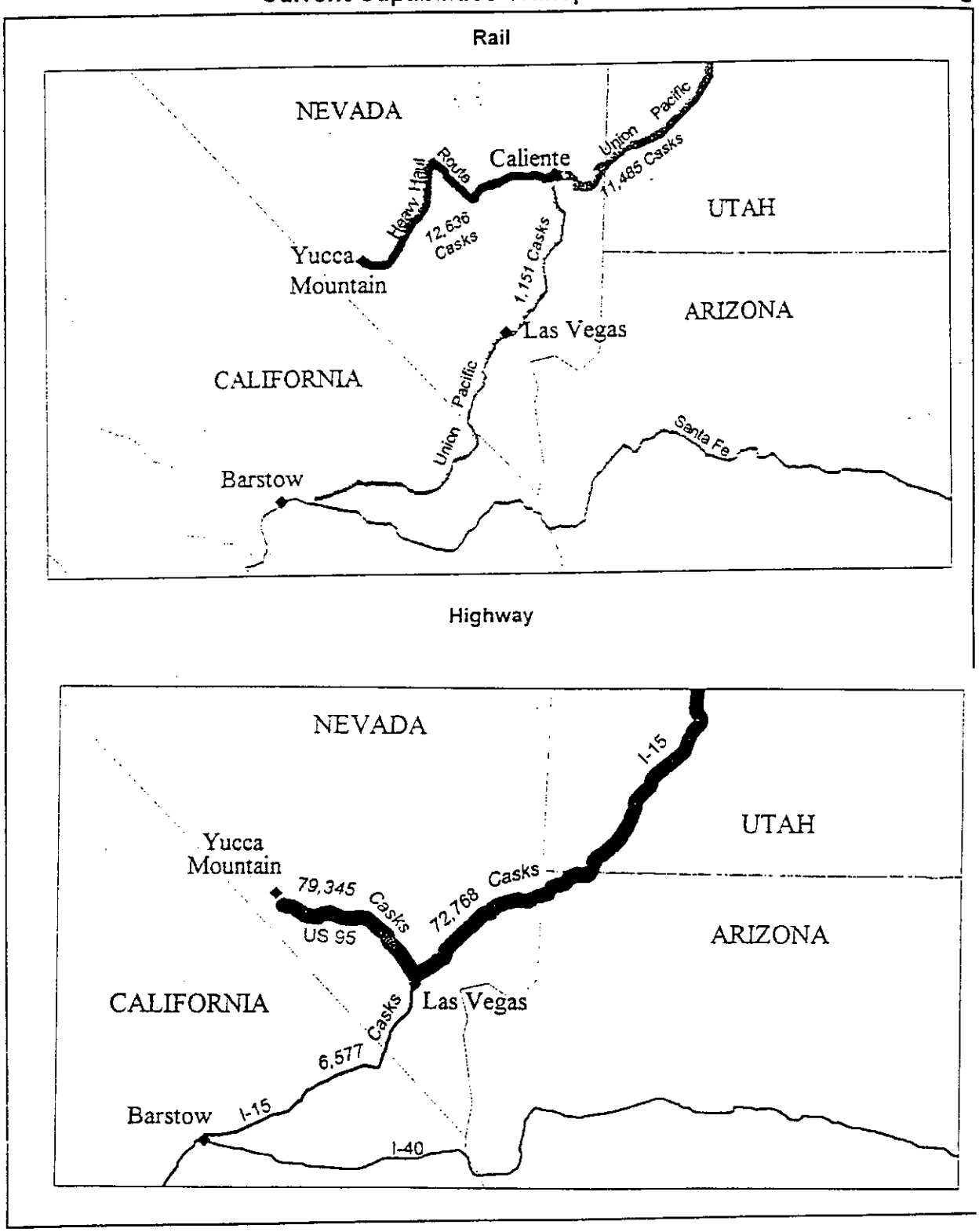


Figure 18-1b (NV). Life of Operations Rail and Highway Cask Shipments in (NV) Current Capabilities Transportation Choices/Consolidated Southern Routing

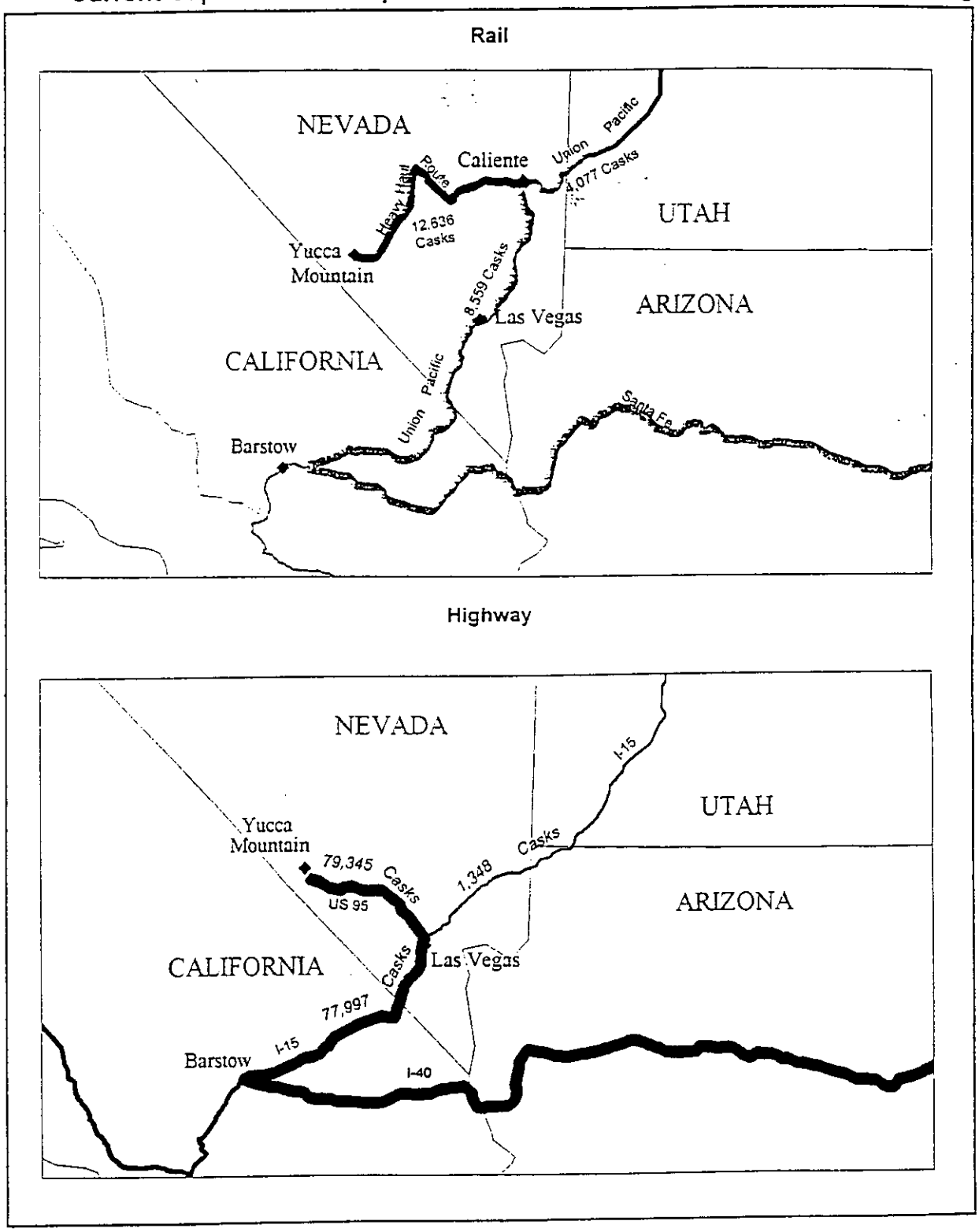


Figure 18-2a. Life of Operations Rail and Highway Cask Shipments MPC Base Case Transportation Choices/Default Routing

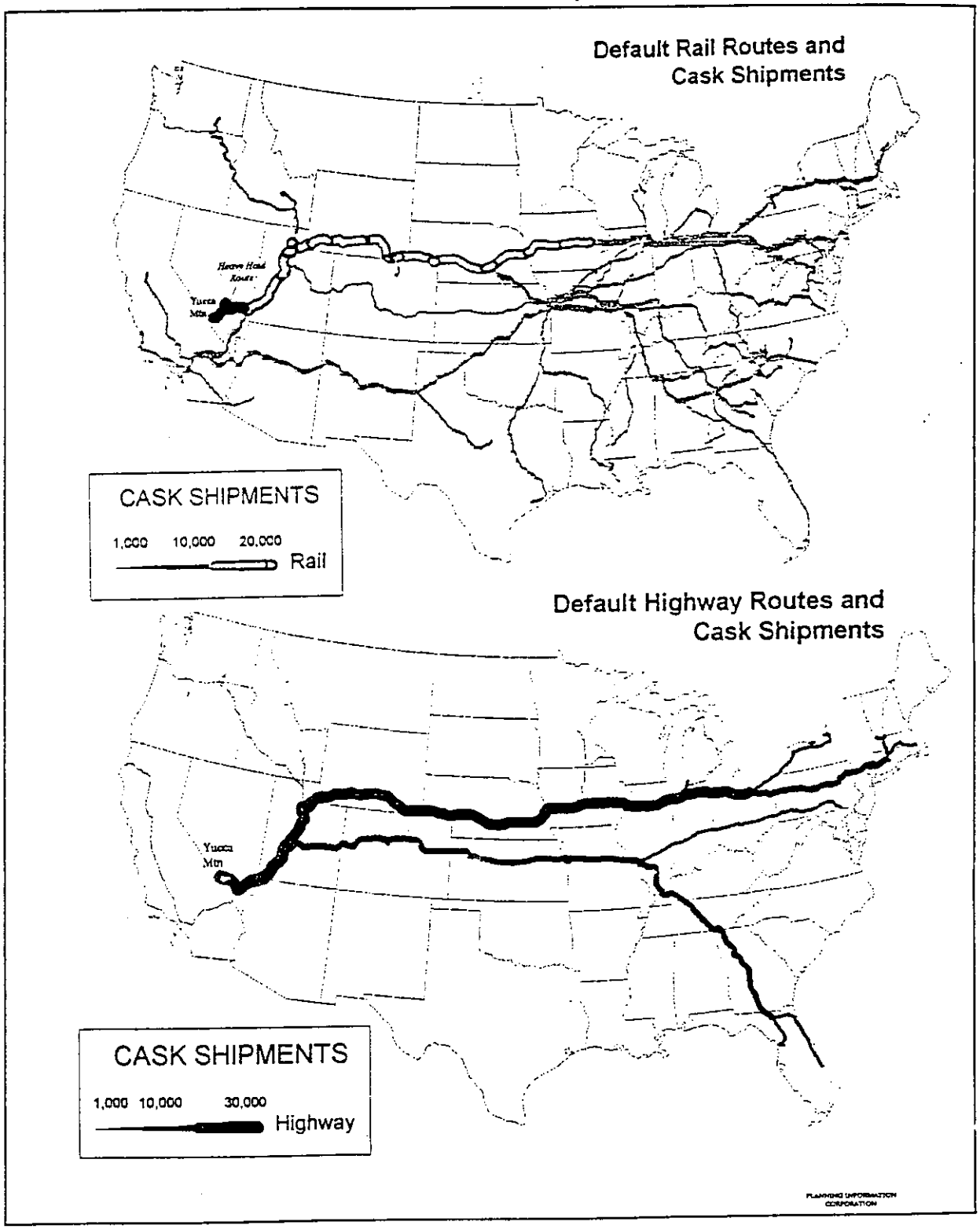


Figure 18-2b. Life of Operations Rail and Highway Cask Shipments MPC Base Case Transportation Choices/Consolidated Southern Routing

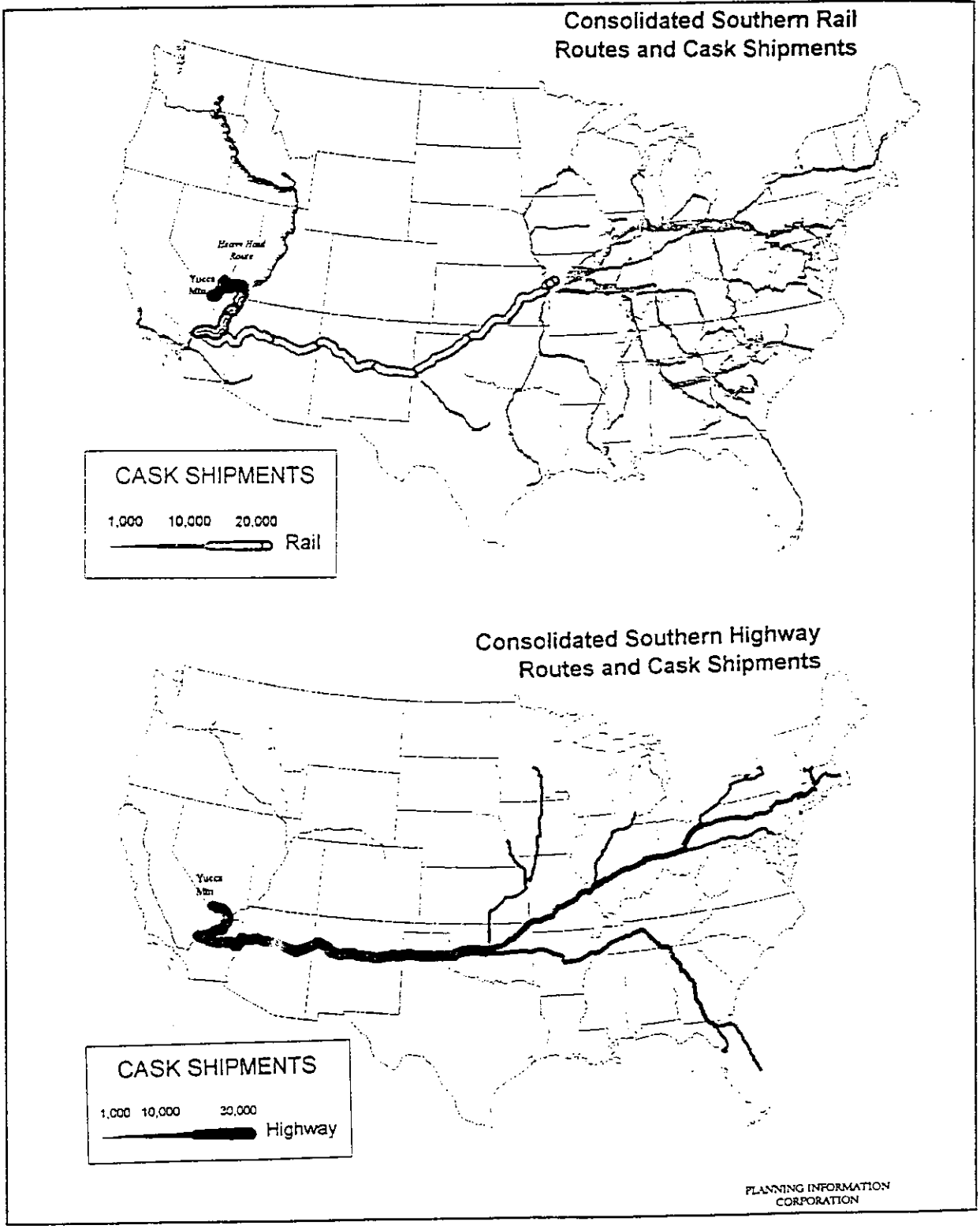


Figure 18-2a (NV). Life of Operations Rail and Highway Cask Shipments in (NV) MPC Base Case Transportation Choices/Default Routing

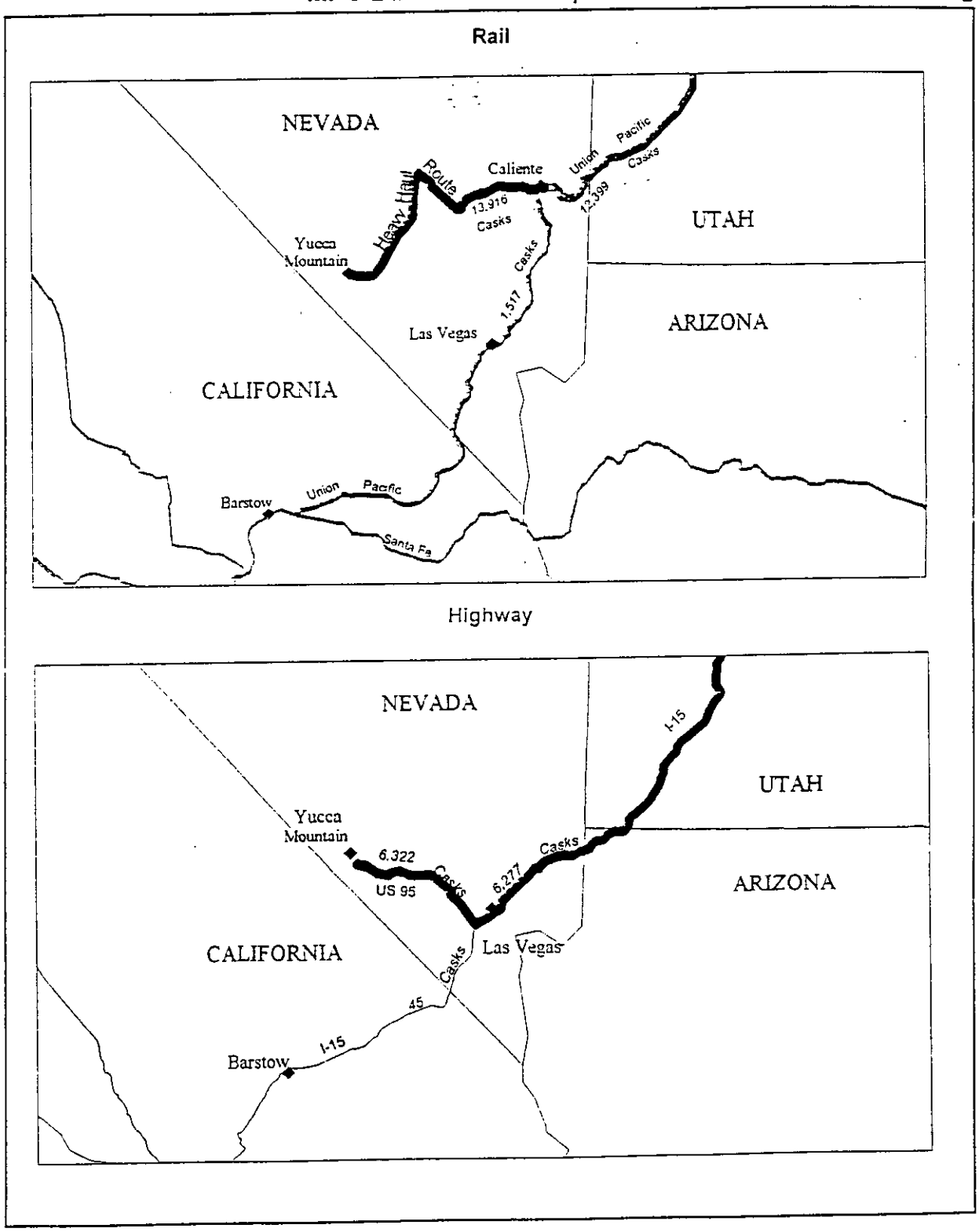


Figure 18-2b (NV). Life of Operations Rail and Highway Cask Shipments in (NV) MPC Base Case Transportation Choices/Consolidated Southern Routing

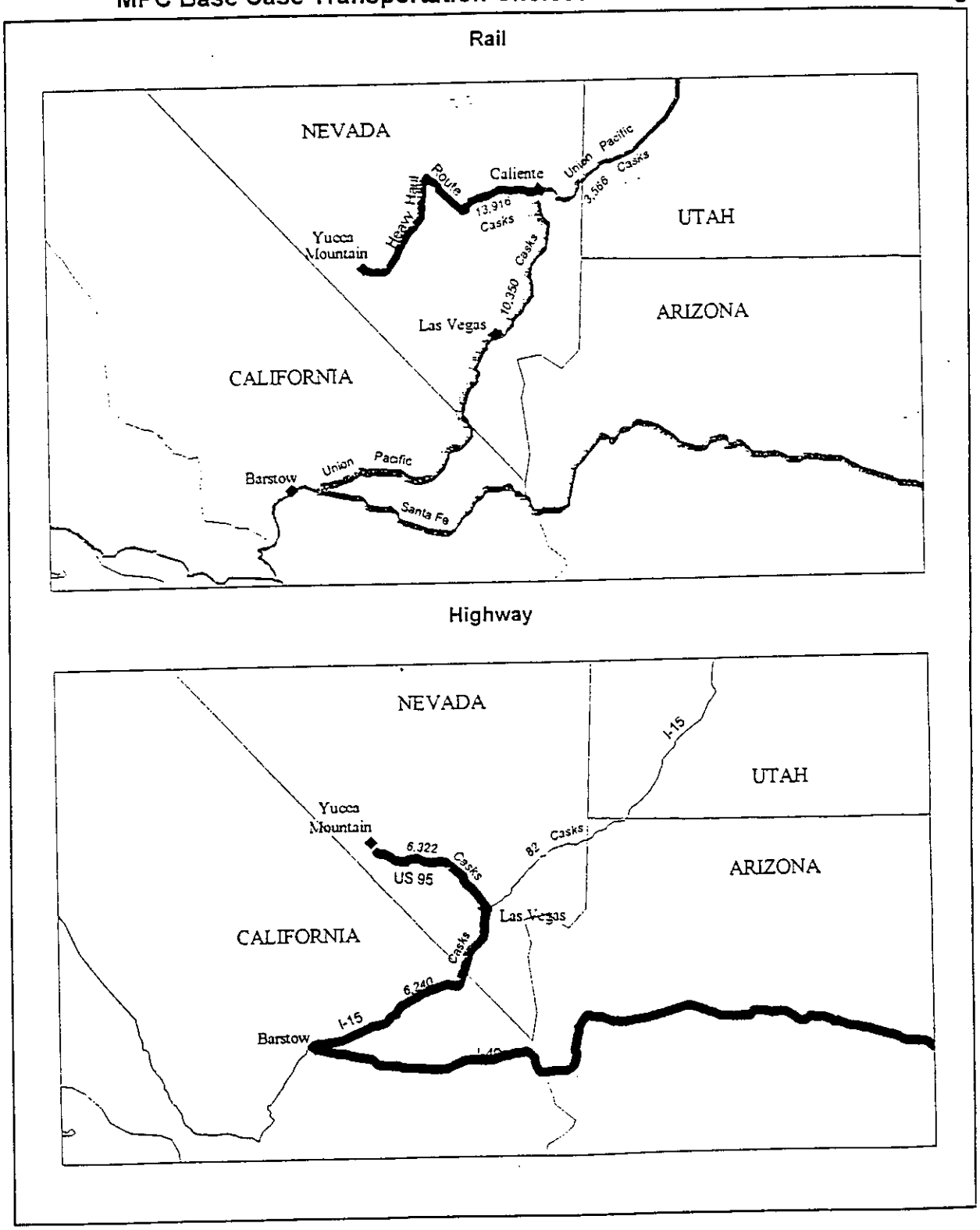


Figure 18-3a. Life of Operations Rail and Highway Cask Shipments Maximum Rail Transportation Choices/Default Routing

