# Appendix N

Are Fear and Stigmatization
Likely, and How Do They Matter

Robert E. O'Connor studies the origins and consequences of risk perceptions. In the past 4 years his work has appeared in *Risk Analysis, Journal of Risk Research, Risk — Health, Safety, & Environment, Risk Decision and Policy, Public Understanding of Science, Social Science Quarterly, and American Journal of Political Science.* The U.S. Environmental Protection Agency is funding his present research on the development and application of ecological and socioeconomic indicators for integrated assessment of aquatic ecosystems of the Atlantic Slope in the Mid-Atlantic States.

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# ARE FEAR AND STIGMATIZATION LIKELY, AND HOW DO THEY MATTER

## Lessons from Research on the Likelihood of Adverse Socioeconomic Impacts from Public Perceptions of the Proposed Yucca Mountain Repository

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## Executive Summary

The report summarizes the research on perception-based impacts and stigma effects and uses this research to assess qualitatively the likelihood that perceptions of danger and of stigma, regardless of whether they are based on accurate scientific assessments, might result in adverse socioeconomic impacts on Nevada, particularly the Las Vegas area.

There is a consensus among social scientists that a quantitative assessment of the potential impacts from risk perceptions of the repository and the transportation of spent nuclear fuel and high-level radioactive waste is impossible at this time and probably unlikely even after extensive additional research. The implication is not that impacts would probably be large, but simply difficult to quantify. Social scientists do not know enough to identify what would be the level of concern during the operation of a repository. Similarly, we cannot specify the links between those attitudes and individual decisions that would have socioeconomic impacts. Based upon what we do know from surveys and from analogues, we can assess qualitatively what outcomes seem most likely.

**Effects from Perceptions of the Proposed Repository**
In the absence of a large accident at the repository or a continuing series of smaller accidents, there is little reason to expect adverse effects:

- Although, when asked, many people report that they think of nuclear things as dangerous, these attitudes are usually not salient in people's lives and therefore do not influence personal decisions.

- Yucca Mountain is 90 miles from Las Vegas.

- Studies show few indications of adverse socioeconomic effects (and many positive socioeconomic effects) in places that currently safely store or dispose of radioactive waste.

- People who choose to vacation in Las Vegas are less likely to be concerned about the repository than people who choose to vacation elsewhere. Opening a repository, if there is any impact, would likely reinforce the preferences of people who do not intend to visit Las Vegas with or without an operating repository 90 miles away. People who like to visit Las Vegas would likely pay little attention.

- If the repository would be such a powerful disincentive to investors, businesses considering relocating to southern Nevada, and retirees and others considering relocating in the area, some effects of those perceptions should already be apparent. It is widely known that Congress has ordered DOE to characterize Yucca Mountain for consideration for a repository and that key program documents suggest that the site may be acceptable. If the proposed repository is such a powerful disincentive, prudent investors, facing a possible opening of the repository, would not

be investing in southern Nevada. Similarly, we would see a decline in population in southern Nevada as businesses and people decide to settle elsewhere in anticipation of future risks and stigma. There is no evidence of this behavior. Indeed, the opposite is true.

The assessment that substantial adverse socioeconomic impacts from perceptions of the repository are quite unlikely assumes that operations at the facility will not have either a major accident (e.g., an explosion with a significant release of ionizing radiation bringing about exposures downwind, some cases of radiation poisoning, and deaths) or periodic smaller accidents (e.g., damaged canisters with some releases of ionizing radiation). These events would most likely raise fears about the repository, make the repository salient to people in southern Nevada, result in some social amplification of risk, and perhaps even stigmatize the region. Adverse socioeconomic effects from perceptions of an accident-prone repository might be substantial even with the repository 90 miles away. Without nuclear accidents at Yucca Mountain, these effects are quite unlikely.

**Effects from Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste**
Absent accidents, there is no reason to expect impacts for property owners in areas beyond the transportation corridors. Even absent accidents, however, two studies report that, at least temporarily, a decline in residential property values of approximately 3 percent may be expected in transportation corridors in urban areas. Data from other transportation experiences (e.g., transuranic waste to WIPP) suggest that impacts on property values might be negligible or nonexistent. More research on whether property values have fluctuated with the transportation of radioactive materials would be beneficial, although the research would not allow analysts to know with certainty whether there would be any impacts from perceptions of shipments of spent nuclear fuel and high-level radioactive waste to a Yucca Mountain Repository, or how long such impacts would persist.

# Are Fear and Stigmatization Likely, and How Do They Matter?

# Lessons from Research on the Likelihood of Adverse Socioeconomic Impacts from Public Perceptions of the Proposed Yucca Mountain Repository

## 1.0 Introduction

### 1.1 Background

In 1982, Congress passed the Nuclear Waste Policy Act (NWPA) to provide a framework for managing the nation's spent nuclear fuel and high-level radioactive waste. In 1987, Congress significantly amended the Act. These amendments directed the Secretary of Energy to study only Yucca Mountain as the site for a potential monitored geologic repository and, after completion of the studies, to recommend whether the President should approve the site for development as a repository. In response to the Act, the U.S. Department of Energy (DOE) has maintained a program of investigations and evaluations to assess the suitability of the Yucca Mountain site as a geologic repository, and to provide information for the environmental impact statement (EIS) required by the NWPA to accompany any approval recommendation.

The National Environmental Policy Act of 1969 (NEPA) process for the Yucca Mountain site has included meetings with the public to scope what DOE should include in the EIS and, subsequently, the publication of the *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* (U.S. Department of Energy 1999) (Draft EIS) in July 1999 and the *Supplement to the 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* (U.S. Department of Energy 2001) (Supplement) in May 2001. Many comments on the Draft EIS and the Supplement, including several from the State of Nevada, contend that DOE would strengthen the EIS by giving attention to the possible impacts of perceptions associated with the proposed repository and the transportation of spent nuclear fuel and high-level radioactive waste.

Several different individuals and organizations have examined the potential socioeconomic impact of perceptions. DOE sponsored some of this research itself. In addition, DOE has made funding available to the State of Nevada and to county governments in southern Nevada to hire experts to evaluate the DOE-funded research as well as to conduct their own studies. As a result, there is a substantial body of literature that has explored possible socioeconomic impacts of perceptions about the proposed repository and transportation of spent nuclear fuel and high-level radioactive waste to such a repository.

Early in the site evaluation process for Yucca Mountain, the State of Nevada suggested a potential for perception-based impacts to cause adverse effects to the socioeconomic environment of the State of Nevada. The State's concern was:

- If many people perceive significant risks to themselves associated with the transportation and disposal of spent nuclear fuel and high-level radioactive waste, and

- If those risk perceptions then influence individual behavioral decisions, then

- Nevada, and particularly the Las Vegas area, will become a less attractive location for vacations, relocation of individuals and families, and business investments and relocations.

The concern, at its most extreme, is that perceptions of the Las Vegas area as a dangerous place could bring about a mass stigmatization of the Las Vegas area as a place that people should avoid. This mass stigmatization could then lead to a collapse of the tax base of southern Nevada.

In 1986, the State of Nevada initiated research on these "special effects" to "... devise methods for characterizing