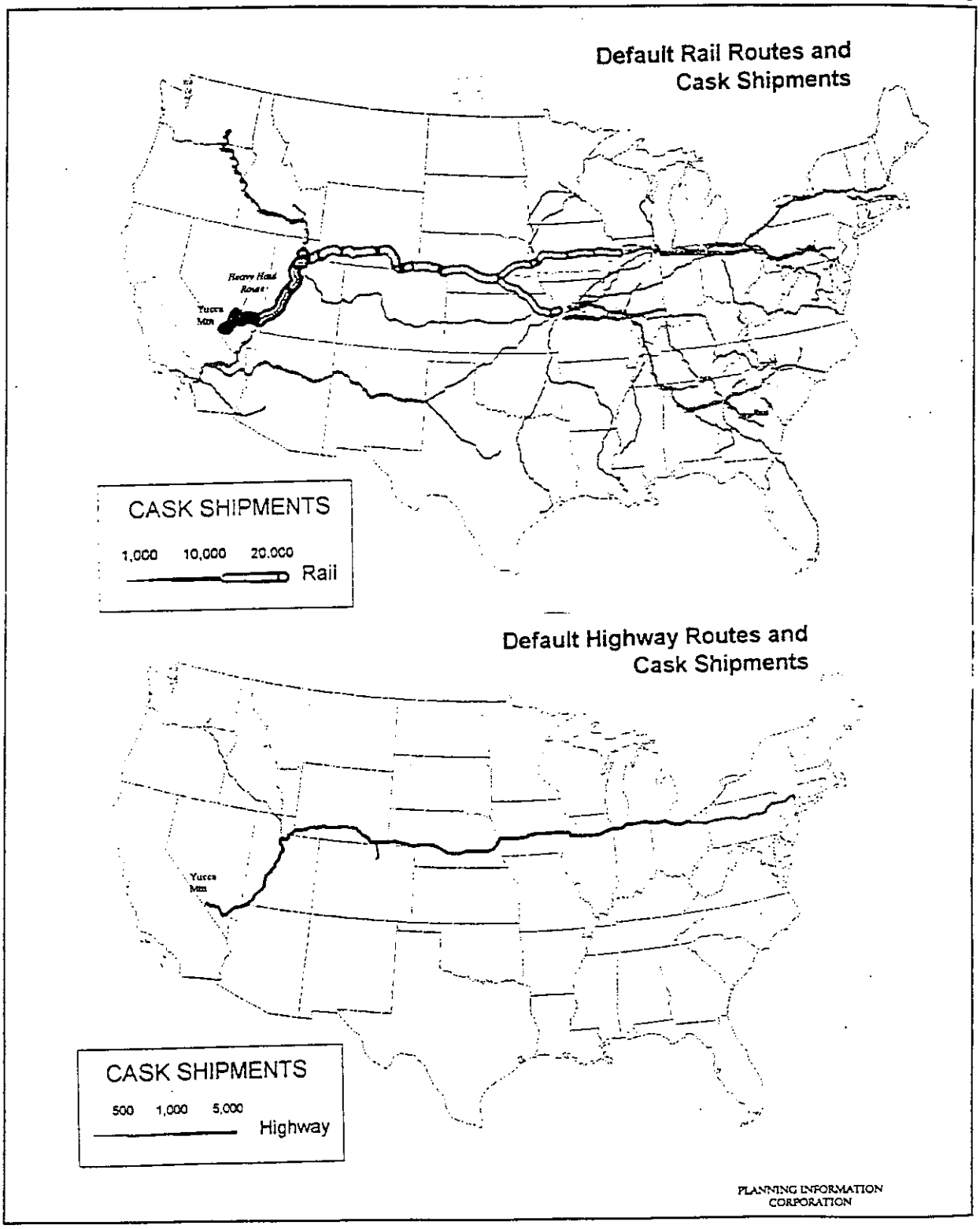


Figure 18-3b. Life of Operations Rail and Highway Cask Shipments Maximum Rail Transportation Choices/Consolidated Southern Routing

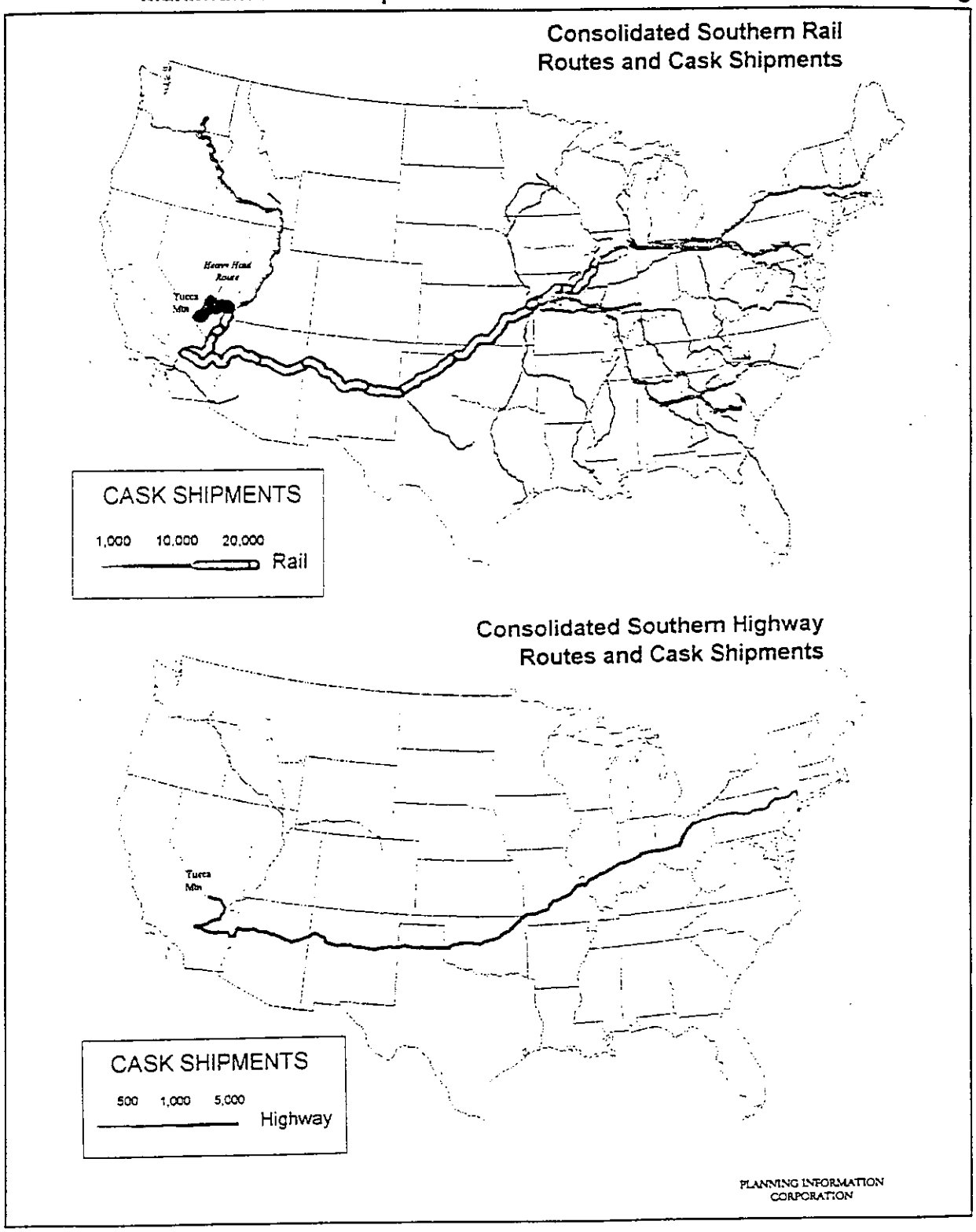


Figure 18-3a (NV). Life of Operations Rail and Highway Cask Shipments in (NV) Maximum Rail Transportation Choices/Default Routing

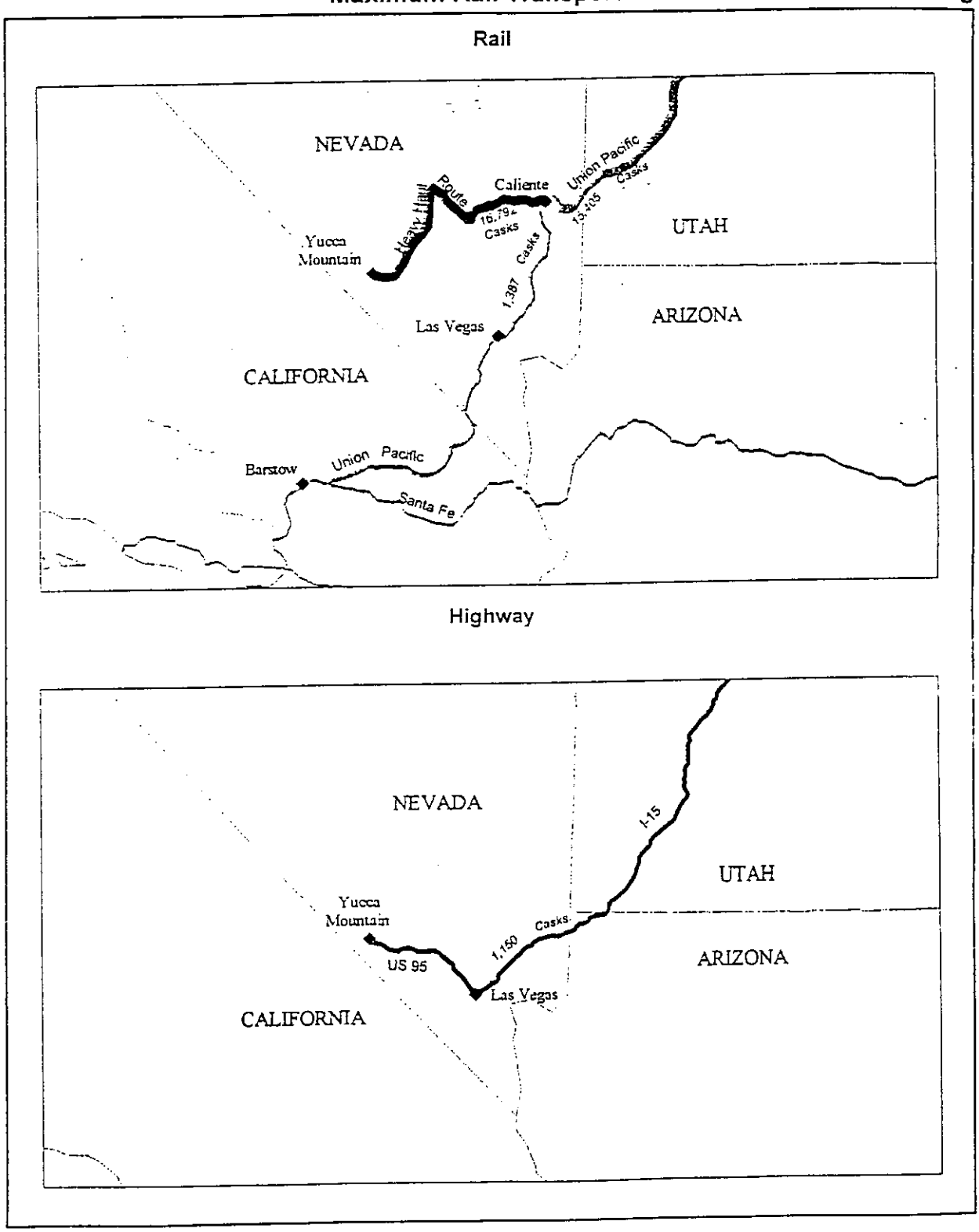
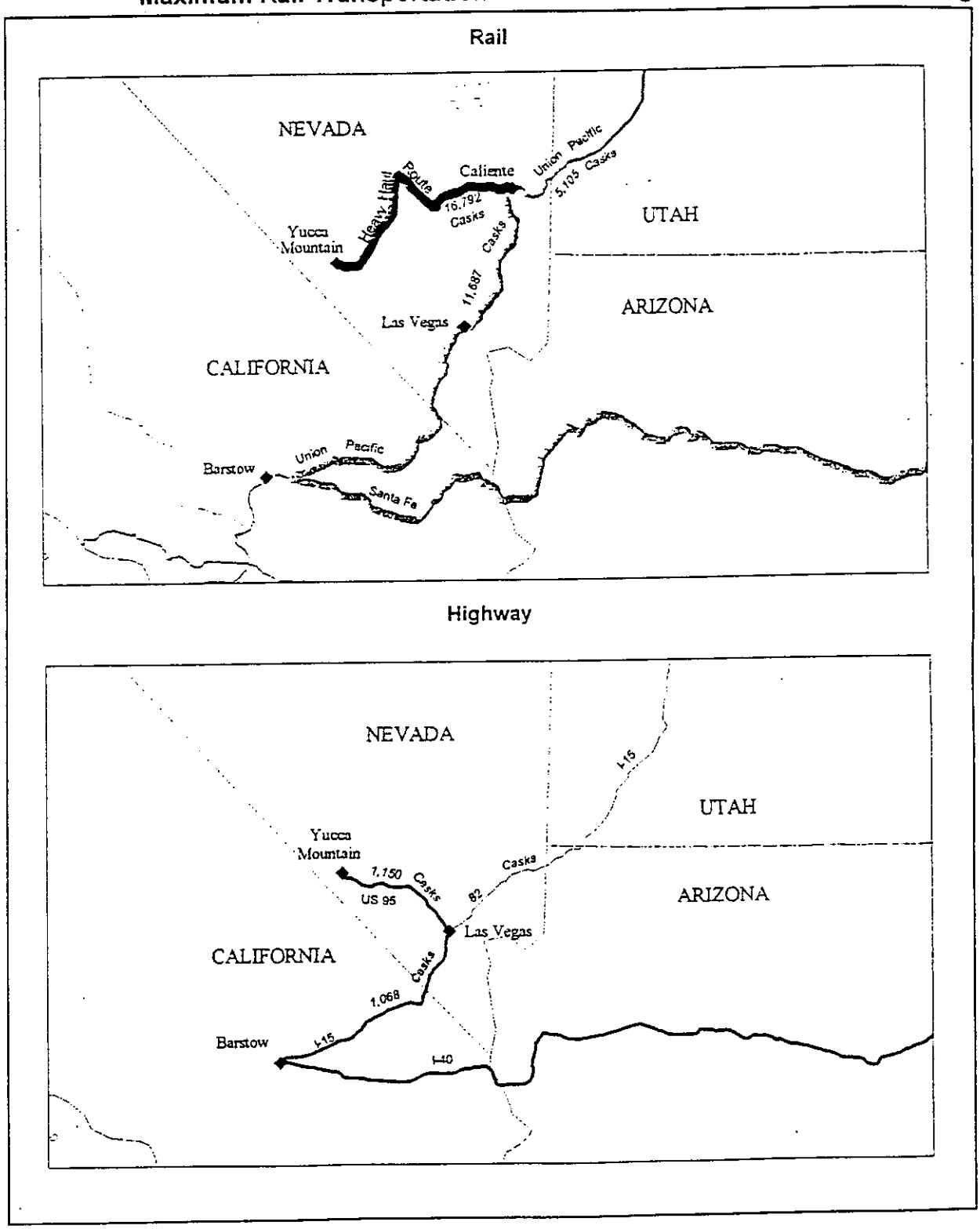


Figure 18-3b (NV). Life of Operations Rail and Highway Cask Shipments in (NV) Maximum Rail Transportation Choices/Consolidated Southern Routing



- One pair of Nevada segments are the Union Pacific line and a segment of I-15 near the Las Vegas Strip. A second pair of Nevada segments are the Union Pacific rail line near the Utah-Nevada border, and a segment of I-15 as it crosses the Moapa Indian Reservation northeast of Las Vegas.

Under all three scenarios of transportation choices (as indicated in Table 18-1), consolidated southern routing would eliminate rail and highway shipments through Wyoming and Colorado, and substantially reduce rail and highway shipments from Utah into Nevada. At the same time, however, consolidated southern routing would substantially increase rail and highway shipments through New Mexico, through California east of Barstow and into Nevada along the Las Vegas Strip. Though not presented in table 17-1, consolidated southern routing has effects further east in the national routing system for SNF and HLW—e.g., in Chicago, Kansas City, and St. Louis. Other routing options would also have systems effects, increasing rail or highway shipments through certain communities, and reducing shipments through others.

Table 18-1. Life of Operations Rail and Highway Cask Shipments Default and Consolidated Southern Routing 5 Rail and 5 Highway Cask Segments

	CURRENT CAPABILITIES			MPC BASE CASE			MAXIMUM RAIL		
	Default Routing	Consol So. Rtg	Change	Default Routing	Consol So. Rtg	Change	Default Routing	Consol So. Rtg	Change
Rail Segments:									
Wyo: UP	8286	0	-8286	9315	0	-9315	11114	0	-11114
Col: SP	362	0	-362	79	0	-79	214	0	-214
NV: UP @ UT line	11485	4077	-7408	12399	3566	-8833	15405	5105	-10300
NM: SF	770	9418	8648	808	10202	9394	631	11959	11328
NV: UP @ LV Strip	1151	8559	7408	1517	10360	8843	1387	11687	10300
Hwy Segments:									
Wyo: I-80	31109	54	-31055	14319	10	-14309	1083	10	-1073
Col: I-70	39496	0	-39496	9877	0	-9877	0	0	0
NV: I-15 @ Moapa	72768	1348	-71420	6277	82	-6195	1150	82	-1068
NM: I-40	3630	74181	70551	0	24186	24186	0	1073	1073
NV: I-15 @ Strip	6577	77997	71420	45	6240	6195	0	1068	1068

19. THE NATIONAL SHIPMENT CAMPAIGN: ANNUAL SHIPMENTS

What are the annual impacts of the national shipment campaign for the nation's network of major railroads and highways? Do the impacts vary from year 1 to year 2, or 3, for example, or from year 1 to year 10 to year 20? These questions are relevant to the planning and management of a national shipment campaign. For example, DOE's May 28, 1996 notice regarding the acquisition of transportation services indicates (pg. 1) that "Initially, spent-fuel delivered to the Federal site would be canistered. . .but at some point* . . . the contractor may be required to handle uncanistered spent-fuel." What modifications in the oldest-fuel-first prioritization for spent fuel acceptance and pickup (see Section 5) would be necessary to limit pickup to canistered fuel in the first two acceptance years?

Another concern is the preparedness of state, local, and tribal officials to manage risk and respond to emergencies associated with SNF and HLW shipments. Compounding this concern is the current Congressional intent to accelerate the first shipments of SNF and HLW, perhaps as early as 1998 or 1999. Further complicating the planning process are the initiatives to privatize the transportation process, through a series of contracts with regional servicing agents (RSAs). Finally, many analysts share the belief that the number of shipments should be reduced by using higher-volume rail and truck containers that are yet to be developed or licensed, and by improvements to waste-handling infrastructure that could be expensive to complete.

The scenarios developed for this assessment reveal significant differences between the overall campaign and its initial shipment years. In the current capabilities scenario, for example, about 35 percent of the MTU would be shipped by truck, a percentage which increases to 66 percent in the initial three shipment years. In the MPC base case scenario of transportation choices, about 11 percent of total MTU would be shipped by truck, a percentage which increases to 27 percent in the initial three shipment years—even more if improvements in loading capacity and/or near-site infrastructure were not implemented with casks available for the startup of the shipment campaign.

Figures 18-1, 18-2 and 18-3 present origin sites and affected rail and highway routes (default routing) under the current capabilities scenario of transportation choices in years 1, 2, and 3 of the prospective shipment campaign. While it is possible that the special arrangements and improvements implied by the MPC base case and maximum rail scenarios could be implemented by year 1, it can also be argued that the current capabilities are likely to be operative in the initial years, regardless of the strategy for the overall shipment campaign.

Figures 18-4 and 18-5 present origin sites and affected rail and highway routes (default routing) in year 20 of the prospective shipment campaign—in this case comparing affected routes and cask shipments under the current capabilities and maximum rail scenarios of transportation choices.

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* RSA Phase C contract years 3-5 (see "Timing of RSA Phases": VU-Graph Presentations for July 9, 1996 Presolicitation Conference, ref 2).

Year 1 Routes and Cask Shipments

Figure 19-1 shows the likely pattern of shipments comprising the 1,200 MTU first-year requirement of S. 1936, assuming the oldest-fuel-first priority acceptance ranking described above. The default routing is essentially unconstrained, as might be developed by an RSA or by DOE contract carriers. Shipments would be made from 8 sites with rail access and 20 sites with truck-only access:

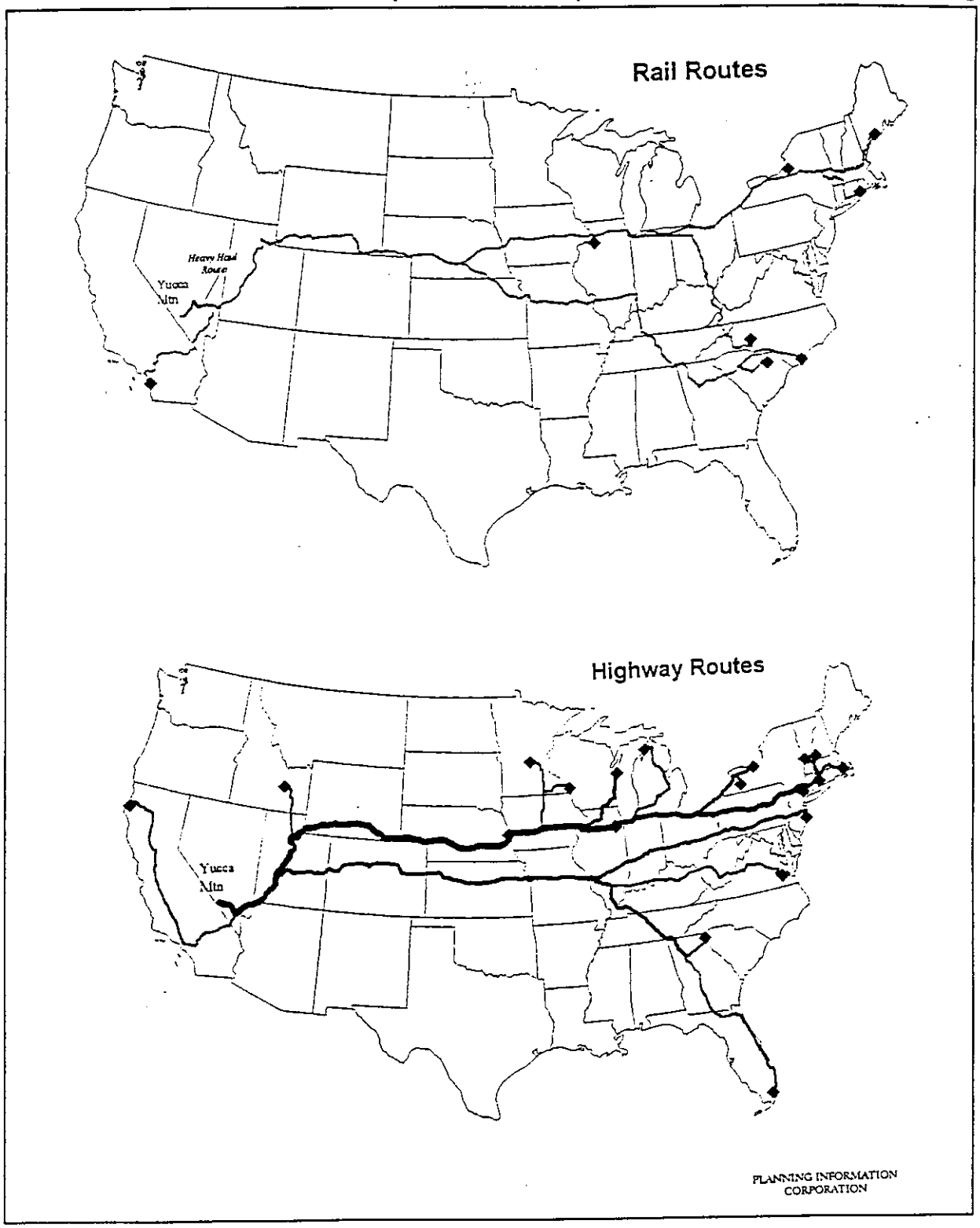
Rail Shipments

Origin	Casks
CA: San Onofre	2
CT: Millstone	12
IL: Quad Cities	7
NC: Brunswick	14
NC: McGuire	2
ME: Maine Yankee	11
NY: Nine Mile Point	15
SC: Robinson	1
TOTAL	64

Truck Shipments

Origin	Casks
CA: Humboldt Bay	87
CT: Haddam Neck	131
FL: Turkey Point	90
ID: INEL	6
IL: Braidwood	9
IL: Dresden	344
IL: Morris	755
MA: Pilgrim	10
MA: Yankee Rowe	73
MI: Big Rock Point	9
MN: Monticello	12
NE: Ft. Calhoun	25
NJ: Oyster Creek	246
NY: Ginna	118
NY: Indian Point	160
NY: West Valley	83
SC: Oconee	35
VA: Surry	44
VT: Vermont Yankee	189
WI: LaCrosse	28
WI: Point Beach	151
TOTAL	2,605

Figure 19-1. Year 1 Cask Shipments by Route and Origin
Current Capabilities Transportation Choices/Default Routing



Year 2 Routes and Cask Shipments

In the second year, the shipment schedule shows an increased number of shipment origin sites (13 railroad, 24 truck), as shown in Figure 19-2. The weight of SNF is the same as in year 2 (at least 1,200 MTU) and the number of casks is somewhat lower than year 1:

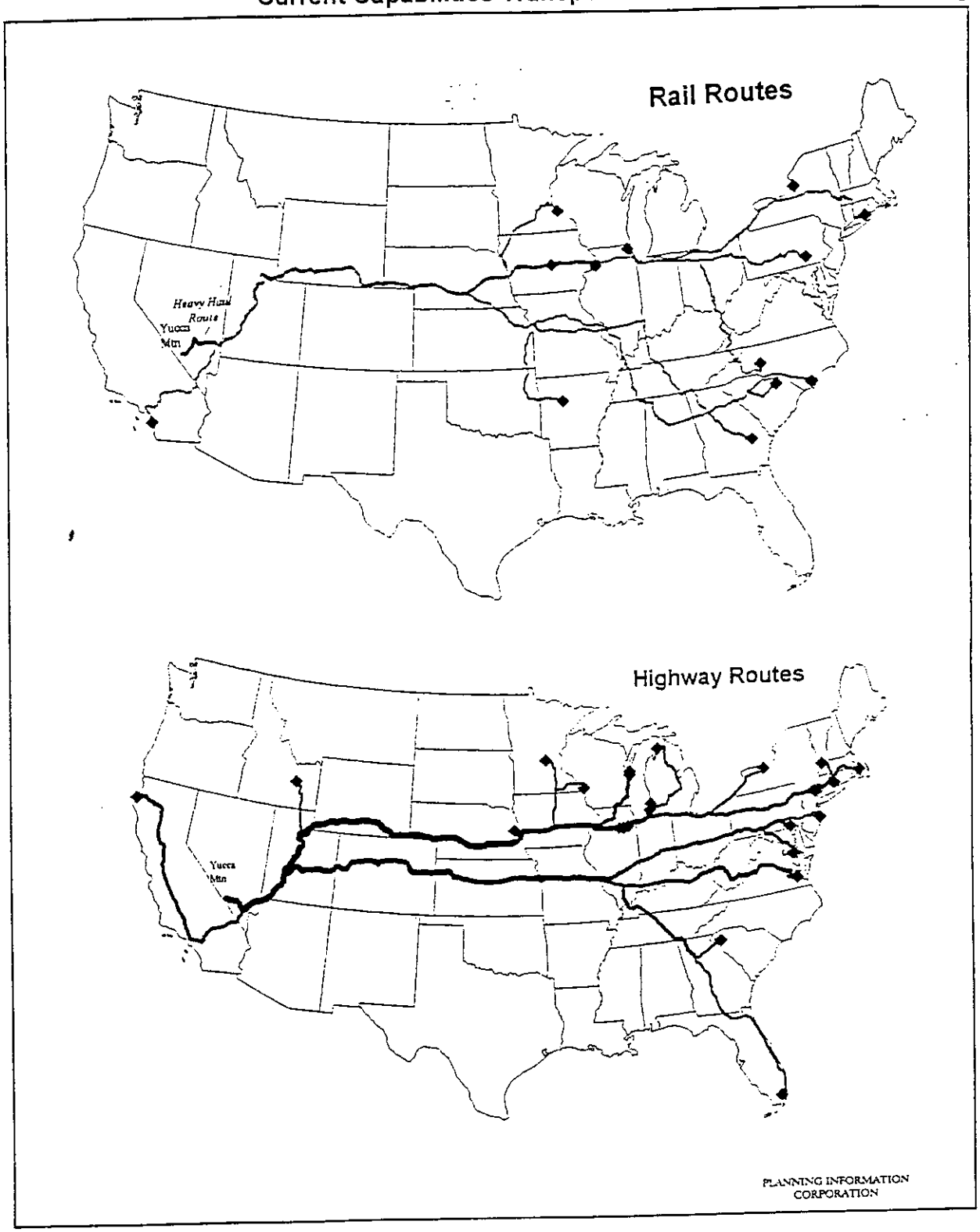
Rail Shipments

Origin	Casks
AR: Arkansas Nuclear	5
CA: San Onofre	2
CT: Millstone	13
GA: Hatch	1
IA: Duane Arnold	8
IL: Quad Cities	21
IL: Zion	9
MN: Prairie Island	6
NC: Brunswick	10
NC: McGuire	9
NY: Nine Mile Point	18
PA: Three Mile Island	3
SC: Robinson	1
TOTAL	106

Truck Shipments

Origin	Casks
CA: Humboldt Bay	109
CT: Haddam Neck	101
FL: Turkey Point	95
ID: INEL	17
IL: Braidwood	11
IL: Dresden	184
IL: Morris	235
MA: Pilgrim	66
MA: Yankee Rowe	40
MD: Calvert Cliffs	32
MI: Big Rock Point	11
MI: Cook	63
MI: Palisades	205
MN: Monticello	13
NE: Ft. Calhoun	36
NJ: Oyster Creek	28
NY: Ginna	37
NY: Indian Point	72
PA: Peach Bottom	187
SC: Oconee	26
VA: Surry	226
WI: Kewaunee	56
WI: LaCrosse	13
WI: Point Beach	119
TOTAL	1,982

Figure 19-2. Year 2 Cask Shipments by Route and Origin
Current Capabilities Transportation Choices/Default Routing



Year 3 Routes and Cask Shipments

In year three, the volume of shipment increases from 1,200 to 2,000 MTU, increasing both the number of casks and the number of shipment sites (18 rail and 27 truck), as shown in Figure 19-3. However, we still assume the current capabilities scenario and unconstrained routing.

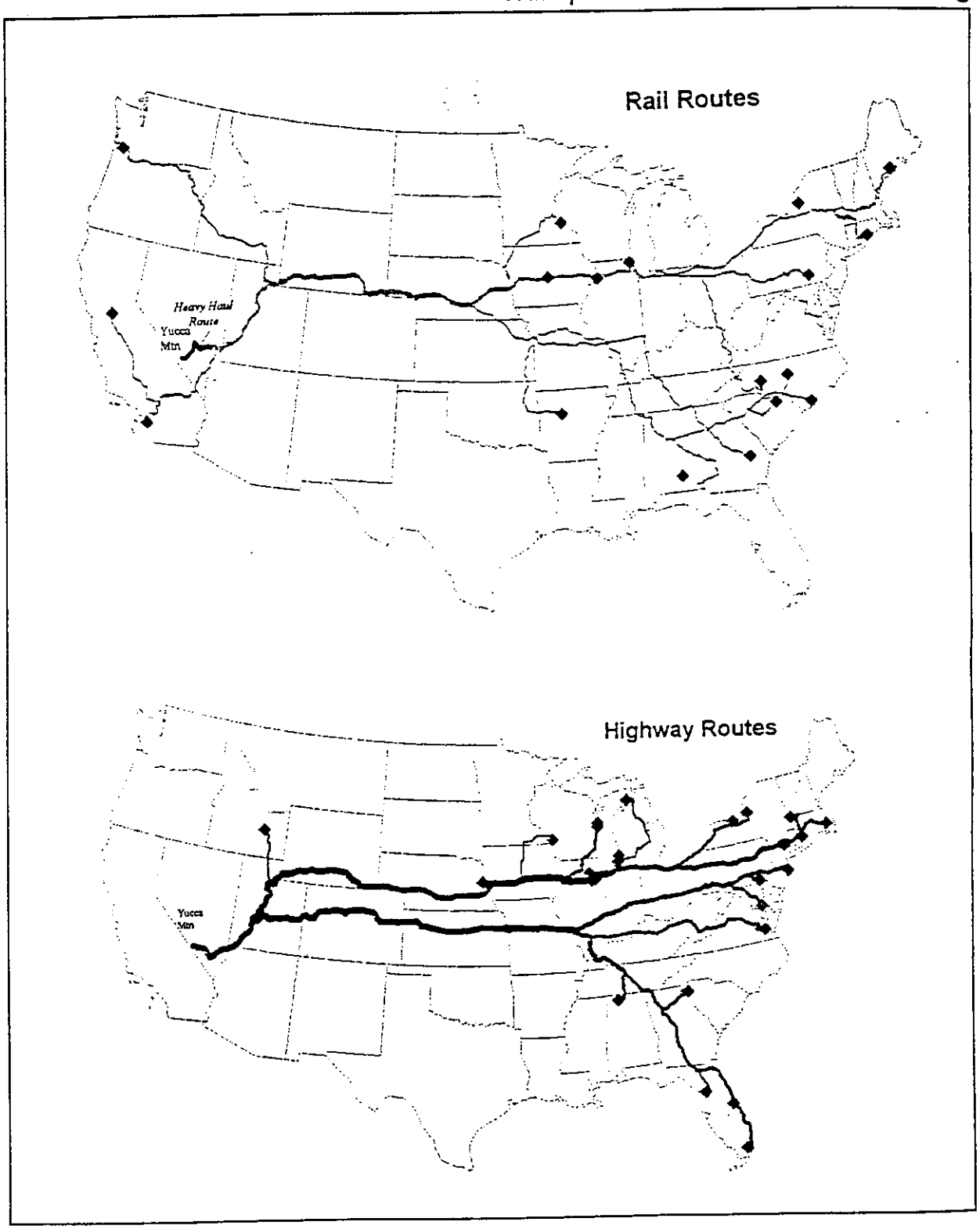
Rail Shipments

Origin	Casks
AL: Farley	3
AR: Arkansas Nuclear	6
CA: Rancho Seco	7
CA: San Onofre	2
CT: Millstone	22
GA: Hatch	1
IA: Duane Arnold	6
IL: Quad Cities	27
IL: Zion	17
ME: Maine Yankee	10
MN: Prairie Island	6
NC: Brunswick	17
NC: Harris	6
NC: McGuire	16
NY: Nine Mile Point	8
OR: Trojan	1
PA: Three Mile Island	15
SC: Robinson	1
TOTAL	171

Truck Shipments

Origin	Casks
AL: Browns Ferry	165
CT: Haddam Neck	100
FL: Crystal River	2
FL: St. Lucie	52
FL: Turkey Point	151
ID: INEL	31
IL: Braidwood	23
IL: Dresden	451
IL: Morris	68
MA: Pilgrim	214
MA: Yankee Rowe	76
MD: Calvert Cliffs	184
MI: Big Rock Point	23
MI: Cook	64
MI: Palisades	68
NE: Ft. Calhoun	96
NJ: Oyster Creek	148
NY: FitzPatrick	134
NY: Ginna	122
NY: Indian Point	124
PA: Peach Bottom	342
SC: Oconee	215
VA: Surry	165
VT: Vermont Yankee	109
WI: Kewaunee	41
WI: LaCrosse	16
WI: Point Beach	125
TOTAL	3,309

Figure 19-3. Year 3 Cask Shipments by Route and Origin Current Capabilities Transportation Choices/Default Routing



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Year 20 Routes and Cask Shipments

After several years, it is possible that the utilities and RSAs (or DOE) would implement changes in containers and transportation infrastructure to improve the efficiency and cost-effectiveness of shipments. Figures 19-4 and 19-5 compare the current capabilities (CCP) and the maximum rail (MXR) scenarios in year 20 of the transportation program postulated in this analysis. Under the CCP scenario, rail shipments would be made from 37 sites and truck shipments from 27 sites; under the MXR scenario, 62 of 64 sites would be rail-capable. Modes are indicated as T1 and T2 for legal weight one- or two-assembly containers, or R75 and R125 for the small and large rail containers.

	CCP Scenario		MXR Scenario	
Origin	Mode	Casks	Mode	Casks
AL: Browns Ferry	T2	112	R125	6
AL: Farley	R125	6	R125	6
AR: Arkansas Nuc.	R75	11	R125	7
AZ: Palo Verde	R125	10	R125	10
CA: Diablo Canyon	T1	213	R125	11
CA: San Onofre	R125	5	R125	5
CT: Haddam Neck	T1	41	R75	4
FL: Crystal River	T1	66	R75	6
FL: St. Lucie	T1	139	R125	8
FL: Turkey Point	T1	88	R125	5
GA: Hatch	R125	10	R125	10
GA: Vogtle	R75	14	R75	14
IA: Duane Arnold	R75	6	R125	3
IL: Braidwood	R75	15	R125	9
IL: Byron	R75	20	R125	12
IL: Dresden	T2	439	R75	43
IL: La Salle	R75	19	R125	10
IL: Quad Cities	R75	15	R75	15
IL: Zion	R75	6	R125	4
KS: Wolf Creek	R125	4	R125	4
LA: River Bend	R125	5	R125	5
LA: Waterford	R125	5	R125	5
MA: Pilgrim	T2	74	R75	8
MD: Calvert Cliffs	T1	81	R125	4
ME: Maine Yankee	R125	3	R125	3
MI: Cook	T1	148	R125	8
MI: Fermi	T2	97	R125	5
MI: Palisades	T1	56	R125	3
MN: Monticello	T2	68	R75	7
MN: Prairie Island	R125	3	R125	3
MS: Grand Gulf	T2	140	R125	7
NC: Brunswick	R125	15	R125	15
NC: Harris	R75	4	R125	3
NC: McGuire	R75	20	R125	7
NE: Ft. Calhoun	T1	43	R75	4
NH: Seabrook	R125	4	R125	4
NJ: Hope Creek	T2	15	R125	7
NJ: Oyster Creek	T2	89	R125	5
NJ: Salem	T1	137	R125	8
NY: FitzPatrick	T2	100	R125	5
NY: Ginna	T1	38	T4	10
NY: Indian Point	T1	139	T4	18
OH: Davis-Besse	R125	3	R125	3
OH: Perry	R125	7	R125	7
PA: Beaver Valley	R75	11	R125	7
PA: Peach Bottom	T2	119	R125	6
PA: Susquehanna	R125	13	R125	13
PA: Three Mile Isld	R75	6	R125	4
SC: Catawba	R125	9	R125	9
SC: Oconee	T1	223	R125	12
SC: Robinson	R75	4	R75	4
SC: Savannah River	R	18	R	18
SC: Summer	R125	4	R125	4
TN: Sequoyah	R75	7	R125	5
TN: Watts Bar	R125	6	R125	6
TX: Comanche Peak	R125	13	R125	13
TX: South Texas	R125	7	R125	7
VA: North Anna	R75	6	R125	3
VA: Surry	T1	107	R125	6
VT: Vermont Yankee	T2	64	R75	7
WA: Hanford	R	143	R	143
WA: WNP	R125	4	R125	4
WI: Kewaunee	T1	37	R125	2
WI: Point Beach	T1	52	R125	4
TOTALS				
Truck		2,925		28
Rail		461		595

Figure 19-4. Year 20 Cask Shipments by Route and Origin Current Capabilities Transportation Choices/Default Routing

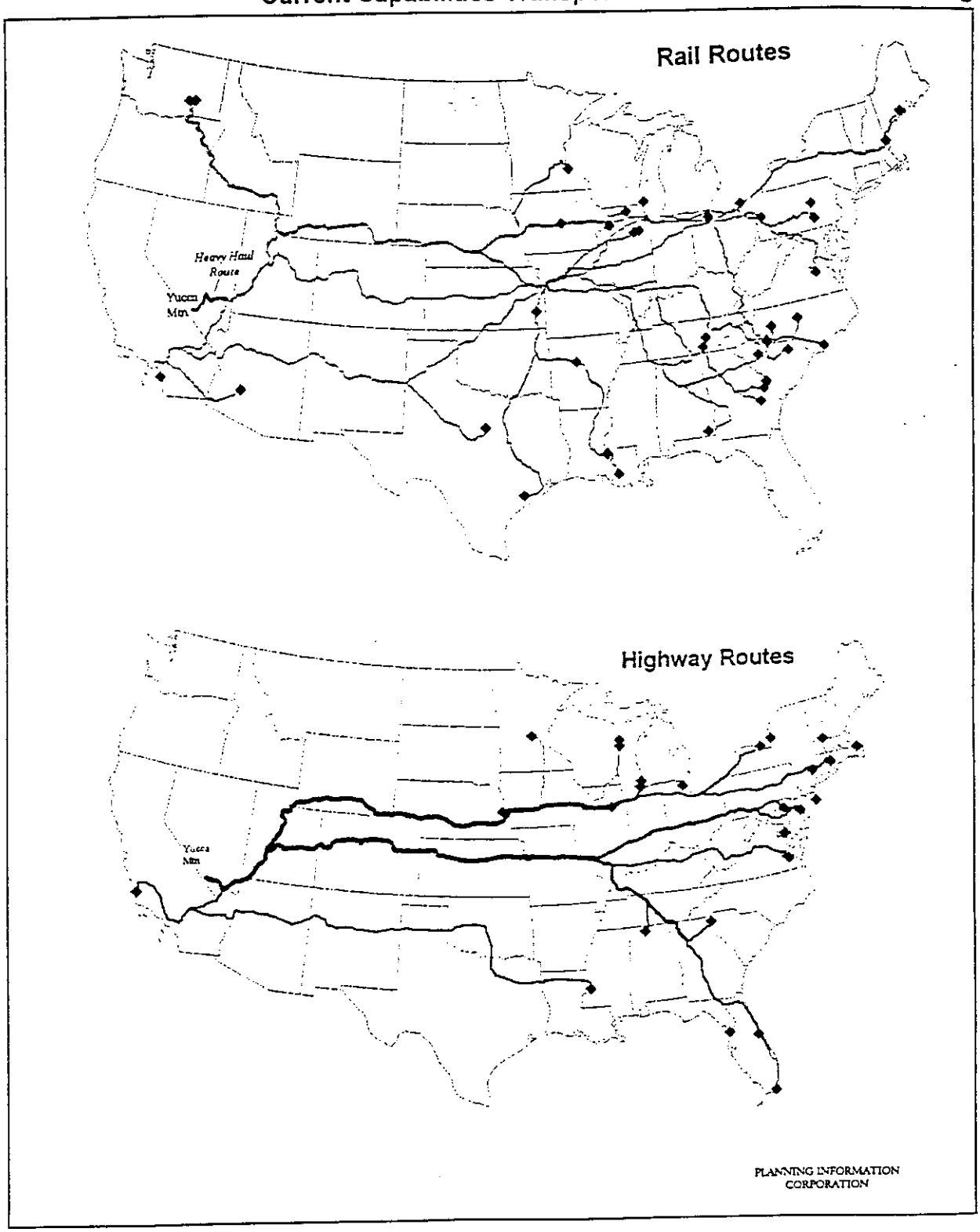
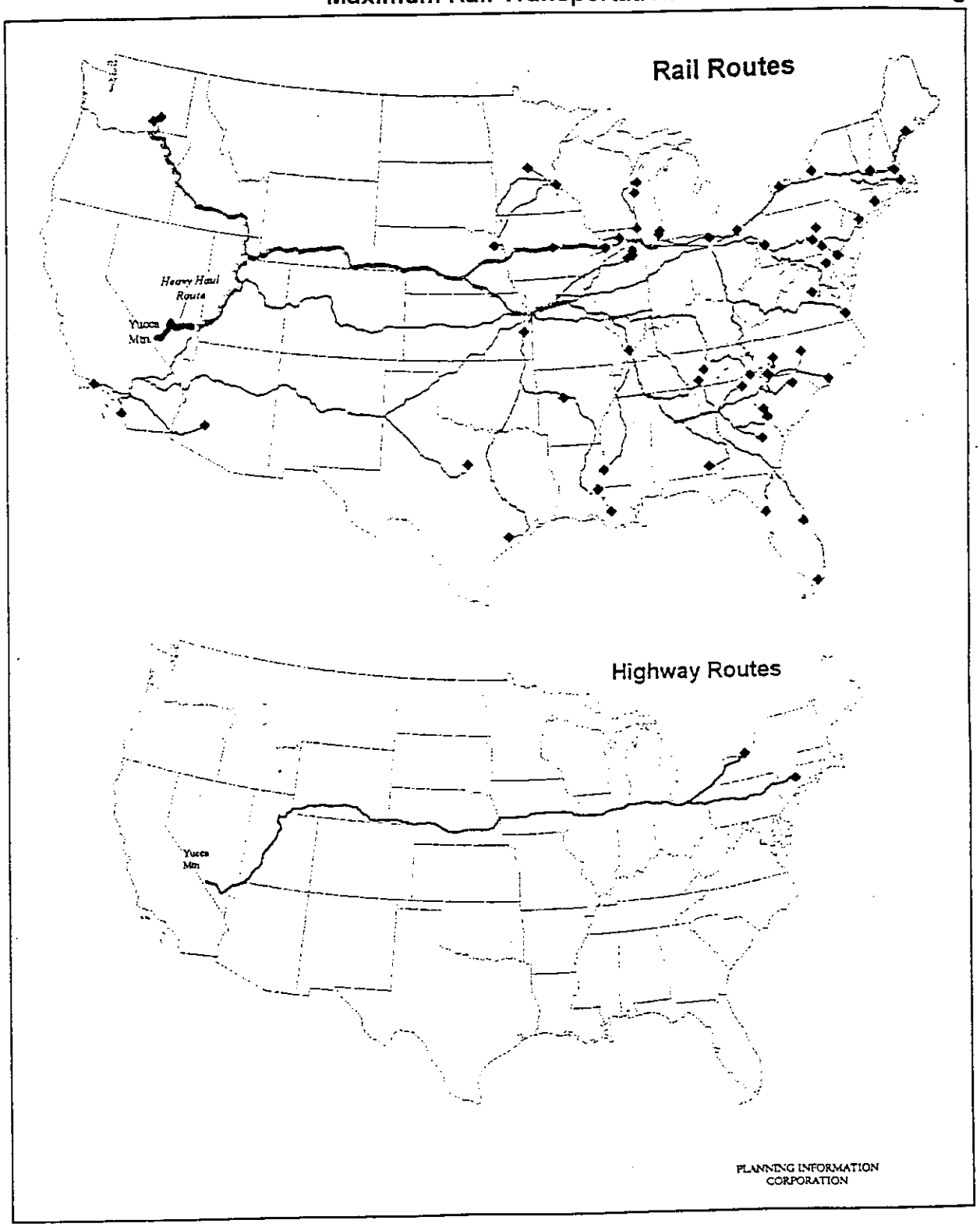


Figure 19-5. Year 20 Cask Shipments by Route and Origin Maximum Rail Transportation Choices/Default Routing



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20. TRANSPORTATION OPERATIONS REQUIREMENTS

Planning and managing a national shipment campaign requires reliable information on total metric tons shipped, total cask shipments, affected rail and highway route mileage, and total cask shipment miles. These variables yield useful indexes for comparing scenarios for the national shipment campaign: e.g., cask shipments per MTU shipped, cask shipments per affected route mile. Presented on an overall basis in this section, these measures may in other contexts be reviewed on a year-by-year or sub-region basis.

MTU Shipped

Given the inventory assumptions discussed in Section 2 above, about 86,600 MTU of SNF would be shipped to a centralized storage facility in Nevada. Given the acceptance rate assumptions discussed in Section 3, about 4,440 MTU would be shipped in the first three acceptance years. Given current capabilities transportation choices discussed in Section 11, about 36 percent of total MTU would be shipped via public highways, about 66 percent in the first three acceptance years. (This assumes, of course, that the centralized storage facility would be capable of receiving legal-weight truck shipments and reloading its bare fuel into storage canisters and casks.) Given the MPC base case scenario of transportation choices, about 11 percent of total MTU would be shipped by public highways, about 27 percent in the first three acceptance years. (This assumes the implementation of policies required to persuade utilities and/or regional servicing agents to upgrade loading facilities and near-site infrastructure.)

Cask Shipments

Given the cask options discussed in Section 6 and the "current capabilities" transportation choices discussed in section 11, about 92,000 cask shipments would be made over the 30-year shipment campaign, of which 86 percent would be on public highways by legal-weight truck. If the high-capacity GA-4/9 legal-weight truck were available and used throughout the shipment campaign, total cask shipments would be reduced to about 31,400, including about 71 percent by legal-weight truck.

During the first three acceptance years, about 8,200 casks shipments should be expected under the current capabilities scenario, almost all (96 percent) by legal-weight truck. Again, the high-capacity GA-4/9 cask, if available and used during the initial years, would reduce cask shipments substantially, from 8,200 to about 2,200. Even so, about 85 percent of the casks shipments would be by legal-weight truck on public highways. The MPC base case scenario of transportation choices, if implemented, would reduce total cask shipments from 92,000 to about 40,000 and the portion involving legal-weight truck shipments on public highways would be reduced from 86 percent to 65 percent. If, in addition, the high-capacity GA-4/9 cask were available and used, total casks shipments could be further reduced to 20,200, and the LWT portion of total cask shipment could be reduced to 31 percent.

Route Miles Affected

Given the transportation choices discussed in Section 11, and the default routing criteria discussed in Section 14, about 18,800 miles of railroad* and about 13,700 miles of public highways would receive shipments of SNF and/or HLW during the national shipment campaign. The MPC base case scenario of transportation choices increases the mileage of railroads impacted, from 18,800 to 21,200, and reduces the mileage of public highways impacted—from 13,700 to about 10,200. Total route mileage, however, is similar in the two cases—about 32,500 rail and highway route miles in the current capabilities scenario versus about 31,400 route miles in the MPC base case.

Route mileage impacted is the basic measure by which DOE proposes to allocate the variable amounts to be distributed to states for training local emergency responders and/or rail and highway inspectors.[25] In addition to a base amount provided to any affected state for planning and coordination, the variable amount would be allocated to response areas of an 80-mile radius, with no double counting of rail or highway routes within a response area (pg. 14). Wyoming, for example, with over 400 I-80 route miles and another 400 miles of UP railroad impacted under default routing, might receive variable funds for 2½ response areas. Nevada, where cask shipments could impact I-15, US-95, and the UP railroad, might receive variable funds for two response areas. The route mileage measure does not reflect the number of casks shipments along particular segments, or the amount of radioactive material in those shipments.

Cask Shipment Miles

Cask shipment miles, the product of cask shipments and distance from each origin site, is a measure which adjusts route mileage for the number of cask shipments expected along each segment. Given the cask options discussed in Section 6 and the current capabilities scenario of transportation choices discussed in Section 11, the national campaign would involve about 76 million cask shipment miles, 5 million in the first three acceptance years. Of these, 82 percent would be legal-weight truck shipments on public highways, 95 percent in the first three acceptance years.

The high-capacity GA-4/9 cask, if available and used, would substantially reduce total cask shipment miles, from 76 to 29 million, and from 5.1 million to 1.4 million over the first three acceptance years. The legal-weight truck portion of total cask shipment miles would be reduced (from 82 to 51 percent, from 95 to 82 percent in the first three acceptance years), but would still comprise a substantial majority of total cask shipment miles.

The MPC base case scenario of transportation choices, if implemented, would further reduce cask shipment miles, from 29 to 21 million and from 1.4 million to 1.0 million over the first three acceptance years. In the process, the legal-weight truck portion of total cask shipment miles would be reduced from 51 percent to about 27 percent, and from 82 percent to 66 percent in the first three acceptance years.

Identified by route segment, information on cask shipment miles would assist state and local officials to estimate route-specific accident and incident rates, allocate shipment monitoring and escorting efforts, estimate radiation exposure for corridor populations, etc.

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* Excluding the 162-mile heavy-haul route from Caliente to Yucca Mountain.

Cask Shipment Miles Per MTU Shipped

Cask shipment miles per MTU shipped is a measure of the amount of radioactive material in shipments expected along particular routes, or along all affected routes. It is one measure of the efficiency of the overall shipment campaign, or of its effects in particular corridor segments.

Given the current capabilities scenario of transportation choices, the average cask shipment mileage per MTU shipped is about 2,400 miles, about 4,300 over the first three acceptance years. On average, each MTU shipped by legal-weight truck requires 5,900 cask shipment miles, compared with about 430 cask shipment miles when shipped by rail.

The high-capacity GA-4/9 cask, if available and used, would substantially reduce cask shipment miles per MTU shipped, from 2,400 to about 820. The reduction reflects the reduction in cask shipment miles required to ship an MTU on public highways by legal-weight truck.

The MPC base case scenario of transportation choices, if implemented, would also effect a substantial reduction in cask shipment miles per MTU shipped. This reduction reflects the mix of rail and truck shipment in the MPC base case scenario. Cask shipment miles per MTU shipped by legal-weight truck is actually higher in the MPC base case than in the current capabilities scenario. Sites which are more difficult to upgrade for rail shipment are among those most distant from the Yucca Mountain destination.

Cask Shipments Per Route Mile Affected

How many cask shipments are expected over each route mile affected by the national shipment campaign? How many cask shipments are expected over particular route segments?

Given the current capabilities scenario of transportation choices (Section 11) and default routing criteria (Section 13) each affected rail route mile should expect about 1,500 rail cask shipments over the 30-year shipment campaign, and each affected highway route mile should expect about 13,400 LWT cask shipments.

The high-capacity GA-4/9 legal-weight truck cask, if available and used, would reduce cask shipments along each affected highway route mile from 13,400 to about 3,200.

The MPC base case scenario of transportation choices would reduce cask shipments along each affected highway route mile from about 13,400 to about 6,500, and shipments along each affected rail route mile (more rail route mileage is affected in the MPC base case) from 1,500 to about 1,460 rail casks.

Table 20-1. MTU Shipped, Cask Shipments, Route Miles Affected Cask Shipment Miles Life of Operations and Shipment Years 1 through 3 . . . Default Routing

	LIFE OF OPERATIONS (YR 1-31).....					SHIPMENT YEARS 1-3.....				
	RAIL	HWY:T1/2	TOT:T1/2	HWY:T4/9	TOT:T4/9	RAIL	HWY:T1/2	TOT:T1/2	HWY:T4/9	TOT:T4/9
MTU SHIPPED:										
Current Capabilities	55593	31045	86638	31045	86638	1495	2944	4439	2944	4439
MPC Base Case	76844	9855	86699	9855	86699	3240	1200	4440	1200	4440
Maximum Rail	84704	1995	86699	1995	86699	4185	255	4440	255	4440
CASK SHIPMENTS:										
Current Capabilities	12636	79345	91981	31370	44006	327	7856	8183	1855	2182
MPC Base Case	13916	26093	40009	6322	20238	574	3352	3926	791	1365
Maximum Rail	16792	4722	21514	1150	17942	781	692	1473	181	962
ROUTE MILES AFFECTED:										
Current Capabilities	18805	13695	32500	13695	32500	18805	13695	32500	13695	32500
MPC Base Case	21210	10224	31434	10224	31434	21210	10224	31434	10224	31434
Maximum Rail	23507	4178	27685	4178	27685	23507	4178	27685	4178	27685
CASK SHIPMENT MILES:MIL										
Current Capabilities	14.0	62.3	76.3	14.7	28.7	0.8	18.2	19.1	4.3	5.1
MPC Base Case	15.3	24.1	39.4	5.7	21.0	1.4	8.2	9.6	1.9	3.3
Maximum Rail	16.8	4.0	20.8	1.0	17.8	1.9	1.7	3.6	0.4	2.4
CASK SHIP MI PER MTU:										
Current Capabilities	425	5892	2384	1391	823	2491	2322	2328	2322	2347
MPC Base Case	345	6749	1073	1593	539	2442	2458	2455	2458	2451
Maximum Rail	362	5790	487	1472	439	2471	2476	2473	2416	2461
CASK SHIP PER RT-MILE:										
Current Capabilities	1496	13356	6493	3154	2194	43	1332	586	314	158
MPC Base Case	1463	6505	3103	1536	1487	75	438	513	103	178
Maximum Rail	1494	2764	1686	703	1375	103	91	194	23	126

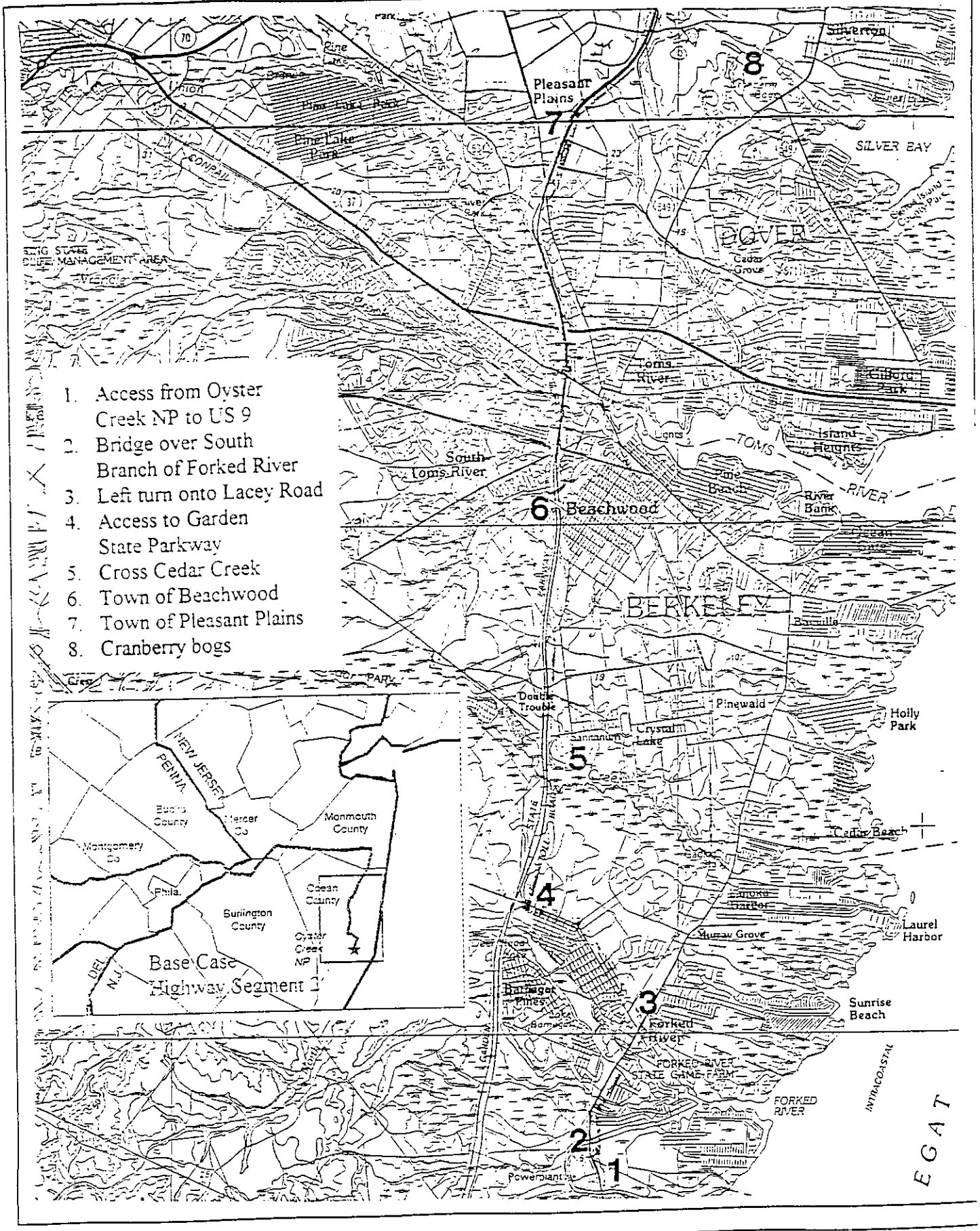
21. ROUTE FEATURES

The routing and cask shipment results presented in Sections 16 through 20 are in a sense only the first part of the information base required in planning and managing a national campaign for shipment of spent fuel and high-level waste. The second part is information regarding key features on or along the routes identified. The "key features" may include:

- Features of the route itself—e.g., bridges, intersections, grades, road geometry.
- Route conditions—e.g., pavement and bridge conditions, average daily and peak traffic flows, traffic service levels, accident rates.
- Route segments particularly affected by seasonal traffic, special event traffic, scheduled construction projects, or seasonal weather conditions.
- Facilities along routes which may require consideration in transportation options—e.g., schools, hospitals, sports stadiums, weighing stations, rest areas.
- Administrative boundaries—e.g., state, county, and city boundaries, state patrol and highway maintenance zones.
- Socioeconomic conditions—e.g., resident population, per capita income, workplace employment.
- Route-segment specific transportation management policies—e.g., state-designated routes, rush hour avoidance zones, designated rest or staging areas, safe havens.

Much of the relevant route-specific information must be assembled from various state and local sources. Other elements may be generated in process, as shippers coordinate with federal, state and local agencies in planning and managing a national shipment campaign. A geographically-referenced information base could help organize information on a complex and evolving array of topics and alternatives in origin and corridor communities, as well as provide a record of segment-specific policies and agreements among relevant stakeholders. The following figure[26] suggests how geographically-referenced information regarding route features might be developed, maintained and shared (in hard-copy or electronic form) among stakeholders in a national shipment campaign.

Figure 21-1. Oyster Creek Highway Route Features



APPENDIX A: TRANSPORTATION CHOICE SCENARIOS: DOE ASSUMPTIONS

While DOE has not estimated annual shipments by route segment, several DOE studies consider transportation choices on a site-by-site basis: a 1996 "preliminary transportation strategy study for a potential Nevada repository",[21] and a 1993 evaluation of the use of MPCs in DOE's high-level waste management system.[22] This appendix reviews the transportation choice assumptions in the two DOE studies, comparing them with those in the scenarios developed for this report.

Transportation Strategy Study 2

This study,[21] prepared as a basis for evaluating transportation options to a potential repository in Nevada, includes in Table F3 an estimate of the number of casks and MTU shipped from each commercial site and the four defense sites over the life of the program. The estimates are not annualized or keyed to proposed acceptance schedules or prioritization policies. Also, while the number of cask shipments is presented, the type of casks shipped is not.

To provide a basis for comparison, we have estimated the types of casks implied by Table F3 of DOE's Transportation Strategy Study 2 (see Table A-2): Data on the number of assemblies and MTU at each reactor was assembled (Ref #13, Table B6), aggregated for shipment sites, and used to calculate the average MTU per assembly at each site. The number of assemblies implied by the MTU in Table F3 was estimated by dividing MTU by the average MTU per assembly. The implied assemblies per cask was estimated by dividing assemblies by the number of casks identified in Table F3. The type of casks implied by Table F3 was identified by comparing estimated assemblies per cask with the capacity (in PWR or BWR assemblies) of small and large MPCs.

DOE's Transportation Strategy Study 2 implies that 11 sites which ship by truck in Nevada's MPC Base Case would instead ship by rail: Sites in columns 1 and 2 below would ship by small MPC, while those in column 3 would ship by large MPC.

Big Rock	LaCrosse	Palisades
Crystal River	Pilgrim	Peachbottom
Fort Calhoun	Vermont Yankee	St. Lucie
Humboldt Bay	Yankee Rowe	

Also, DOE's Transportation Strategy 2 implies that Three Mile Island would ship by large MPC, rather than by small MPC, as assumed in Nevada's MPC base case.

The transportation choices implied by DOE's study are, with the exception of a single site (Haddam Neck, assumed to ship by truck in the DOE study), identical to the "maximum rail scenario" discussed in Section 11 above, and could be implemented only through a set of incentives such as those discussed in the maximum rail scenario. Compared to Nevada's MPC base case, the transportation choices implied by DOE's study would significantly reduce highway impacts and total cask shipments, in the process increasing reliance on rail shipment. However, the necessary investments to improve cask

loading capabilities and near-site infrastructure could be greater than those required under the MPC base case scenario of transportation choices, and substantially greater than under the current capabilities scenario.

Evaluation of Using MPCs

This study,[22] prepared as part of DOE's MPC initiative, includes in Appendix D a set of shipment projections "based on the assumption that individual utilities will request the largest cask they can effectively handle" (page D-1). The study did not include shipments of HLW or spent fuel from defense sites. Nor did it explain the basis for its judgement that 83 storage locations could effectively handle a large MPC, while 19 could effectively handle a small MPC, and only 14 require canistered truck shipments. Perhaps it refers to locations that, with incentives, could be upgraded to effectively handle the cask types specified. The study did consider storage locations, reaching different judgements for storage locations at the same site (e.g., Millstone 1 versus Millstone 2 and 3, San Onofre 1 versus San Onofre 2 and 3, St. Lucie 1 versus St. Lucie 2).

The MPC evaluation assumes ten storage locations would ship by truck (or require special handling: heavy-haul, cask-to-cask transfer, barge) which the transportation strategy study assumes will be shipped by rail:

Big Rock	Humboldt Bay	Callaway
Dresden 1	LaCrosse	Oconee
Fort Calhoun	Yankee Rowe	Point Beach
		San Onofre 1

The transportation strategy study assumes that the locations in columns 1 and 2 above would ship by small MPC, while those in column 3 would ship by large MPC.

The 1993 MPC evaluation and the 1996 transportation strategy study reach differing rail cask conclusions at thirteen sites:

Arkansas Nuclear	Rancho Seco	Brunswick
Duane Arnold	Salem	Dresden 2 and 3
Oyster Creek	Three Mile Island 1	Quad Cities
Palisades	Turkey Point	Robinson
		Vogtle

The transportation strategy study assumes that the locations in columns 1 and 2 would ship by large rail; the MPC evaluation assumes these locations would ship by small rail. The transportation strategy study assumes that the locations in column 3 would ship by small rail; the MPC evaluation assumes these locations would ship by large rail.

Table A-1. Utility Transportation Choice Scenarios: by Storage Location

	FUEL STRG LOCATION:	TRANSP CHOICE: TS2	APD
1	ARKANSAS NUCLEAR 1	R125	R75
2	ARKANSAS NUCLEAR 2	R125	R75
3	ARKANSAS NUCLEAR DRY STRG	R125	R75
4	BEAVER VALLEY 1	R125	R125
5	BEAVER VALLEY 2	R125	R125
6	BELLEFONTE 1	R125	R125
7	BELLEFONTE 2	R125	R125
8	BIG ROCK 1	R75	LWT
9	BRAIDWOOD 1	R125	R125
10	BROWNS FERRY 1-2	R125	R125
11	BROWNS FERRY 3	R125	R125
12	BRUNSWICK 1	R75	R125
13	BRUNSWICK 1 PWR POOL	R75	R125
14	BRUNSWICK 2	R75	R125
15	BRUNSWICK 2 PWR POOL	R75	R125
16	BYRON 1	R125	R125
17	CALLAWAY 1	R125	LWT
18	CALVERT CLIFFS 1-2	R125	R125
19	CALVERT DRY STORAGE	R125	R125
20	CATAWBA 1	R125	R125
21	CATAWBA 2	R125	R125
22	CLINTON 1	R125	R125
23	COMANCHE PEAK 1	R125	R125
24	COOK 1	R125	R125
25	COOPER STATION	R75	R75
26	CRYSTAL RIVER 3	R75	R75
27	DAVIS-BESSE 1	R125	R125
28	DAVIS-BESSE DRY STRG	R125	R125
29	DIABLO CANYON 1	R125	R125
30	DIABLO CANYON 2	R125	R125
31	DRESDEN 1	R75	LWT
32	DRESDEN 2	R75	R125
33	DRESDEN 3	R75	R125
34	DUANE ARNOLD	R125	R75
35	ENRICO FERMI 2	R125	R125
36	FARLEY 1	R125	R125
37	FARLEY 2	R125	R125
38	FITZPATRICK	R125	R125
39	FORT CALHOUN	R75	LWT
40	FORT ST VRAIN	LWT	LWT
41	FORT ST VRAIN DRY STRG	LWT	LWT
42	GINNA	LWT	LWT
43	GRAND GULF 1	R125	R125
44	HADDAM NECK	LWT	LWT
45	HARRIS 1	R125	R125
46	HARRIS 1 BWR POOL	R125	R125
47	HATCH 1-2	R125	R125
48	HOPE CREEK	R125	R125
49	HUMBOLDT BAY	R75	LWT
50	INDIAN POINT 1	LWT	LWT
51	INDIAN POINT 2	LWT	LWT
52	INDIAN POINT 3	LWT	LWT
53	KEWAUNEE	R125	R125
54	LACROSSE	R75	T
55	LASALLE 1-2	R125	R125
56	LIMERICK 1-2	R125	R125
57	MAINE YANKEE	R125	R125
58	MCGUIRE 1	R125	R125
59	MCGUIRE 2	R125	R125
60	MILLSTONE 1	R75	R75
61	MILLSTONE 2	R75	R75
62	MILLSTONE 3	R75	R125
63	MONTICELLO	R75	R75
64	NINE MILE POINT 1	R125	R125
65	NINE MILE POINT 2	R125	R125
66	NORTH ANNA 1&2	R125	R125
67	NORTH ANNA DRY STRG	R125	R125
68	OCONEE 1&2	R125	LWT
69	OCONEE 3	R125	LWT
70	OCONEE DRY STORAGE	R125	LWT
71	OYSTER CREEK 1	R125	R75
72	OYSTER CREEK DRY STRG	R125	R75
73	PALISADES	R125	R75
74	PALISADES DRY STORAGE	R125	R75
75	PALO VERDE 1	R125	R125
76	PALO VERDE 2	R125	R125
77	PALO VERDE 3	R125	LWT
78	PEACHBOTTOM 2	R125	LWT
79	PEACHBOTTOM 3	R125	LWT
80	PERRY 1	R125	R125
81	PILGRIM 1	R75	R75
82	POINT BEACH 1&2	R125	R125
83	POINT BEACH DRY STRG	R125	R125
84	PRAIRIE ISLAND 1&2	R125	R125
85	PRAIRIE ISLAND DRY STRG	R125	R125
86	QUAD CITIES 1	R75	R125
87	RANCHO SECO 1	R125	R75
88	RANCHO SECO DRY STRG	R125	R75
89	RIVER BEND 1	R125	R125
90	ROBINSON 2	R75	R125
91	ROBINSON DRY STORAGE	R75	R125
92	SALEM 1	R125	R75
93	SALEM 2	R125	R75
94	SAN ONOFRE 1	R125	LWT
95	SAN ONOFRE 2	R125	R125
96	SAN ONOFRE 3	R125	R125
97	SEABROOK 1	R125	R125
98	SEQUOYAH 1	R125	R125
99	SHOREHAM	NA	NA
100	SOUTH TEXAS 1	R125	R125
101	SOUTH TEXAS 2	R125	R125
102	ST LUCIE 1	R125	R125
103	ST LUCIE 2	R125	R125
104	SUMMER 1	R125	R125
105	SURRY 1&2	R125	R125
106	SURRY DRY STORAGE	R125	R125
107	SUSQUEHANNA 1-2	R125	R125
108	SUSQUEHANNA DRY STRG	R125	R125
109	THREE MILE ISLAND 1	R125	R75
110	TROJAN	R125	R125
111	TURKEY POINT 3	R125	R75
112	TURKEY POINT 4	R125	R75
113	VERMONT YANKEE 1	R75	R75
114	VOGTLE 1-2	R75	R125
115	WASH NUCLEAR 2	R125	R125
116	WATTS BAR 1&2	R125	R125
117	WATERFORD 3	R125	R125
118	WOLF CREEK 1	R125	R125
119	YANKEE-ROWE 1	R75	LWT
120	ZION 1&2	R125	R125
121	HANFORD SNF STRG	LWT	LWT
122	HANFORD SNF STRG	LWT	LWT
123	INEL SNF STRG	LWT	LWT
124	INEL SNF STRG	LWT	LWT
125	INEL SNF STRG	LWT	LWT
126	SAVANNAH RV SNF STRG	LWT	LWT
127	SAVANNAH RV SNF STRG	LWT	LWT
128	WEST VALLEY SNF STRG	R125	LWT
129	WEST VALLEY SNF STRG	R125	LWT
130	MORRIS	R125	R125
131	MORRIS	R125	R125
132	GENERAL ATOMICS	LWT	LWT

Shipment Cask Options: R125: Large MPC for up to 21 PWR or 40 BWR
R75: Small MPC for up to 12 PWR or 24 BWR
LWT: Legal-weight truck casks.... GA-4/9 if a NLI-1/2 or NAC LWT otherwise

Transp Choice: TR2: NV Transp Strategy, Study 2 (DOE: Feb'96, Tbl F-3), PIC
APD: MPC Prelim Evaluation (DOE: Mar 1993, Appendix D)

Table A-2. Cask Types Implied by DOE's Transportation Strategy Study 2

SITE#	NUCLEAR REACTOR SITES:	DOE TR2:TBL F3 CASKS	DOE TR2:TBL F3 MTU	PIC EVALUATION: REAC TYPE	PIC EVALUATION: MTU/A	PIC EVALUATION: A/CASK	PIC EVALUATION: EST C-TYPE
1	ARKANSAS NUCLEAR 1,2	128	1151	PWR	0.44	20	R125
2	BEAVER VALLEY 1,2	106	1015	PWR	0.46	21	R125
3	BELLEFONTE 1,2	0	0	PWR	NA	NA	???
4	BIG ROCK	40	63	BWR	0.13	12	R75
5	BRAIDWOOD 1,2	119	1049	PWR	0.42	21	R125
6	BROWNS FERRY 1,2,3	210	1537	BWR	0.19	39	R125
7	BRUNSWICK 1,2	207	915	BWR	0.18	24	R75
8	BYRON 1,2	130	1147	PWR	0.42	21	R125
9	CALLAWAY 1	75	640	PWR	0.44	19	R125
10	CALVERT CLIFFS 1,2	145	1143	PWR	0.38	21	R125
11	CATAWBA 1,2	128	1193	PWR	0.43	22	R125
12	CLINTON 1	65	453	BWR	0.18	38	R125
13	COMANCHE PEAK 1,2	105	918	PWR	0.45	19	R125
14	COOK 1,2	146	1350	PWR	0.44	21	R125
15	COOPER STATION	106	458	BWR	0.19	23	R75
16	CRYSTAL RIVER 3	89	491	PWR	0.46	12	R75
17	DAVIS-BESSE 1	58	509	PWR	0.47	19	R125
18	DIABLO CANYON 1,2	133	1191	PWR	0.45	20	R125
19	DRESDEN 1,2,3	355	1424	BWR	0.17	23	R75
20	DUANE ARNOLD	64	457	BWR	0.18	39	R125
21	ENRICO FERMI 2	77	501	BWR	0.18	36	R125
22	FARLEY 1,2	123	1140	PWR	0.46	20	R125
23	FITZPATRICK	73	519	BWR	0.18	39	R125
34	FORT CALHOUN	89	381	PWR	0.36	12	R75
25	FORT ST VRAIN	???	???	HTG	0.01	NA	LWT
26	GINNA	???	???	PWR	0.38	NA	LWT
27	GRAND GULF 1	121	852	BWR	0.18	39	R125
28	HADDAM NECK	???	???	PWR	0.41	NA	LWT
29	HARRIS 1	69	553	PWR	0.45	19	R125
29	HARRIS 1 BWR POOL	???	???	BWR	0.19	NA	R125
30	HATCH 1,2	184	1332	BWR	0.18	39	R125
31	HOPE CREEK	101	717	BWR	0.19	38	R125
32	HUMBOLDT BAY	17	29	BWR	0.07	23	R75
33	INDIAN POINT 1,2,3	???	???	PWR	0.43	NA	LWT
34	KEWAUNEE	59	466	PWR	0.39	21	R125
35	LACROSSE	14	38	BWR	0.11	24	R75
36	LASALLE 1,2	176	1262	BWR	0.18	39	R125
37	LIMERICK 1,2	165	1129	BWR	0.18	37	R125
38	MAINE YANKEE	91	717	PWR	0.38	21	R125
39	MCGUIRE 1,2	151	1419	PWR	0.44	22	R125
40	MILLSTONE 1,2,3	347	1734	BWR	0.26	19	R75
41	MONTICELLO	95	394	BWR	0.18	23	R75
42	NINE MILE POINT 1,2	148	1030	BWR	0.19	38	R125
43	NORTH ANNA 1,2	131	1149	PWR	0.46	19	R125
44	OCONEE 1,2,3	204	1897	PWR	0.46	20	R125
45	OYSTER CREEK 1	92	651	BWR	0.18	39	R125
46	PALISADES	69	575	PWR	0.40	21	R125
47	PALO VERDE 1,2,3	204	1687	PWR	0.41	20	R125
48	PEACHBOTTOM 2,3	225	1602	BWR	0.18	38	R125
49	PERRY 1	86	605	BWR	0.18	38	R125
50	PILGRIM 1	117	506	BWR	0.19	23	R75
51	POINT BEACH 1,2	107	837	PWR	0.39	20	R125
52	PRAIRIE ISLAND 1,2	106	807	PWR	0.38	20	R125
53	QUAD CITIES 1,2	314	1347	BWR	0.18	23	R75
54	RANCHO SECO 1	24	228	PWR	0.46	21	R125
55	RIVER BEND 1	69	488	BWR	0.18	38	R125
56	ROBINSON 2	70	345	PWR	0.44	11	R75
57	SALEM 1,2	123	1136	PWR	0.46	20	R125
58	SAN ONOFRE 1,2,3	175	1469	PWR	0.40	21	R125
59	SEABROOK 1	47	439	PWR	0.46	20	R125
60	SEQUOYAH 1,2	103	979	PWR	0.46	21	R125
61	SHOREHAM	0	0	BWR	NA	NA	NA
62	SOUTH TEXAS 1,2	76	808	PWR	0.54	20	R125
63	ST. LUCIE 1,2	147	1151	PWR	0.38	21	R125
64	SUMMER 1	59	525	PWR	0.45	20	R125
65	SURRY 1,2	120	1085	PWR	0.46	20	R125
66	SUSQUEHANNA 1,2	211	1470	BWR	0.18	39	R125
67	THREE MILE ISLAND 1	56	523	PWR	0.46	20	R125
68	TROJAN	38	359	PWR	0.46	21	R125
69	TURKEY POINT 3,4	107	1011	PWR	0.46	21	R125
70	VERMONT YANKEE 1	138	602	BWR	0.18	24	R75
71	VOGTLE 1,2	218	1024	PWR	0.46	10	R75
72	WASHINGTON NUCLEAR 2,3	81	555	BWR	0.18	38	R125
73	WATERFORD 3	75	597	PWR	0.41	19	R125
74	WATTS BAR 1,2	32	300	PWR	0.46	20	R125
75	WOLF CREEK 1	63	575	PWR	0.46	20	R125
76	YANKEE-ROWE 1	45	127	PWR	0.24	12	R75
77	ZION 1,2	144	1375	PWR	0.46	21	R125
	Sub-Total	8385	60195		0.28	25	

REFERENCES

1. DOE/OCRWM Notice of Proposed Policy and Procedures (May 10, 1996)
   Safe Transportation and Emergency Response Training: Technical Assistance and Funding.

2. DOE/OCRWM Waste Acceptance, Storage and Transportation
   Notice and request for expression of interest and comments (May 28, 1996)
   Draft Concept of Operations: Waste Acceptance, Storage and Transportation (June 1996).
   Draft Statement of Work: Waste Acceptance and Transportation Services (June 1996).

3. 1992 Acceptance Priority Ranking: Revision 1 (May 1993)
   DOE/RW-0419 (through December 31, 1991)

   1994 Acceptance Priority Ranking: (March 1995)
   DOE/RW-0457 (through December 31, 1993)

   1995 Acceptance Priority Ranking: (May 1996)
   Unpublished (through November 28, 1994)

4. Spent Fuel Storage Requirements: 1994-2042 (June 1995)
   DOE/RW-0432-Revision 1

5. Integrated Data Base - 1994 (September 1995)
   DOE/RW, Revision 11 (Table 2.7)

6. Aging Nuclear Power Plants: Managing plant Life and Decommissioning U.S. Office of Technology Assessment (September 1993) OTA-E-575.

7. Draft Waste Management Programmatic EIS for Managing, Treatment, Storage, and Disposal of Radioactive and Hazardous Waste.
   DOE/EIS-0200-D (August 1995, Vol I, pp. 9-12).

8. DOE Programmatic Spent Nuclear Fuel Management FEIS (April 1995)
   DOE/EIS-0203-F Volume 1 (Tables 1-1 and 1-2).

9. DOE Final Interpretation of Nuclear Waste Acceptance Issues
   DOE/OCRWM April 28, 1995.

10. Petition for Declaratory Judgement and Review of Final Decision of USDOE: Reply Brief of State Petitioners and Intervenors (December, 1995)
    State of Michigan and the Michigan Public Service Commission et al. (U.S. Court of Appeals in the District of Columbia Circuit)
    Decision in favor of petitioners: Indiana Michigan Power Co. et al. v. Department of Energy, NO. 95-1279 (U.S. Court of Appeals, July 23, 1996).

11. 1994 Acceptance Priority Ranking and Annual Capacity Report (March 1995)
    DOE/RW-0457 (Appendix B).

12. Multi-Purpose Canister System Evaluation:
A Systems Engineering Approach (September 1994)
DOE/RW-0445 (Table 2.2-1)

13. Spent Nuclear Fuel Discharges from U.S. Reactors: 1994
DOE/EIA SR/CNEAF/96-01 (February 1996).

14. Report on High-Level Nuclear Waste:
Prepared Pursuant to Assembly Concurrent Resolution No. 8 of the 1987 Nevada Legislature (December 1988, pg 26). Nevada Nuclear Waste Project Office.

15. Multi-Purpose Canisters in the Civilian Waste Management System
Jeff Williams DOE/OCRWM (October 27, 1994)

16. NRC Information Digest: 1995 (March 1995)
NUREG-1350 (Tables 16 and 17).

17. Facility Interface Capability Assessment (FICA) Project Report (September 1995)
Prepared by J.M. Vielbrock and N. Mote (Nuclear Assurance Corporation) for Oak Ridge National Laboratory and DOE/OCRWM. ORNL/SUB/86-97393/6

18. Near-Site Transportation Infrastructure Project: Final Report (February 1992)
Prepared by J.M. Vielbrock and N. Mote (Nuclear Assurance Corporation) for DOE/Chicago Operations Office (DOE/CH/1044-1).

19. Rail Transportability of the Large MPC Study Report (March 1995)
TRW Environmental Safety Systems for DOE/OCRWM.

20. High-Level Nuclear Waste Shipping Route Maps to Yucca Mountain, and Shipment Number Estimates:
Multi-Purpose Canister Base Case (January 1995).
Nevada Nuclear Waste Project Office

21. Nevada Potential Repository:
Preliminary Transportation Strategy Study 2 (February 1996)
By TRW for DOE/OCRWM

22. Preliminary Evaluation of Using Multi-Purpose Canisters Within the Civilian Radioactive Waste Management System (March 24, 1993; Revision 0).
By TRW for DOE/OCRWM.

23. HIGHWAY 3.1—An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual. Prepared by P.E. Johnson, D.S. Joy, D.B. Clarke, and J.M. Jacobi (March 1993).

24. INTERLINE 5.0—An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual. Prepared by P.E. Johnson, D.S. Joy, D.B. Clarke, and J.M. Jacobi (March 1993).

25. DOE/OCRWM: May 10, 1996
Notice of Proposed Policies and Procedures for Safe Transportation and Emergency Response Training Technical Assistance and Funding under NWPA section 180(c).

26. Pilot Study: SNF Shipments, Routing, Transportation Issues:
Oyster Creek, NJ to Yucca Mountain, NV (March 1996)
Planning Information Corporation for Council of State Governments/Northeast

Pilot Study: SNF Shipments, Routing, Transportation Issues:
Brunswick, NC to Yucca Mountain, NV (March 1996)
Planning Information Corporation for Southern States Energy Board

ATTACHMENT W

TABLE 1
YMDEIS TRANSPORTATION IMPACTS
TRUCK SHIPMENTS OF CIVILIAN SNF
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file bt.map.prn
DOE TRUCK SHIPMENT NUMBERS (DEIS, Table J-5)

Reactor/Storage Site (State)	Proposed Action (2010-2033)	Modules 1 or 2 (2010-2048)
Browns Ferry (AL)	1,175	2,067
Diablo Canyon (CA)	632	1,308
Humboldt Bay (CA)	44	44
Haddam Neck (CT)	255	255
Crystal River (FL)	283	442
St. Lucie (FL)	681	1,086
Turkey Point (FL)	582	871
Dresden/Morris (IL)	1,386	1,569
Pilgrim (MA)	316	476
Yankee-Rowe (MA)	134	134
Calvert Cliffs (MD)	757	1,140
Big Rock Pt (MI)	131	131
DC COOK (MI)	824	1,235
E Fermi (MI)	312	764
Palisades (MI)	367	454
Monticello (MN)	267	342
Callaway (MO)	392	735
Grand Gulf (MS)	516	1,016
Cooper (NE)	274	454
Fort Calhoun (NE)	258	362
Oyster Creek (NJ)	424	519
Salem/Hope Creek (NJ)	1,027	1,992
Fitzpatrick/Nine Mile Pt (NY)	1,094	1,971
Ginna (NY)	309	379
Indian Pt (NY)	701	1,155
Peach Bottom (PA)	924	1,408
Oconee (SC)	1,007	1,500
Surry (VA)	647	902
Vermont Yankee (VT)	369	484
Kewaunee (WI)	288	401
Lacrosse (WI)	37	37
Pt Beach (WI)	575	742
Total	16,988	26,375

TABLE 2
YMDEIS TRANSPORTATION IMPACTS
RAIL SHIPMENTS OF CIVILIAN SNF
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file ca.rail.prn)
DOE RAIL SHIPMENT NUMBERS (DEIS, Table J-6)

Reactor/Storage Site (State)	Proposed Action (2010-2033)	Modules 1&2 (2010-2048)
Farley(AL)	103	157
Arkansas(AR)	170	252
Palo Verde(AZ)	156	350
Rancho Seco(CA)	21	21
San Onofre(CA)	143	207
Millstone(CT)	367	524
Hatch(GA)	128	197
Vogtle(GA)	195	431
Arnold(IA)	105	158
Braidwood(IL)	95	215
Byron(IL)	136	244
Clinton(IL)	103	200
LaSalle(IL)	89	172
Quad Cities(IL)	299	419
Zion(IL)	147	250
Wolf Creek(KS)	52	106
River Bend(LA)	48	101
Waterford(LA)	49	91
Maine Yankee(ME)	60	60
Prairie Island(MN)	151	221
Brunswick(NC)	201	321
Harris(NC)	150	258
McGuire(NC)	253	427
Seabrook(NH)	37	83
Davis-Besse(OH)	44	71
Perry(OH)	42	82
Trojan(OR)	33	33
Beaver Valley(PA)	86	160
Limerick(PA)	262	497
Susquehanna(PA)	119	219
Three Mile Island(PA)	71	113
Catawba(SC)	148	253
Robinson(SC)	75	97
Summer(SC)	46	82
Sequoyah(TN)	90	161
Watts Bar(TN)	21	121
Comanche Peak(TX)	90	246
South Texas(TX)	151	358
North Anna(VA)	101	167
WPPSS(WA)	53	107

	4690	8232

TABLE 3
YMDEIS TRANSPORTATION IMPACTS
TRUCK SHIPMENT MILES OF CIVILIAN SNF
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file bt.map.prn)
DOE HIGHWAY DISTANCES (DEIS, Table J-11)

Reactor/Storage Site (State)	kms	Miles	Shipments Prop. Action (2010-2033)	Shipment-Miles	Shipments Mod. 1 or 2 (2010-2048)	Shipment-Miles
Browns Ferry (AL)	3442	2139	1,175	2,513,038	2,067	4,420,808
Diablo Canyon (CA)	1016	631	632	398,989	1,308	825,756
Humboldt Bay (CA)	1749	1087	44	47,818	44	47,818
Haddam Neck (CT)	4519	2808	255	716,033	255	716,033
Crystal River (FL)	4319	2684	283	759,486	442	1,186,194
St. Lucie (FL)	4588	2851	681	1,941,426	1,086	3,096,018
Turkey Point (FL)	4842	3009	582	1,751,048	871	2,620,555
Dresden/Morris (IL)	3059	1901	1,386	2,634,468	1,569	2,982,309
Pilgrim (MA)	4722	2934	316	927,178	476	1,396,636
Yankee-Rowe (MA)	4616	2868	134	384,345	134	384,345
Calvert Cliffs (MD)	4278	2658	757	2,012,273	1,140	3,030,372
Big Rock Pt (MI)	3866	2402	131	314,690	131	314,690
DC COOK (MI)	3196	1986	824	1,636,380	1,235	2,452,585
E Fermi (MI)	3524	2190	312	683,189	764	1,672,937
Palisades (MI)	3244	2016	367	739,771	454	915,139
Monticello (MN)	3003	1866	267	498,215	342	638,163
Callaway (MO)	2633	1636	392	641,338	735	1,202,509
Grand Gulf (MS)	3354	2084	516	1,075,383	1,016	2,117,420
Cooper (NE)	2523	1568	274	429,554	454	711,743
Fort Calhoun (NE)	2348	1459	258	376,416	362	528,150
Oyster Creek (NJ)	4424	2749	424	1,165,551	519	1,426,700
Salem/Hope Creek (NJ)	4350	2703	1,027	2,775,939	1,992	5,384,295
Fitzpatrick/Nine Mile Pt (NY)	4234	2631	1,094	2,878,183	1,971	5,185,466
Ginna (NY)	4089	2541	309	785,102	379	962,956
Indian Pt (NY)	4382	2723	701	1,908,713	1,155	3,144,884
Peach Bottom (PA)	4205	2613	924	2,414,283	1,408	3,678,908
Oconee (SC)	3853	2394	1,007	2,410,898	1,500	3,591,208
Surry (VA)	4255	2644	647	1,710,622	902	2,384,824
Vermont Yankee (VT)	4616	2868	369	1,058,382	484	1,388,230
Kewaunee (WI)	3347	2080	288	598,961	401	833,970
Lacrosse (WI)	3014	1873	37	69,294	37	69,294
Pt Beach (WI)	3341	2076	575	1,193,698	742	1,540,390
Total			16,988	39,450,666	26,375	60,851,305

TABLE 4
YMDEIS TRANSPORTATION IMPACTS
RAIL SHIPMENT MILES OF CIVILIAN SNF
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file ca.rail.prn)
DOE RAIL DISTANCES (DEIS, Table J-11)

Reactor/Storage Site (State)	kms	Miles	Shipments Prop. Action (2010-2033)	Shipment-Miles	Shipments Mod. 1 or 2 (2010-2048)	Shipment-Miles
Farley(AL)	4322	2686	103	276,613	157	421,633
Arkansas(AR)	2996	1862	170	316,476	252	469,129
Palo Verde(AZ)	1149	714	156	111,377	350	249,884
Rancho Seco(CA)	1159	720	21	15,124	21	15,124
San Onofre(CA)	750	466	143	66,642	207	96,468
Millstone(CT)	4555	2830	367	1,038,735	524	1,483,098
Hatch(GA)	4229	2628	128	336,355	197	517,671
Vogtle(GA)	4286	2663	195	519,322	431	1,147,836
Arnold(IA)	2572	1598	105	167,807	158	252,510
Braidwood(IL)	2993	1860	95	176,677	215	399,848
Byron(IL)	2806	1744	136	237,125	244	425,430
Clinton(IL)	2998	1863	103	191,875	200	372,573
LaSalle(IL)	2887	1794	89	159,657	172	308,550
Quad Cities(IL)	2829	1758	299	525,599	419	736,542
Zion(IL)	2946	1831	147	269,092	250	457,639
Wolf Creek(KS)	2512	1561	52	81,166	106	165,453
River Bend(LA)	3380	2100	48	100,811	101	212,123
Waterford(LA)	3423	2127	49	104,221	91	193,552
Maine Yankee(ME)	4734	2942	60	176,494	60	176,494
Prairie Island(MN)	2807	1744	151	263,372	221	385,465
Brunswick(NC)	4594	2855	201	573,769	321	916,318
Harris(NC)	4495	2793	150	418,959	258	720,609
McGuire(NC)	4366	2713	253	686,364	427	1,158,409
Seabrook(NH)	4582	2847	37	105,343	83	236,311
Davis-Besse(OH)	3416	2123	44	93,394	71	150,705
Perry(OH)	3519	2187	42	91,837	82	179,301
Trojan(OR)	2031	1262	33	41,646	33	41,646
Beaver Valley(PA)	3645	2265	86	194,781	160	362,383
Limerick(PA)	4216	2620	262	686,360	497	1,301,989
Susquehanna(PA)	4232	2630	119	312,927	219	575,891
Three Mile Island(PA)	4110	2554	71	181,322	113	288,583
Catawba(SC)	4363	2711	148	401,234	253	685,892
Robinson(SC)	4339	2696	75	202,209	97	261,524
Summer(SC)	4299	2671	46	122,878	82	219,044
Sequoyah(TN)	3716	2309	90	207,811	161	371,751
Watts Bar(TN)	3714	2308	21	48,463	121	279,240

CCR_MILES

Comanche Peak(TX)	2716	1688	90	151,888	246	415,160
South Texas(TX)	3228	2006	151	302,873	358	718,070
North Anna(VA)	4347	2701	101	272,811	167	451,083
WPPSS(WA)	1772	1101	53	58,357	107	117,814
Total			4690	10,289,765	8232	17,938,746
Caliente to Yucca Mountain	513	319	4690	1,494,998	8232	2,624,055

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TABLE 5
YMDEIS TRANSPORTATION IMPACTS
MTHMs CIVILIAN SNF SHIPPED BY TRUCK
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file bt.map.prn)
DOE CIVILIAN SNF INVENTORY (DEIS, Tables A-6 & A-7)

Reactor/Storage Site (State)	Proposed Action (2010-2033)	Modules 1 or 2 (2010-2048)
Browns Ferry (AL)	1,932	3,348
Diablo Canyon (CA)	1126	2,187
Humboldt Bay (CA)	29	29
Haddam Neck (CT)	420	420
Crystal River (FL)	512	805
St. Lucie (FL)	1020	1,611
Turkey Point (FL)	1074	1520
Dresden/Morris (IL)	2,146	2,541
Pilgrim (MA)	527	770
Yankee-Rowe (MA)	127	127
Calvert Cliffs (MD)	1142	1,710
Big Rock Pt (MI)	58	58
DC COOK (MI)	1433	2,155
E Fermi (MI)	523	1160
Palisades (MI)	585	733
Monticello (MN)	426	537
Callaway (MO)	702	1288
Grand Gulf (MS)	856	1,610
Cooper (NE)	452	762
Fort Calhoun (NE)	379	534
Oyster Creek (NJ)	699	844
Salem/Hope Creek (NJ)	1,659	3,245
Fitzpatrick/Nine Mile Pt (NY)	1,812	2,900
Ginna (NY)	463	565
Indian Pt (NY)	1164	1,683
Peach Bottom (PA)	1554	2,312
Oconee (SC)	1,865	2,674
Surry (VA)	1194	1689
Vermont Yankee (VT)	609	822
Kewaunee (WI)	451	612
Lacrosse (WI)	38	38
Pt Beach (WI)	876	1143
Total	27,853	42,432

TABLE 6
YMDEIS TRANSPORTATION IMPACTS
MTHMs SNF SHIPPED BY RAIL (DEIS, Tables A-6 & A-7)
NEVADA CURRENT CAPABILITIES SCENARIO (PIC, 9/96)
DOE BASE CASE ROUTING (TRW1999uData,Ch.4, file ca.rail.prn)
DOE CIVILIAN SNF INVENTORY (DEIS, Tables A-6 & A-7)

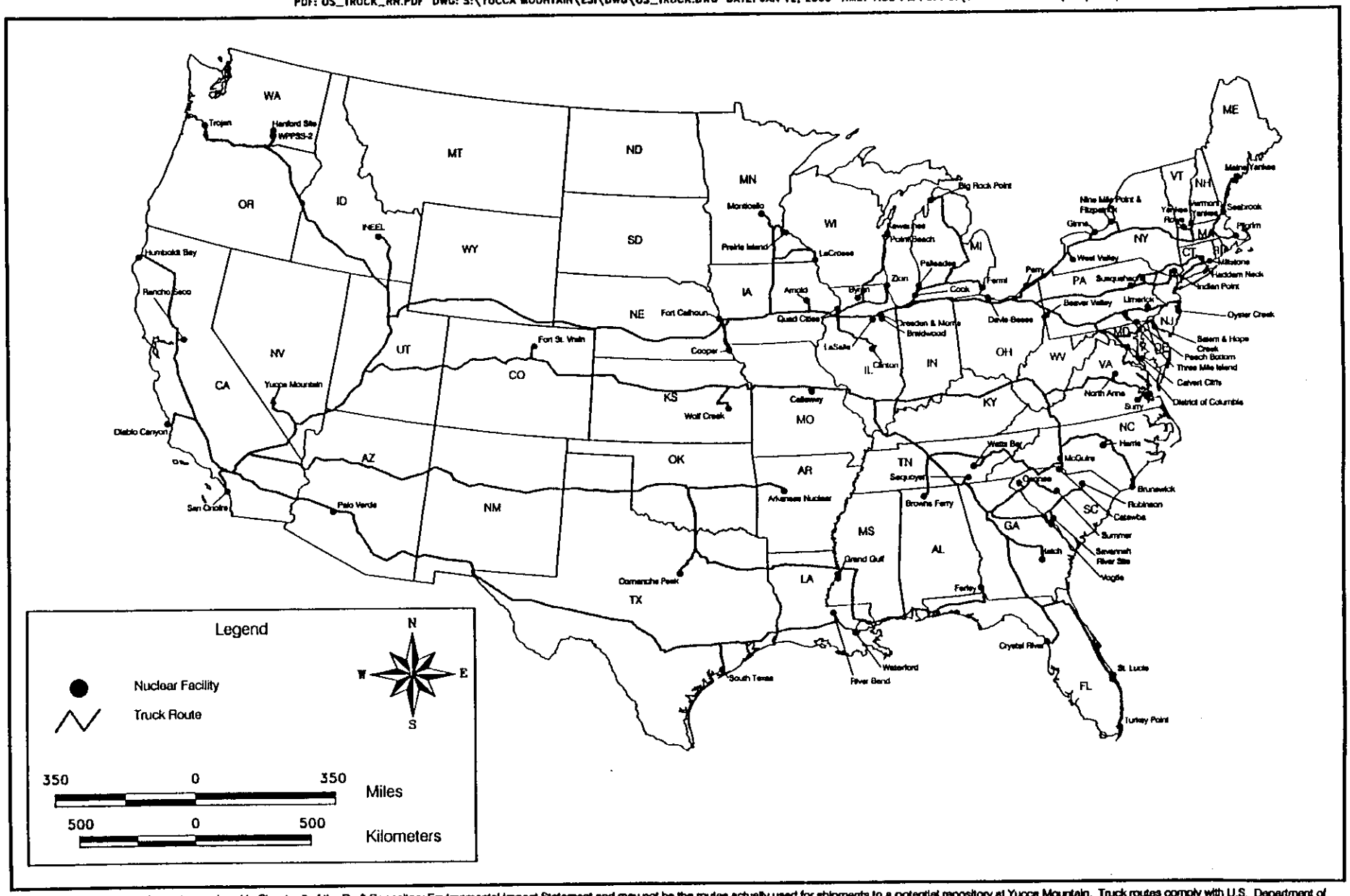
Reactor/Storage Site (State)	Proposed Action (2010-2033)	Modules 1 or 2 (2010-2048)
Farley(AL)	1174	1869
Arkansas(AR)	1109	1650
Palo Verde(AZ)	1674	3573
Rancho Seco(CA)	228	228
San Onofre(CA)	1423	2043
Millstone(CT)	1709	2655
Hatch(GA)	1446	2272
Vogtle(GA)	1080	2458
Arnold(IA)	467	692
Braidwood(IL)	1029	2287
Byron(IL)	1068	2181
Clinton(IL)	477	1084
LaSalle(IL)	952	1863
Quad Cities(IL)	1277	1834
Zion(IL)	1052	1052
Wolf Creek(KS)	630	1278
River Bend(LA)	531	1132
Waterford(LA)	500	938
Maine Yankee(ME)	536	536
Prairie Island(MN)	866	1210
Brunswick(NC)	896	1440
Harris(NC)	750	1205
McGuire(NC)	1439	2527
Seabrook(NH)	425	964
Davis-Besse(OH)	505	825
Perry(OH)	452	910
Trojan(OR)	359	359
Beaver Valley(PA)	1018	1832
Limerick(PA)	1143	2390
Susquehanna(PA)	1276	2373
Three Mile Island(PA)	548	825
Catawba(SC)	1148	2217
Robinson(SC)	384	509
Summer(SC)	526	958
Sequoyah(TN)	1023	1845
Watts Bar(TN)	251	893
Comanche Peak(TX)	998	2635

South Texas(TX)	1012	2319
North Anna(VA)	1184	1955
WPPSS(WA)	581	1167
	35146	62983

ATTACHMENT X

EIS001887

PDF: US_TRUCK_RN.PDF DWG: S:\YUCCA MOUNTAIN\ESA\DWG\US_TRUCK.DWG DATE: JAN 12, 2000 TIME: 1:52 PM PCP: S:\YUCCA MOUNTAIN\ESA\DWG\TRANS.PCP



These routes represent the routes analyzed in Chapter 8 of the Draft Repository Environmental Impact Statement and may not be the routes actually used for shipments to a potential repository at Yucca Mountain. Truck routes comply with U.S. Department of Transportation routing regulations. Rail routes are based on maximizing the distance on mainline track and minimizing the overall distance and number of interchanges between railroads. Direction arrow is approximate.

ATTACHMENT Y

EIS001887

764

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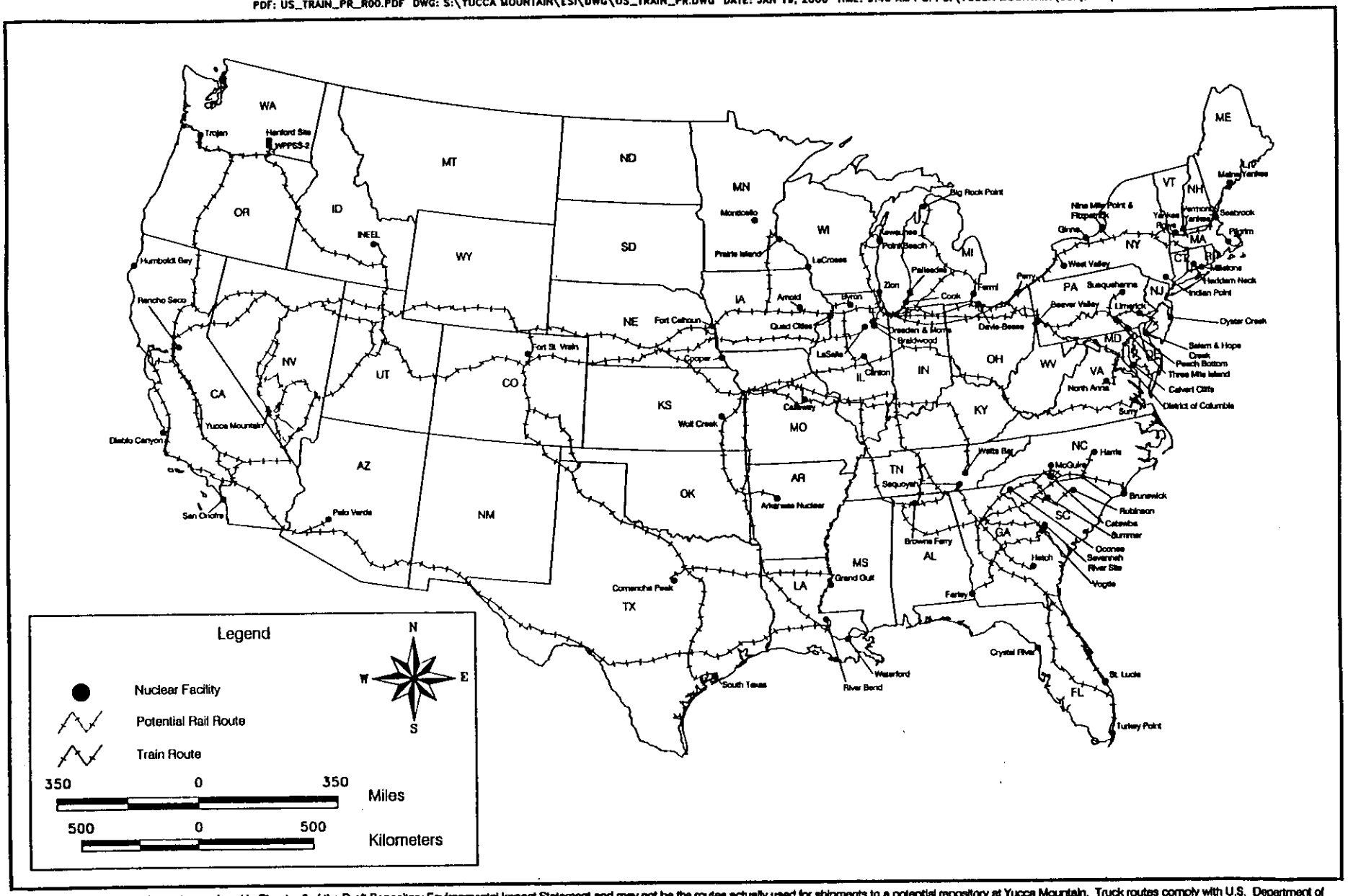

These routes represent the routes analyzed in Chapter 6 of the Draft Repository Environmental Impact Statement and may not be the routes actually used for shipments to a potential repository at Yucca Mountain. Truck routes comply with U.S. Department of Transportation routing regulations. Rail routes are based on maximizing the distance on mainline track and minimizing the overall distance and number of interchanges between railroads. Direction arrow is approximate.

ATTACHMENT Z

COMMENTS OF ROBERT J. HALSTEAD ON BEHALF OF THE STATE OF NEVADA AGENCY FOR NUCLEAR PROJECTS REGARDING THE U.S. NUCLEAR REGULATORY COMMISSION STUDY ASSESSING RISKS OF SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENTS (MODAL STUDY UPDATE)

PRESENTED AT THE PUBLIC MEETING IN
HENDERSON, NEVADA
DECEMBER 8, 1999

PHYSICAL TESTING AND COMPUTER SIMULATION

1. Nevada will continue to pursue full-scale regulatory physical testing of new shipping casks as a requirement for NRC certification and/or DOE procurement

2. Nevada believes issue of full scale physical testing of casks should be addressed in a venue separate from the Modal Study Update

3. Modal Study Update should include physical testing of critical cask components
a. Truck Cask - GA 4: closure bolts and seals (impact and fire, full scale), depleted uranium gamma shield fittings and welds (impact, fire, puncture, full scale or ½ scale), and cask tie-down systems (impact, full scale or ½ scale)
b. Large Rail Cask - TBD (e.g., MPC, NAC/ST, HiStar): closure bolts and seals (impact and fire, full scale), gamma shield (lead, lead/DU, cast iron) interface, fittings and welds (impact, fire, puncture, full scale or ½ scale), and cask tie-down systems (impact, full scale or ½ scale)

4. Modal Study Update should include computer simulations to determine GA-4 truck cask performance under extremely severe accident conditions and to determine failure thresholds for severe fire and impacts

5. Modal Study Update should include computer simulations to determine large rail cask performance under extremely severe accident conditions and to determine failure thresholds for severe fire and impacts

HIGHWAY AND RAILWAY ACCIDENTS

1. Modal Study Update should evaluate historical accidents which created conditions that challenge the NRC cask performance standards:

a. Catastrophic highway infrastructure accidents, including:
June 29, 1983, Greenwich, CT, I-95: Collapse of Mianus River Bridge
March 5, 1985, Waynesville, NC, I-40: Massive rock slide onto highway and tunnel
April 5, 1987, Amsterdam, NY, I-90: Collapse of Schoharie Creek Bridge
July 14, 1988, Burley, ID, I-84:Support impact and overpass collapse
Oct. 17, 1989, Oakland, CA, Nimitz Freeway: Elevated Highway Collapse (earthquake)

b. Truck and rail accidents involving military explosives, including:
April 28, 1973, Roseville, CA, Southern Pacific: Explosion of 18 boxcars
May 24, 1973, Benson, AZ, Southern Pacific: Explosion of 12 boxcars
Aug. 4, 1985, Checotah, OK, I-40: Truck explosion
Nov. 21, 1990, Goldfield, NV, US 95:Truck explosion

c. Highway accidents involving impact and fire/explosion, including:
Dec. 23, 1988, Memphis, TN, I-240: Collision and explosion, propane tanker
May 20, 1991, Bronx, NY: Collision and explosion, gasoline tanker
July 24, 1998, Valdese, NC, I-40: Bridge support impact and fire, gasoline tanker

d. Railway accidents involving high speed impact and/or fire, including:
July 8, 1986, Miamisburg, OH, CSXT: Derailment and fire, multiple chemicals
Feb. 2, 1989, Helena, MT, MT Rail: Derailment and explosion, multiple chemicals
Feb. 26-28, 1989, Akron, OH, CSXT: Derailment and fire, butane tankers
May 12-25, 1989, San Bernardino, CA, Southern Pacific: Derailment, pipeline explosion
July 22-24, 1989, Freeland, MI, CSXT: Derailment and fire, multiple chemicals
Dec. 14, 1994, Cajon Pass, CA, Santa Fe: Collision
Feb. 1, 1996, Cajon Pass, CA, BNSF: Derailment and fire
Feb. 21, 1996, Leadville, CO, Southern Pacific: Derailment and spill, sulfuric acid
Mar. 4-22, 1996, Weyauwega, WI, Wisconsin Central: Derailment and fire, propane tankers

2. Modal Study Update should develop a bounding approach to accident probability which considers:
a. State specific data for most heavily impacted states
b. Route specific data for most likely national routes: I-80, Buffalo - Sacramento; I-70, Baltimore - Cove Fort; I-40, Asheville - Barstow; I-15, SLC - Barstow, US 95, Las Vegas - Tonopah; UP/SP, Chicago-Gibbon-Oakland; UP/SP, St. Louis-Gibbon-SLC-Los Angeles; BNSF, Kansas City-San Bernardino
c. Range of statistical measures to reflect year-to-year variations
d. Actual accident/incident rates for historical U.S. SNF shipments (Truck - 0.7/10.5 per million shipment-miles, Rail - 9.7/19.4 per million shipment-miles, 1970-1990, SAIC,1991)

3. Nevada is currently evaluating historical severe accidents to determine maximum credible events as part of review of DOE YM DEIS. DOE contractor report suggests 1939

Harney, NV rail sabotage incident which caused train to derail at full-speed into deep canyon. DOE YM EA (1986) acknowledged potential for military aircraft carrying live munitions bombing or crashing into rail or truck shipment. Given inherent large uncertainties in PRA, Modal Study Update should analyze accidents with probabilities at least as low as 1 in 10 million per year.

4. Probability of undetected defects and improper loading must be evaluated both as accident-initiating and as consequence-exacerbating factors.

5. Nevada advocates use of dedicated trains and special safety protocols to reduce rail accident probability and consequence. However, Modal Study Update should not consider dedicated trains and administrative controls because:
a. DOE and nuclear industry oppose mandatory use of dedicated trains;
b. DOE YM DEIS assumes use of general rail freight service;
c. Eastern and Western railroads have different opinions regarding maximum speeds (35 mph versus 55 mph); and
d. Dedicated trains can have accidents (TMI shipment in St. Louis)

CONTAINER PERFORMANCE DURING COLLISIONS AND FIRES

1. Modal Study Update must select appropriate casks for analysis: Truck, GA-4 and NAC LWT; Rail - Large MPC, NAC S/T, Hi-Star, although IF-300 will probably see continued use. Several rail casks must be evaluated to address different gamma shield materials and configurations (lead, lead/DU, cast iron).

2. Modal Study Update must develop method of translating maximum credible real world impacts in comparison to regulatory drop onto unyielding surface. Examples: Rail cask 90 mph impact with rock face, bridge support column, oncoming locomotive, or another large rail cask; Truck cask 75 mph impact with rock face, bridge support column, another tractor, etc.

3. Modal Study Update must analyze cask performance in engulfing fire conditions for longer durations and higher temperatures than NRC standards require, to address potential for maximum credible real world fires. Truck cask should analyzed for 1475 degree fire for 8 hours, and 2000 degree fire for 4 hours. Rail cask should be analyzed for 1475 degree fire for 24 hours, and 2000 degree fire for 12 hours.

4. Modal Study Update must consider heat generated by SNF during fire as factor in SNF oxidation. SNF heat is probably an important factor in performance of 5-year to 10-year cooled fuel, and may be factor in seal performance for truck cask carrying 5-year cooled fuel.

SPENT NUCLEAR FUEL ASSEMBLY BEHAVIOR IN ACCIDENT

1. Modal Study Update must select appropriate SNF types for bounding analysis of radiological consequences of both loss of shielding and loss of containment accidents. Greatest radiological risk involves shipment of 5-year cooled, high-burnup PWR fuel (5.0 percent U-235 initial enrichment, 62,000 MWd/MTU burnup, as allowed under NRC Final Rule in 10CFR51). Moderate radiological risk would result from shipment of 26-year cooled, medium-burnup PWR fuel (3.7 percent U-235 initial enrichment, 39,600 Mwd/MTHM, as assumed by DOE in YM DEIS).

2. Modal Study Update must assume complete cladding failure and oxidation in most severe loss of containment accident. Both normal SNF and failed/degraded SNF(including core debris) must be considered in all accident scenarios. Failed/degraded fuel (including core debris) should be assumed to be containerized before shipment, and the container should be credited in boundary calculations.

3. Nevada is evaluating issue of dual-purpose cask container boundary credit.

4. Only way to gain useable knowledge about SNF behavior under extreme conditions is to test real SNF rods and pellets. Actual SNF should be tested to gain understanding of burst/rupture and fracture characteristics. Particle size distribution is a major uncertainty in modeling loss of containment accident release and dispersion.

OTHER TRANSPORTATION SAFETY ISSUES

1. Questionable justification of PRA approach based on historical data, when future shipment numbers and shipment characteristics, based on analysis of DOE YM DEIS and other DOE program documents, are radically different from past shipping campaigns.

2. Need for PRA to consider policy and program issues relevant to safety, such as future Congressional funding for infrastructure maintenance, NTSB safety analysis and USDOT safety inspections; DOE proposal for privatization of transportation services under fixed-cost contracts; and utility interpretation of standard contracts allowing abandonment of commitment to ship oldest fuel first (OFF).

3. Need for comprehensive human factors assessment, including human factors issues relevant to particular cask/transporter systems such as the GA-4. Issues include both driver performance and tractor/trailer performance under anticipated real world conditions, e.g. very long distance hauls cross-country and challenging driving conditions due to Western states road and weather conditions.

ATTACHMENT AA

Radioactive Waste Management Associates

Memo

To: Bob Halstead

From: RWMA

Date: 02/14/00

Re: RISKIND and RADTRAN calculations

Riskind Calculations for rail accident: 26 vs. 10 year old fuel

This memo discusses the procedure used to obtain the results listed in the Yucca Mountain EIS for the population dose during the "maximum reasonably foreseeable accident scenario" involving a train shipment of PWR fuel and compares these results to those of the RADTRAN5 output. Because certain dose limits are wired into the RISKIND code, it was necessary to run RADTRAN5 and compare the results. As an introduction to the RISKIND calculations, we'll first discuss the inputs into the program, including any values that are not specifically mentioned in the YM EIS.

Population Density

On pg. J-62 of the YMEIS, the following statement is made.

> "The analysis used estimated populations in successive 8-kilometer (5-mile)-wide annular rings around the centers of the 21 large urbanized areas (cities and metropolitan areas) in the continental United States (TRW 1999a, page 22). The average population for each ring was used to form a population distribution for use in the analysis. To be conservative in estimating consequences, the analysis assumed that accidents in urbanized areas would occur at the center of the population zone."

The cited reference provides population information on 20 urbanized areas, given in successive 5-mile annular rings. To estimate the average population at the center of an "average" urban area, the average population in each successive annulus was averaged for all cities to come up with a single population distribution as a function of distance away from the center of a population zone. An exponential trendline was then fitted to the data using Microsoft Excel, and the y-intercept determines the population density at the center of the zone. Two approaches were used to estimate the population density at the center: one fitting a trendline to the average population density data provided in the TRW report cited above, and one fitting a trendline to the median data. The densities obtained were 5214 and 4651 persons/km^2, respectively. For this analysis, the average of these two values, 4932.5 persons/km^2 was used.

The affected population is assumed to extend 80 kilometers from the site of the accident, as is given in the Yucca Mountain EIS.

Short Term Exposure Time:

The Yucca Mountain EIS provides no information on what this parameter should be. The default value given in RISKIND is 2 hours, and the maximum allowable value is 100 hours. If everything else is held constant, the calculated difference in population dose does not vary significantly over the range of 2-100 hours exposure time. This is because the major short-term contribution to dose is inhalation from the passing radioactive cloud.

Long Term Exposure Time:

On Page J-59 of the Yucca Mountain EIS, the assumption of long-term exposure time is given:

> "Populations would continue to live on contaminated land for 1 year."

This is the assumption we used to replicate the numbers given in the YMEIS for the maximum reasonably foreseeable accident scenario. This significantly affects the calculations of expected latent cancer fatalities due to a severe accident, when compared with a more standard value of 50 years exposure time (about an order of magnitude more lcf's are calculated using a 50 year exposure time compared with the single year time assumed in the YMEIS). Note that RISKIND caps any individual dose to five rems in a lifetime, the EPA-allowable limit. Thus, RISKIND makes an assumption either about clean-up levels or evacuation. If the populations continues to reside in a contaminated area for a 50-year period, the direct gamma doses will dramatically increase compared to a one-year exposure time.

Fraction of Gamma Radiation:

There is no information in the Yucca Mountain EIS that estimates this parameter. Therefore, the RISKIND default value of 0.6 is used. Changing this number from 0.6 to 0.8 does not significantly alter the results.

Cask Dimensions:

Figure J-4 in the Yucca Mountain EIS is a drawing of a large rail cask. Its length dimension is given as 6-7 meters. For our analysis, a length of 7 meters is used.

There is no information in the Yucca Mountain EIS that estimates the cask radius. The Luna et al sabotage study uses a rail cask having a radius of approximately 1.1m. The default radius given by RISKIND is 1.08m. Since these two values are in agreement, we decided to use RISKIND's default.

Spent Fuel Inventory Data:

We assumed a rail cask carrying 26 PWR assemblies in order to determine our fuel inventory. For the 26-year case, we assumed 39560 MWd/MTU burnup, 25.9 year old spent fuel, as was specified in the YMEIS. We assumed there was 0.46 MTU per assembly, or 11.96 MTU in the rail cask.

CRUD Inventory

In RISKIND, the amount of Cobalt-60 released to the environment during a postulated accident event is a function of two mechanisms: Co-60 from the structural components of the fuel released as a particulate, and Co-60 in CRUD released as a CRUD release. For a "severity 6" accident like the maximum reasonably foreseeable accident, it is assumed that 100% of the CRUD is spalled from the fuel rods and released into the environment. For the structural components of the fuel rods, RISKIND

assumes a release fraction 2.E-5. The two Co-60 contributors are then added to arrive at a release amount.

The determination of health effects resulting from a postulated release is sensitive to the estimate of the CRUD surface activity density, given in $\mu Ci/cm^2$, and the cask cavity surface area, m^2. For our analysis, we assume that the cask cavity surface area is $400m^2$. This is given in the RISKIND help menu as the size of large licensed rail casks. No data is available from the Yucca Mountain EIS concerning this parameter.

The surface activity density of the CRUD is extremely variable. The YMEIS has no data concerning the value they used for this important parameter. RISKIND'S default value is 4 $\mu Ci/cm^2$ for a PWR assembly and 350 $\mu Ci/cm^2$ for a BWR reactor. Appendix D of the RISKIND User's Manual, table D.1 lists the maximum observed Co-60 ($\mu Ci/cm^2$) for a PWR as 0.1 to 140. Table D.4 of the same appendix lists CO-60 activity densities for a variety of PWR reactors as: 140, 100,10,2,16,73,and 19 $\mu Ci/cm^2$. It is important to note that, in RISKIND, the value inputted as the surface activity density is adjusted by the decay of Co-60, according to the age of the fuel. For this Co-60 CRUD data, the age of the fuel and testing methodology is not stated.

The variability of data for CRUD densities makes the estimation of this parameter extremely difficult. To correlate the YMEIS results, we chose the RISKIND default value of 4 μCi Co-60/cm^2, the Co-60 surface density, measured at discharge. In addition, we varied this parameter to determine its effect on consequence assessments.

Meteorological Data and Dispersion Models

The Yucca Mountain EIS specifies that the maximum reasonably foreseeable accident scenario was analyzed as occurring under stable conditions which would not be exceeded 95% of the time. On pg. J-59 (Table J-23), wind speed frequencies are given as functions of stability class. For the two most stable classes (F&G), the average wind speed, using Table J-23, is 1.55m/s. We used this wind speed and stability class F as inputs for the RISKIND problem.

Another decision in RISKIND involves what atmospheric dispersion model coefficients should be used. RISKIND provides three choices for the model: "Based on effective release height," Pasquill-Gifford, and Briggs stability categories. The RISKIND User's Manual states that the Pasquill-Gifford stability categories should be used for ground level or near ground-level releases. The first model determines which coefficients to use based on calculations of effective release heights of a plume of contaminants, serving to decrease calculated consequences using this program. High temperature fires during severe accidents would serve to increase the effective release height through increased buoyancy forces. For our analysis, we sought to determine the effect the choice of dispersion model has on the RISKIND-calculated results, so we ran a "Based on effective release height" and a "Pasquill-Gifford" model for each set of inputs. As is shown on the results table, the choice of atmospheric dispersion model greatly affects the results. This is because RISKIND assumes an accident takes place at the population center; if the effective release height is higher, more radioactive material is dispersed into areas with lower population density, thereby decreasing the total population dose.

Accident Severity

The maximum reasonably foreseeable accident scenario is a category 6 accident. The release fractions specified on page J-57 of the YMEIS (Table J-21) were used as inputs to the RISKIND code. In addition, it is assumed that 100% of the fuel rods will fail in a severe accident.

Results:

Using the above inputs, RISKIND was run to determine the population dose and expected latent cancer fatalities resulting from a category 6 accident involving a rail cask in an urban areas under slowly-dispersing conditions. The table below compares our RISKIND run with the run reported in the YM EIS, pg. J-63.

25.9 Year Fuel Scenario: RWMA Correlation Run

	Population Dose (person-rem)	**Latent Cancer Fatalities**
DOE Yucca Mountain EIS	61,000	31
RWMA	61,500	30.8

Given the large amount of unspecified inputs, the correlation is excellent.

In addition, fuels with different properties were evaluated to determine the effect of CRUD density, age, and the atmospheric model chosen on consequences from the severe rail accident scenario. These are compared in the following table.

RISKIND calculations for severe rail accident consequences

Case	population density	Crud Surface Activity Density	Atmospheric Dispersion Model	Spent Fuel Age	Population Dose	Expected LCFs
	persons/km^2	µCi/cm^2		years	person-rem	
DOE YMEIS				25.9	61000	31
RWMA correlation	4932.5	4	effective release height	25.9	61500	30.8
RWMA RISKIND runs, using population density estimate cited in Yucca Mountain EIS	4932.5	4	Pasquill-Gifford	25.9	219000	109
	4932.5	51.4	effective release height	25.9	61900	31
	4932.5	51.4	Pasquill-Gifford	25.9	220000	110
	4932.5	140	effective release height	25.9	62600	31.3
	4932.5	140	Pasquill-Gifford	25.9	223000	111
	4932.5	1250	effective release height	25.9	71600	35.8
	4932.5	1250	Pasquill-Gifford	25.9	255000	127
	4932.5	4	effective release height	10	80700	40.3
	4932.5	4	Pasquill-Gifford	10	287000	144
	4932.5	51.4	effective release height	10	83700	41.8
	4932.5	51.4	Pasquill-Gifford	10	298000	149
	4932.5	140	effective release height	10	89300	44.7
	4932.5	140	Pasquill-Gifford	10	318000	159
	4932.5	1250	effective release height	10	160000	80
	4932.5	1250	Pasquill-Gifford	10	569000	284
Special Runs: New York City	24000	4	effective release height	25.9	299000	150
	24000	4	Pasquill-Gifford	25.9	1070000	533
	24000	1250	effective release height	25.9	348000	174
	24000	1250	Pasquill-Gifford	25.9	1240000	619
	24000	4	effective release height	10	393000	196
	24000	4	Pasquill-Gifford	10	1400000	698
	24000	1250	effective release height	10	778000	389
	24000	1250	Pasquill-Gifford	10	2770000	1380

The table shows how sensitive consequence estimates are to CRUD activity and the choice of dispersion model. It also shows how considering 25.9-year fuel instead of 10-year fuel can result in a significant underestimate of the consequences of a severe spent nuclear fuel transportation accident.

Further, we performed consequence estimates for a severe accident in a "hyper-urban" area such as Manhattan. It is important to keep in mind that these results only concentrate on fatalities, not on morbidity or economic consequences. The economic consequences resulting from the cleanup and decontamination of such an accident in an urban area would be astronomical: it is important to understand this in order to fully assess the true consequences of a spent fuel accident. RISKIND does not estimate the economic consequences of an accident.

The YMEIS assumes that, in the event of a severe accident, persons will live on the contaminated land for one year before moving. That is, their long-term exposure duration is 1 year. A more realistic assessment may be to use a 50-year exposure period. This will drastically increase the number of expected latent cancer fatalities due to direct gamma groundshine from Co-60 and Cs-137. For comparison, we ran RISKIND using a 50 year long-term exposure duration for spent fuel with a CRUD

activity of 4μCi/cm^2 aged both 25.9 and 10 years. These are shown below. As seen the number of latent cancer fatalities is 8.5 times greater for a 50-year residence time on contaminated land.

RISKIND results: sensitivity to long-term exposure

Long-term Exposure Time (years)	Spent Fuel Age (years)	Atmospheric Dispersion Model	Population Dose (person-rem)	Expected LCFs
1	25.9	Pasquill-Gifford	219,000	109
50	25.9	Pasquill-Gifford	1,870,000	933
1	10	Pasquill-Gifford	287,000	144
50	10	Pasquill-Gifford	2,470,000	1,370
1	25.9	Effective release height	61,500	30.8
50	25.9	Effective release height	525,000	262
1	10	Effective release height	80,700	40.3
50	10	Effective release height	771,000	386

RADTRAN 5 Calculations for a Severe Rail Accident

Because of the wired-in limits in the RISKIND code, it is possible that RADTRAN yields dose estimates that are far higher. In order to address this issue, we ran RADTRAN 5 for conditions similar to those described above. RADTRAN is set up as a "risk" assessment program: it sums the probabilities of each occurrence times its consequences to arrive at an "expected" dose. In order to use RADTRAN to perform a consequence analysis for a severity 6 accident, we needed to make a few adjustments to default values in the program. For example, we considered only one "accident severity category," the most severe accident category given in the Yucca Mountain EIS, and made the probability of this accident 100% in urban areas. We used the same fuel properties as we did in the RISKIND analysis above. The table below shows the results of this analysis.

RADTRAN 5 calculations for severe rail accident consequences

Population Density	Spent Fuel Age	Crud Density	Crud Inventory*	Interdiction Level	Population Dose	Expected LCFs
persons/km^2	years	μCi/cm2	Ci		person-rem	
4932.5	25.9	4	0.55	40	846000	423
4932.5	25.9	4	0.55	1.00E+08	847000	423.5
4932.5	25.9	51.4	7.09	40	847000	423.5
4932.5	25.9	51.4	7.09	1.00E+08	848000	424
4932.5	25.9	1250	172.46	40	870000	435
4932.5	25.9	1250	172.46	1.00E+08	871000	435.5
4932.5	10	4	4.36	40	915000	457.5
4932.5	10	4	4.36	1.00E+08	916000	458
4932.5	10	51.4	56.03	40	922000	461
4932.5	10	51.4	56.03	1.00E+08	923000	461.5
4932.5	10	1250	1362.66	40	1110000	555
4932.5	10	1250	1362.66	1.00E+08	1110000	555

*Crud Inventory is decayed to the age of the spent fuel, Crud Density is assumed to be the density at fuel discharge

RADTRAN 5 appears to give results that are less dependent on CRUD density and spent fuel age than RISKIND results. However, both programs calculate severe fatality consequences resulting from a spent fuel shipping accident.

Some general results can be given. First, the magnitude increase in consequences when considering 10-year fuel vs. 26-year fuel is strongly dependent on the CRUD inventory being considered. Second, it appears as if the DOE YMEIS consequence analysis used dispersion coefficients based on effective release height. The choice of population distribution around the accident site likely causes this discrepancy: more people are assumed to live near the accident, so a ground-level release with no significant buoyancy rise will affect more people in this model. In the case of a severe impact accident with no fire, the Pasquill-Gifford coefficients should be used for a ground-level release, since there will be no buoyancy-induced dispersion from an elevated-temperature event such as a fire.

Further, the economic costs of such an accident would be astounding. In the economic spreadsheet model provided on the RADTRAN website at Sandia National Laboratories, it is estimated that the cleanup costs for a plutonium dispersal accident in an urban area would be ~$400 million *per* km^2. A similar study needs to be performed for a spent nuclear fuel shipping accident. However, the economic model component of RADTRAN 4 and 5 appears to be disabled. We attempted to put economic variable into RADTRAN 4, but the program would not run.

ATTACHMENT BB

Radioactive Waste Management Associates

Memo

To: Bob Halstead

From: RWMA

Date: 02/14/00

Re: RADTRAN IV Economic Analysis

This memo discusses the inputs, methodology, and results of a RADTRAN IV economic analysis of a severe accident involving a rail cask of spent nuclear fuel in an urban area. It is divided into two rough sections. The first section discusses the equations used by RADTRAN to estimate economic impacts. The second section discusses our results obtained from running the RADTRAN IV economic code.

I. RADTRAN equations used in the economic analysis of spent fuel accidents

We will only be discussing urban costs, as these are the relevant inputs needed for our analysis.

RADTRAN II and RADTRAN III User's Guides assume the following land use distribution for an urban area:

RADTRAN Default Land use Assumptions: Urban Environment

Description	% of land
High-density residences ≤ 6 floors	10
High-density residences ≥ 6 floors	10
Single family residences	20
Public Land	20
Commercial Land	20
Parks, Cemeteries	10
Undeveloped/Vacant Land	10

The parameter which controls the choice of equations for determining the economic impact of transportation accidents is the Decontamination Factor, or $DECON_n$. $DECON_n$ is described as follows:

$$DECON_n = \frac{n \cdot PPS \cdot RF \cdot AER \cdot \bar{x}_n \cdot V_d}{CULVL}$$

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n	= number of curies per package
PPS	= packages per shipment (1)
RF	= release fraction of spent fuel inventory for each family of radionuclides
AER	= fraction of released fuel in aerosol form
$\bar{X}_n$	= atmospheric dilution factor in area n
V_d	= deposition velocity
CULVL	= Cleanup Level following an accident

In the RADTRAN IV User's Guide, chapter 3, the following discussion on the CULVL value is given:

> Clean-Up Level (CULVL). This factor describes the required level to which contaminated surfaces must be cleaned up (EPA, 1977). The default value is set to the proposed guideline of 0.2 $\mu Ci/m^2$. Note that this value applies to the sum of deposited activity over all isotopes of a multi-isotope material and that the default cleanup value is not widely accepted.

In our analysis of economic costs, the default CULVL was retained. For a sensitivity analysis, a RADTRAN IV run was also performed using a CULVL value of 1 $\mu Ci/m^2$, the maximum value allowed as input.

The Decontamination factor (DECON) is the ration of the contamination level before cleanup to the eventual cleanup level. In determining equations for cleanup costs, the DECON values are grouped into clusters based on the following divisions. Note that the variable names DECON and DF are the same, and are used interchangeably in the RADTRAN User's Guides.

DF_1	= 0.1	= minimum level of detectability.
DF_2	= 1.0	= criteria level for cleanup. This value corresponds to a contamination level equal to CULVL.
DF_3	= 20	= maximum contamination level for low to moderate range
DF_4	= 40	= max level for which cleanup criterion level is feasible

RADTRAN IV uses the CULVL value and the other data for the radionuclide inventory to assign a decontamination factor for a given area of contamination. The atmospheric dilution factor, deposition velocity, and release fraction are radionuclide-specific. Then, RADTRAN assigns economic consequence equations for the following divisions:

DECON<DF_2:

For areas in which the Decontamination Factor is less than the criteria level for cleanup, there is no cleanup cost outside of the initial fixed costs.

DF_2<DECON<DF_3:

For areas in which the Decontamination Factor is greater than the criteria level for cleanup, but less than twenty times this level, the RADTRAN II and RADTRAN III User's Guides specify values and equations for economic consequences. These values are derived from per-capita values, then multiplied by the percentage of land occupied by each division. Thus, for example, it is assumed that cleanup of High-Density Residences having $\geq$ 6 floors is $40 per capita. Since it is assumed that 10% of a city is covered by these buildings, the cost of cleanup is $40 *.1 or $4 per person.

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Description	Cleanup Costs ($)
Survey Costs (fixed)	200,000 * Area
Evacuation Costs (fixed)	180 * Pop. Density * Area
Income Loss	230 * Pop. Density * Area
Cleanup Costs:	
High-Density Residences ≥ 6 floors	2 * Pop. Density * Area
High-Density Residences ≤ 6 floors	4 * Pop. Density * Area
Single-family Homes	73.1 * Pop. Density * Area
Public Land	10.6 * Pop. Density * Area
Commercial Land	5.6 * Pop. Density * Area
Parks, Cemeteries	3.9 * Pop. Density * Area
Undeveloped/Vacant Land	22,000 * Area

The above criteria is then combined into a single equation, given below:

Cost of Cleanup (DF_2<DECON<DF_3)
= [2.2e5 + (509.2*Pop. Density)]*Area

DF_3<DECON<DF_4:

Similarly, for areas in which the Decontamination Factor is greater than twenty times the criteria level for cleanup, but less than forty times this level, the RADTRAN II and RADTRAN III User's Guides specify values and equations for economic consequences. These values are derived from per-capita values, then multiplied by the percentage of land occupied by each division. Thus, for example, it is assumed that cleanup of High-Density Residences having ≥ 6 floors is $40 per capita. Since it is assumed that 10% of a city is covered by these buildings, the cost of cleanup is $40 *.1 or $4 per person.

Description	Cleanup Costs ($)
Survey Costs (fixed)	200,000 * Area
Evacuation Costs (fixed)	180 * Pop. Density * Area
Income Loss	230 * Pop. Density * Area
Cleanup Costs:	
High-Density Residences ≥ 6 floors	18.7 * Pop. Density * Area
High-Density Residences ≤ 6 floors	37.4* Pop. Density * Area
Single-family Homes	235 * Pop. Density * Area
Public Land	112 * Pop. Density * Area
Commercial Land	284 * Pop. Density * Area
Parks, Cemeteries	5.1 * Pop. Density * Area
Undeveloped/Vacant Land	22,000 * Area

The above criteria is then combined into a single equation, given below:

Cost of Cleanup (DF_3<DECON<DF_4)
= [2.2e5 + (1102*Pop. Density)]*Area

DECON>DF_4:

For areas where the contamination level is greater than 40 times the criterion cleanup level, it is assumed that the land will be permanently interdicted, and economic costs stem from relocation and opportunity costs.

Description	Cleanup Costs ($)
Survey Costs (fixed)	100,000 * Area
Evacuation Costs (fixed)	180 * Pop. Density * Area
Personal Income Loss	5880 * Pop. Density * Area
Corporate Income Loss	2470 * Pop. Density * Area
Land Value Loss	23,000 * Pop. Density * Area
Permanent Relocation Cost	3874 * Pop. Density * Area
Relocation of Government Operations	67 * Pop. Density * Area
Security Cost	1,200,000 * Area

The above criteria is then combined into a single equation, given below:

Cost of Cleanup (DECON > DF_4)
= [1.3e6 + (35470*Pop. Density)]*Area

II. RWMA Economic Analysis using RADTRAN IV

This section highlights the inputs needed for the economic analysis in addition to the CULVL value discussed in the previous section.

Keywords used in Economic Analysis:

ECONF:

This parameter is the discount factor used to account for inflation. Since the RADTRAN 4 economic model gives results in 1980 dollars, this has to be updated to present value using an interest rate. One way to approximate this is to use the Consumer Price Index:

Cost (2000) = Cost (1980) * (CPI (2000)/CPI (1980))

According to the Federal Reserve Bank of Minneapolis, the CPI in 1980 was 82.4, and the CPI in 2000 is projected to be 171, based on the change from 4 th quarter 1998 to 4th quarter 1999. Thus, the ECONF factor used as input for RADTRAN will be the ratio of the two consumer price indexes, or 2.08.

ONSCST:

This parameter specifies the estimated on-scene costs for cleanup of a spent fuel accident of a given severity. The severity of the accident is determined by the release fraction for the fuel. There are four values inputted into the ONSCST array. The first value is a basic cost for determining that there was no release. This cost corresponds to a release fraction (RF) of 0.0. the second value is a cost estimate for accidents with overall release fractions $0<RF\leq .01$; the third for $.01<RF\leq .10$; and the fourth for $RF>.10$. Each species category (eg, NOBLE, PARTICULATE, VOLATILE, RUTHENIUM) has a release fraction for each accident severity category. The overall release fraction is determined from the fraction of the total inventory released.

In the RADTRAN 4 User's Manual, example output file 3 includes economic impacts of transportation by rail in rural areas. This analysis uses the following values for ONSCST:

ONSCST 250 2400 2400 5000

These numbers correspond to the values given in the RADTRAN III User's Manual for spent fuel particulate releases. As an initial estimate, our analysis of a severe train accident in an urban area used these values.

EMRCST:

This parameter estimates the immediate cost for a given severity category for emergency response. Since we are only concerned with one accident severity category here (the maximum reasonably foreseeable accident scenario), there will be one estimate here.

In the RADTRAN 4 User's Manual, example output file 3 includes economic impacts of transportation by rail in rural areas. This analysis uses the following values for EMRCST:

EMRCST 20 400 500 600 1500 1700 2100 2500

These EMRCST values correspond to values for each of 8 severity categories. Since our analysis is only considering one category, we use the cost estimate for the most severe category. I will also use the EMRCST value for severity category 6, because I am unclear whether the most severe accident considered by the YMEIS falls into category 6 or category 8.

Since the current analysis is for an accident requiring cleanup costs, the cost involved with initial emergency response will be a relatively small component of the overall costs. For this reason, we are using the values suggested in the RADTRAN IV example problem, keeping in mind that this is likely to result in an underestimate of the true cost of an accident.

Results:

The first step in using RADTRAN IV is to ensure it calculates similar health consequences to those calculated using RADTRAN 5. This is done to check our inputs as well as to check the program itself. We took the inputs from the RADTRAN 5 calculation of impacts from 10-year cooled, 4 $\mu Ci/cm^2$ CRUD density, spent nuclear fuel transported in a rail cask containing 26 PWR assemblies. We assumed the same population density (4932.5 persons/km^2) and release fractions for maximum accidents. The comparison is given below.

Comparison between RADTRAN 5 and RADTRAN 4

Program used	Population Density persons/km^2	Spent Fuel Age years	Crud Density Ci/cm2	Crud Inventory* Ci	Population Dose person-rem	Expected LCFs
RADTRAN 5	4932.5	10	4	4.36	915000	457.5
RADTRAN 4	4932.5	10	4	4.36	857000	428.5

The table shows that RADTRAN 4 computes consequences that are reasonably close to those given by RADTRAN 5. The conservative nature of the calculated consequences using RADTRAN 4 when compared to the consequences calculated using RADTRAN 5 suggest that the economic impacts could be greater than those calculated and reported here.

The following table shows the results of all RADTRAN 4 calculations performed by RWMA. It shows the economic consequences of a severe spent fuel accident to be crippling.

RADTRAN 4: Calculations of Economic Impacts of Max. Reasonably Foreseeable Rail Accident

File Name	Spent Fuel Age	CRUD Inventory*	ECONF	ONSCST				EMRCST	Pop. Dose	Expected LCFs	Economic Cost
	years	Ci	*	RF = 0	0<RF<.01	.01<RF<.1	RF>.1	$	person-rem		$
one.in4	10	4.36	1	250	2400	2400	5000	2500	857000	428.5	4.53E+09
two.in4	10	4.36	2.08	250	2400	2400	5000	2500	857000	428.5	9.42E+09
three.in4	10	56.03	1	250	2400	2400	5000	2500	864000	432	4.53E+09
four.in4	10	56.03	2.08	250	2400	2400	5000	2500	864000	432	9.42E+09
five.in4	10	4.36	1	250	2400	2400	5000	1700	857000	428.5	4.53E+09
six.in4	10	4.36	2.08	250	2400	2400	5000	1700	857000	428.5	9.42E+09
seven.in4	25.9	0.55	1	250	2400	2400	5000	2500	852000	426	4.53E+09
eight.in4	25.9	0.55	2.08	250	2400	2400	5000	2500	852000	426	9.42E+09
nine.in4	25.9	7.09	1	250	2400	2400	5000	2500	853000	426.5	4.53E+09
ten.in4	25.9	7.09	2.08	250	2400	2400	5000	2500	853000	426.5	9.42E+09
eleven.in4	25.9	0.55	1	250	2400	2400	5000	1700	852000	426	4.53E+09
twelve.in4	25.9	0.55	2.08	250	2400	2400	5000	1700	852000	426	9.42E+09

One more analysis was done to perform a sensitivity analysis on the impact of the cleanup level on economic costs. For this scenario, we reran file "eight.in4," which corresponds to 25.9-year cooled fuel, corrected to 2000 dollars, this time using a CULVL value of 1.0 $\mu Ci/m^2$, the maximum level allowed by RADTRAN IV. In this case, the calculated economic cleanup cost was $3,180,000,000, about 1/3 the cost of the $0.2 \mu Ci/m^2$ cleanup level case.

It is important to note that the economic figures obtained through the RADTRAN IV code are extremely conservative. Regardless, the estimated consequences are crippling.

ATTACHMENT CC

Radioactive Waste Management Associates

Memo

To: R Halstead

From: M Lamb and M Resnikoff

Date: 02/22/00

Re: Comment Summary – Yucca Mtn Draft EIS

Summary

After reviewing DOE/EIS-0250D, *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (July, 1999), with emphasis on the transportation of spent fuel to the proposed repository, a number of questions have been raised which need answer. Below is an outline summarizing some of the key deficiencies of the EIS. Many of the comments listed below follow a central theme: the EIS uses outdated experimental data and improper mathematical models to arrive at unbelievable estimates of health consequences due to incident-free transportation and accident scenarios. No new experiments have been performed to assess shipping cask response to postulated accident conditions or sabotage scenarios, even though the current generation of casks bear little resemblance to the casks used in experiments cited by the current EIS. No new estimation of the frequencies of severe accidents is made, even though rail and highway conditions, such as speed limits, have changed since the cited studies were performed. Computer models estimating release fractions in a terrorist strike are used which cannot properly model the casks involved. When the deficiencies in the EIS's treatment of transportation are assessed, it becomes clear that new experimental studies are necessary to provide a realistic assessment of the costs of transportation. These new experiments must involve an updated Modal Study, new experiments concerning modern cask response to sabotage events, and new traffic surveys estimating the frequency of severe accidents. The outlined points below are just brief summaries, and detailed analyses of each point will be provided at a later date.

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1. Use of data from the Modal Study to estimate accident severities and probabilities of severe accidents

1.1. Use of "mid-lead" temperature as parameter determining accident severity

1.1.1. Lead (MP 621°F) will stabilize the inner core temperature in the event of a fire until it is completely melted. This has the affect of insulating the inner core from temperature increases for an extended period of time. Uranium, with a much higher melting point, will not melt, resulting in an inner core temperature that will rise constantly with heat input; therefore, inner cores of newer casks are expected to have higher temperatures during a fire of a given intensity.

1.1.2. The use of mid-lead temperature results in grouping of all fires with temperature greater than 1050°F into one consequence category, since lead-nickel alloying occurs here, weakening the integrity of the older casks. Since uranium and/or stainless steel will behave differently under temperature duress, new classifications based on its properties must be used for categorizing fire intensities.

1.2. Use of "reference cask" containing a water jacket neutron shield

The Modal Study models the dead air space resulting from the evaporation of the water jacket neutron shield to reduce the heat transfer rate from a fire to the cask by over 70%. Modern casks use polypropylene, not water jackets; hence the estimated heat transfer rate in fire events is a significant underestimate of the behavior of modern casks (Audin states this may result in a reduction in the time it takes to melt the lead cask from 1.09 hours to 20 minutes)

1.3. "Lead cask bias" used to select most appropriate measurement parameter

The decision to use strain on the inner cask wall as the primary measure of cask response is based on lead's tendency to "slump" when subjected to high loading, resulting in high strains on inner cask wall. However, uranium and/or stainless steel, is strong and rigid and thus will not slump. Rather, the force from impacts will be transferred to the joints and welds of the cask, likely resulting in a greater force being applied to them than those in a lead cask. The choice of strain as the sole measurement parameter for physical duress will likely lead to an underestimation of the damage caused to newer casks through rupture of welds and seals in the event of an accident. Therefore, new experiments must be performed to model this behavior.

1.4. Incorrect use of "distribution" and "frequency" of velocities

The EIS states that, even though the average speed limit on national interstates has increased since the Modal Study, the distribution of accidents, and the frequency distribution of accidents, on the highways is not likely to change. However, no evidence is

...435 cited to support this statement. The National Highway Safety Traffic Administration (NHTSA 1998), along with numerous other agencies, have provided evidence that increases in speed limit lead to more accidents, more fatalities, and a greater proportion of vehicles traveling at higher speeds. All of these suggest that the DOE is incorrect in claiming that increased speed limits will not affect accident severity distributions. In one study assessing the change in Interstate fatalities in states which raised the speed limit in 1995, the NHSTA discovered that "Interstate fatalities experienced a statistically significant increase in those states that raised their posted speed limits late in 1995 or early in 1996." (NHTSA 1998) Further, the Insurance Institute for Highway Safety reported that distributions of travel velocities do indeed change with increased speed limits. For example, the Institute cited traffic statistics in New Mexico, finding that "the proportion of motorists exceeding 70mph grew from 5 percent shortly after speed limits were raised [from 55 to 65 mph] to 36 percent." (Institute). This shows that the EIS's statement that traffic velocity distributions will not be affected is incorrect, which leads to the conclusion that the probabilities of severe accidents used by the EIS are also incorrect and likely to be underestimates. This provides another reason why the Modal Study is not useful or relevant to current transportation conditions.

1.5. Improper assumptions regarding the location of severe accidents

The Modal Study correlated severe accidents with high velocities, concluding that the most severe accidents will take place, both for rail and truck, in rural environments. However, most severe rail accidents take place at downgrades, which are as likely to be located in suburban areas as rural ones. Further, the probability of a severe truck fire is greater in urban and suburban environments then it is in rural ones. Refer to Resnikoff, 1993.

In determining severe accident scenarios, the EIS assumed that severe accidents had an equal probability of occurring anywhere, with the probability in each population zone being determined by the length of time each truck or train passes through it. Since trucks and trains spend less time in urban zones, some of the most severe accident scenarios are considered "not reasonably foreseeable" in urban areas. Accident data does not support the assumption that severe accidents are randomly distributed (Resnikoff, 1993). Therefore, the DOE needs to assess the consequences of these most severe accidents as occurring in urban zones.

1.6. Improper Exclusion of most severe accident scenarios

1.6.1. The Modal Study used as its "average highway conditions" a stretch of Interstate 5 in Los Angeles and Orange counties. For example, it tallied the number, height, and geographic conditions of the bridges on this stretch and used these to estimate the number of bridges of a certain height. This was then used to estimate how many tall bridges existed in the entire nation for spent fuel trucks to cross. Using this, it was determined that an accident involving a truck falling off a high bridge was not

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"reasonably foreseeable" and its consequences were not determined. Since this stretch of highway is dominated by urban areas, the distribution of bridge types is biased in favor of small, short bridges, like the ones that cross over other roads. This is not representative of national conditions and leads to the unnecessary exclusion of a potentially disastrous consequence.

1.6.2. The Modal Study assumes that the probability of train accidents involving the falling off of a bridge is the same as that for the highway scenario, with the geographic conditions also taken from the highway estimations. More clearly, the Study used data taken from Interstate 5 to estimate the geographic conditions of national train routes, including bridge heights. Thus, the same argument given for the highway scenario (point 1.5.1) holds here, but more so since there is no proof that highway and rail conditions are similar.

1.6.3. The method of rejecting accidents having a yearly probability less than one in 10 million is arbitrary and incorrect when performing a probabilistic risk assessment. The product of the probability and the likely consequences are what determine significance in a risk assessment.

1.6.4. DOE consistently offers estimations of health effects due to transportation without giving a range of likely effects in the event of an accident. This is based on the assumption that the effects given are "conservative." However, the points raised here show that the studies are not conservative: unless new studies are performed, a range of possible health effects should be given.

1.6.5. If the DOE insist on using the "reasonably foreseeable" criteria of 1 in 10 million mentioned above, improper accident distribution data, unknown cask response to accident conditions, and improper estimation of accident probabilities (all mentioned above) will make some circumstances not deemed "reasonably foreseeable" in the Modal Study "reasonably foreseeable." These events must be considered in any acceptable consequence analysis.

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2. Improper Attention to Sabotage and Terrorism Scenarios

2.1. Inadequate Selection of "Reference Weapons"

2.1.1. The 1999 Sandia Study (Luna et al) needs to be more specific on the type of device it selected for computer simulation. Although the report claims that the vagueness was necessary to prevent the document from being classified, it is necessary to provide more details so a thorough analysis of its findings can be performed. This is the only way to test the validity of the computer simulations used in the report.

2.1.2. The DOE needs to make clear exactly what range of devices is available for consideration as "reference devices." It is our belief that devices such as the Milan

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Anti-Tank Missile and the US TOW 2 Anti- Tank missile, reported to have armor-penetrating capabilities of greater than 1000mm (39.4 inches) and greater than 700 mm (28.5 inches), respectively, must be considered (Norris).

2.1.3. All Sandia reports considering sabotage implicitly assume that a terrorist attack will involve a single strike using a single charge or missile. However, some devices can be fired multiple times in quick succession: the US TOW 2 can be fired up to three times in 90 seconds (Norris, Halstead & Ballard). The DOE needs to address the potential for a multiple-strike terrorist attack, which is likely to cause significantly more damage then the scenario modeled in the Sandoval and Luna reports.

2.2. **Improper extrapolation of previous experiments to current cask designs**

2.2.1. Use of "Swept Volume" as a surrogate for fraction of respirable material released

2.2.1.1. The equation listed in the Luna report which attempts to define a "swept mass" solely in terms of the geometric properties of the hole left by the charge does not balance its units. This will be analyzed in detail in the Review Comments. If this equation turns out to be invalid, the entire analysis performed in the Luna report and cited in the EIS becomes irrelevant, requiring a completely new analysis. Until this is addressed the results correlating swept volume and respirable aerosol production cannot be trusted.

2.2.1.2. The relationship assumes that there is only one hole into the fuel cask (i.e. an entry hole but no exit hole). Multiple holes will significantly increase the amount of respirable material released (Luna estimated it to be by a factor of 10). Due to the possibility that certain weapons can completely penetrate a cask, or that a cask will be penetrated by multiple shots, any relationship relying on a single hole entry into the cask is not credible as a worst-case scenario.

2.2.1.3. The "one hole assumption" results in another underestimation of the fraction of respirable aerosol produced by the oxidation of UO_2. Assuming a cask is fully penetrated, this will create a flow of oxygen into the cask, which will result in the oxidation of UO_2 to U_3O_8, a fine powder of mostly respirable particles. This oxidation rate is increased significantly at temperatures above 250^0C (Aronson). Temperatures this high will be likely in the event of a missile strike coupled with a fire. This significant source of respirable aerosols was not accounted for in the Luna correlation exercises.

2.2.1.4. Using a geometric correlation assumes that all casks, and all devices used in an attack, will exhibit the same thermal properties as the cask in the Sandoval experiments. Since the thermal properties of uranium are very different from lead, this will not be the case. Because of this, it is not enough to simply

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assume a relationship between aerosol released and swept volume, and use this to estimate releases in unrelated casks. This ignores the thermal mechanisms of aerosol generation, such as oxidation of UO_2 under elevated temperatures. Further, different attack devices will impart a different amount of heat into the cask, resulting in different aerosol production rates as a function of thermal input. This will be likely to change to relationship between swept volume and aerosol released, making any correlation attempt between different casks or different devices trivial.

2.2.2. Estimation of respirable aerosol produced due to breach of pressurized rods

Luna cited irrelevant data to estimate the amount of surrogate fuel aerosol that could be created within the cask and released in the event of a breach. The cited experiment showed a linear relationship between the energy density in the material from the impact of a calibrated hammer on brittle objects and mass of particulate material having diameter smaller than 10μm. However, the materials chosen were refractory to ensure that melting and vaporization were not observed. In the event of a missile strike, temperature effects are likely to be extremely significant. Therefore, any study that tries to estimate aerosol production as a function of energy density, but does not include temperature effects, is irrelevant and should not be used. Because of this, the estimate of 5% aerosol production due to HEDD impact is not accurate or conservative. It may do better to assume that all of the uranium mass not accounted for in the Sandoval studies (assumed to be inside the cask and deposited on its walls) was of respirable size and able to be expelled in the event of cask compromise. This will significantly alter the consequence analysis, since about 1% of the total UO_2 mass, and 37% of the mass released from the pins, was "unaccounted for" in the Sandoval full-scale experiment. A direct measurement of the amount of material deposited inside the cask walls is necessary to estimate how much aerosol is produced due to HEDD action. Therefore, a new study is recommended with more complete sampling procedures in order to obtain an experimental value for the respirable aerosol production due to the HEDD. The 5% value assumed is likely to be low.

2.2.3. Unsubstantiated reduction in the spent fuel-surrogate fuel ratio

Luna attempts to reduce the value used by Sandoval which accounts for the fact that spent fuel will produce more respirable aerosols then the surrogate fuel used in most experiments. Luna quotes the following experimental estimations of this ratio: .53, 5.6, .71, .42, 3, 2.8, 2.5, 3, 12. From this, it is estimated that 3 is the most appropriate ratio, even though the range of experimentally-determined ratios differs over 3 orders of magnitude. Further, after Luna (correctly) dismisses all values less than 1.0 as implausible, it would make sense to use the largest cited value for a conservative approximation. Alternately, the geometric mean of a large distribution of numbers is

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often used for estimation purposes (a value of 4 in this case), so long as a range based on the standard deviation about the mean is given as well.

However, more likely is that the large distribution of estimated ratios suggests that there is no clear, reproducible relationship between the amount of spent fuel and surrogate fuel aerosols produced from a blast of given intensity. Thus, it is argued that *no* ratio is acceptable. Rather, the inconsistent data suggest that the only way to determine spent fuel response to a detonation is to detonate a cask containing spent fuel and analyze the results. Short of doing this, the correlation used by Luna is arbitrary, non-conservative, and unacceptable.

2.3. SCAP computer code used without sufficient benchmarking

The Luna study attempts to utilize a computer model as a replacement for actual experimentation in order to determine the possible damage caused by two HEDD's on state-of-the-art shipping casks. However, the code that they use admittedly does not model multi-layered targets well. The Luna study "benchmarks" the SCAP code against the Sandoval full-scale test and determines that the code predicts penetration depth well, but underestimates the size of the hole created by the penetration. In an attempt to remedy this, the Luna report multiplies the predicted hole size by a factor of 2.0 to obtain "correct" results, then proceeds to do the same when modeling other cask designs. This approach is seriously incorrect. It assumes that the code will consistently model all cask layer or shell arrangements, including different numbers of layers, which is incorrect. With no experimental data to prove this, this assertion is unacceptable. It cannot be assumed that a computer code which, when used to model multi-layered targets could result in "serious difficulties in comparing SCAP modeling output and experimental data" (Robinson), would be expected to model, for example, a lead-steel interface with the same degree of incorrectness as a lead-uranium interface. Therefore, until an experimental proof of the merits of using the SCAP code to model the behavior of a shaped charge strike on a uranium-shielded cask is performed, the code cannot be considered validated. Further, since the code underestimated the true size of the hole in the Sandoval experiments, it cannot be assumed that this code will provide a conservative approximation of penetration damage. This leads to the call for a full set of experiments designed to determine the true effect of a HEDD explosion on cask integrity.

2.4. Omission of two important sabotage scenarios

2.4.1. Nevada intermodal transfer station sabotage event

The EIS, on pg. J-95, states that section J.1.5 evaluates the effects of sabotage on intermodal transfer stations. However, there is no section J.1.5, and there is no mention of this potential sabotage event again. It is essential to perform an analysis of the likely effects of a successful sabotage event on an intermodal transfer station because of its unique conditions. For one, shipping casks at an intermodal station

...436 will be stationary. This eliminates some of the problems associated with striking a moving target optimally that were presented in the EIS. Also, this makes the possibility of a multiple-cask release possible. Third, the appeal among potential saboteurs of attacking a station rather than a truck or train must be addressed. Intermodal transfer will also occur at reactor sites without rail access. All of these factors suggest that the potential for sabotage at an intermodal station must be addressed in a comprehensive manner.

2.4.2. Barge transport sabotage event

The EIS does not consider the consequences of a possible sabotage event on a barge shipment of spent nuclear fuel. As this is one of the transportation options being considered, it is important to consider the effects of a successful sabotage event, including the breach of shipping casks and release of radioactive material into the air and water, especially near populated areas, water supplies, or natural environments. It is essential to address this concern, especially since there was no discussion of the consequences of severe barge accidents, which were determined by the EIS to be not reasonably foreseeable.

2.5. **Failure to identify/profile potential "Threat Groups"**

It would be helpful to provide some general profiles of potential "Threat Groups" in terms of characterizing exactly what these groups are capable of doing, and the relative likelihood of each group performing a sabotage act. This would help in determining what types of weapons, forces, expertise, etc can be expected to be utilized by different groups, providing the DOE with a better estimate of what safeguards must be put in place. The *Final Environmental Impact Statement: U.S. Spent Fuel Policy, Storage of Foreign Spent Power Reactor Fuel* (1980: DOE/EIS-0015) provides a list of "Threat Groups" to nuclear fuel storage and transportation; a similar, but updated, list would be helpful.

2.6. **Improper dismissal of considering the probability of terrorist events**

The EIS and the Luna report both consistently state that, since sabotage events are not randomly occurring, no estimation of their probability can be made, other than assuming they are "extremely rare." However, some comment should be made concerning the increase in large-scale terrorist attacks and how this relates to the need for sufficient safeguards against such attacks. Even though attacks are not random events, some effort should be made to identify trends, such as the increase in attacks on American soil over the last few years. This provides a proper foundation through which to analyze the level of protection required from terrorist attacks.

2.7. **Failure to present a true "worst case scenario" for consequence analysis**

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2.7.1. Use of "averaged" wind conditions instead of wind blowing in one direction

The inputs used by the DOE in determining health effects of a successful sabotage scenario assume generalized wind conditions. For a true worst-case scenario, the impact of a radiological release directly downwind from a large population center, such as an office building, prison, stadium, etc. must be addressed. The use of wind conditions averaged over all directions dilutes the effect of a single-direction wind event.

2.7.2. Use of "average" (neutral) weather conditions, instead of worst-case conditions

The EIS states that, because the time and place of a sabotage event cannot be predicted, average weather conditions for the entire United States must be used. However, it seems likely that potential saboteurs will, to the degree feasible, plan sabotage events around those weather conditions that are the most damaging. Thus, for a true "worst case" sabotage scenario, weather conditions leading to the greatest consequences should be used.

2.7.3. "One bullet assumption"

As has been previously discussed, the consideration of only a single HEDD strike in the simulation of a sabotage event is unrealistic. Terrorists who are serious about causing a significant release of radioactive material, and who have the means of obtaining armor-penetrating weaponry, will likely bring a complete arsenal, including several armor-penetrating devices, incendiary devices, etc. Therefore, cask response to multiple missile penetrations, especially if they are fired in succession such that missiles strike an already damaged cask, must be addressed. It is extremely likely that the damage done to an already-penetrated cask will be substantial. This has not been assessed by the DOE and must be in order for the sabotage portion of the EIS to be considered complete.

2.7.4. Failure to consider effects of breached cask coupled with long-duration fire

The EIS assumes that there will be no significant secondary effects on the cask after missile impact, since the casks themselves are not flammable. However, the trucks and trains carrying them are flammable. Further, there is the possibility of deliberately causing a fire, either by truck bomb or other method, to intensify the damage from a penetrated cask. This scenario must be taken into account.

2.8. **Failure to assess social, psychological, environmental, or economic costs**

In order to be able to truly assess the consequences of a successful sabotage event, the full scale of effects must be studied. The DOE has commissioned studies addressing the

...436 psychological impacts of radiation accidents on the public, but similar studies have not been performed for this EIS. In addition, no consideration of the cost of cleanup of such an event is given. Below is a skeleton outline of the various factors not considered by the EIS that need considerable attention.

2.8.1. Social/psychological costs not addressed
- 2.8.1.1. Increased fear of nuclear energy, and nuclear industry
- 2.8.1.2. Fear of vulnerability to attack (see Oklahoma City bombing)
- 2.8.1.3. Susceptibility of foreign-born citizens to discrimination
- 2.8.1.4. Distrust of government that transports materials capable of such destruction

2.8.2. Environmental costs not addressed
- 2.8.2.1. Groundwater and/or surface water contamination→ more human costs
- 2.8.2.2. Loss of land use near site for significant amount of time

2.8.3. Economic costs not addressed
- 2.8.3.1. Cleanup costs
- 2.8.3.2. Decontamination costs
- 2.8.3.3. Lost workdays due to radioactive contamination of roads, buildings, etc
- 2.8.3.4. Loss of tourism in Las Vegas, eg, due to contamination or fear
- 2.8.3.5. Evacuation costs
- 2.8.3.6. Relocation costs

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3. Inputs to computer models predicting exposure levels

3.1. Use of temperature and strain as independent variables

Refer to Resnikoff, 1993. In many severe accidents, high impacts are coupled with vehicle fires. In predicting probabilities of accidents of a given severity, the probability of fire of a certain severity is multiplied by the probability of an impact of a given strain. This tends to underestimate the "true probability" of strain-fire accidents, as these two variables are not independent. This is another artifact of the Modal study needing revision.

3.2. Inconsistent assumptions made in RADTRAN4 and RISKIND

3.2.1. DOE employs RADTRAN4 for total risk, summing individual accident probabilities multiplied by consequences. RISKIND is employed to assess the maximum accident consequences. The assumptions employed should be identical, but they are not. RADTRAN4 assumes ingestion of contaminated food after an accident in rural areas in determining collective population dose; RISKIND assumes no radiological dose to populations from ingestion of contaminated food after an accident in determining maximum accident scenarios. It is unclear why these two inputs are different.

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3.2.2. In calculating effects to the maximally exposed individual in an accident scenario, the EIS assumes that this person is located 360 meters (~1200 ft) from the site. In calculating effects to the maximally exposed individual in a sabotage scenario, the EIS assumes this person is 140 meters (~460 ft) from the site. It is unclear where these distances came from, or why they are different.

3.3. **Incident-free exposure assumptions**

3.3.1. Escorts

DOE based its estimates of annual dose to escorts on regulations that we believe are insufficient to ensure the safety of the transportation vehicles. We recommend that these requirements be increased so that there is always at least one armed escort travelling in a separate vehicle from all truck shipments, and in separate rail cars for all train shipments. This will increase the estimated dose to escorts.

3.3.2. Individuals stuck in traffic

DOE assumes that individuals exposed to radiation dose due to being stuck in traffic near a transportation vehicle will occur only once per individual. However, personal driving patterns are not random, since people (especially commuters) tend to be on the same road at the same time of day. Therefore, persons being stuck in traffic near a transportation vehicle once are likely to be stuck multiple times.

3.4. **Population density**

The EIS uses average population densities from the 1990 Census to estimate the "worst-case" accident and sabotage scenarios. This ignores time-dependent, such as daytime population densities in cities due to worker commuting (Manhattan's population doubles every day), tourist population densities, special-event and localized densities. The maximum population densities used in the RISKIND code should reflect these factors.

3.5. **Characteristics of spent fuel used in accident consequence estimates**

3.5.1. Age of spent fuel

Simply put, the longer a given type of fuel is removed from a reactor prior to shipment, the less radioactive it is. Fuel which has cooled for a long time has had the time to undergo decay reactions, reducing its level of radioactivity. The DOE assumes in its estimates a spent fuel age of 25.8 years, even though fuel is only required to be cooled for 5 years prior to transportation. This results in a reduced estimate of hazard. Unless the DOE can show through legal requirements that spent fuel will be aged 25.8 years prior to shipment, it is not appropriate to use this age in its exposure assessments for incident-free and accident scenarios.

...437 A more likely scenario is that older fuel, already stored in storage casks at reactor sites or at the proposed PFS storage facility in Utah, will remain stored while newer fuel, stored in fuel pools, but aged more than five years, will first be transported off the reactor site so that reactors can be decommissioned more rapidly. DOE has established an acceptance quota for reactor fuel; for utilities, the most advantageous use is to further reactor decommissioning. Further, DOE would have to pay the cost of casks and transportation of this newer fuel. Older fuel would then be shipped at a much later date.

In a 25.8-year period, important radioactive contaminants in irradiated fuel will have decayed away. For example, Co^{60}, a main contributor to radiation dose from crud spallation, has a half-life on the order of 5 years. Concentrating on 25.8-year fuel decreases the amount of Co^{60} modeled by a factor of 2^5, seriously reducing possible radiological effects in the event of a release.

438 **4. Improper attention to Intermodal Transfer Station**

4.1. Crash scenarios analyzed

4.1.1. Airplane crash scenario

The airplane crash scenario assumes that the crash velocities will be those typical of takeoff and landing operations. As a worst-case scenario, the potential impact of a crashing military jet traveling at 600mph should be considered. This is likely to cause release of some radioactive material.

5. Economic analysis of transportation costs

439 5.1. The EIS did not assess the costs of severe accidents when assessing the transportation costs involved in the Yucca Mountain Project. In order to aid in the adequate preparation for potential accidents, an estimate of the true cost of remedying such an accident is essential. This assessment must include, but is not limited to, the following: emergency costs, surface cleanup costs, decontamination costs (of roadways, buildings, groundwater, surface water, etc.), hospital costs to injured parties, lost workdays due to building contamination, economic losses due to fear of contamination, loss of tourism (e.g., in the event of an accident in Las Vegas), evacuation costs, relocation costs, contaminated food embargo costs, insurance costs, legal costs, governmental costs, and so forth.

Summary:

The above points are not exhaustive: however, they give a good indication of some of the major
440...deficiencies in the EIS's treatment of transportation. Because of these deficiencies, it is recommended that DOE perform a completely new transportation assessment, using new experimental data. This new experimental data involves sabotage, transportation accident

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...440 frequencies, and transportation accident release fractions and consequences. For the sabotage experiments, it is recommended that new tests be performed subjecting modern rail and truck casks to multiple strikes with a TOW 2 missile or its equivalent. The computer model used in the Luna report is unjustified and unacceptable. For the accident release fractions, it is recommended that the DOE perform a new Modal Study, using modern truck and rail casks and developing new parameters with which to measure accident severity and cask response. Further, modern data needs to be collected concerning the effect of speed limit on accident distributions.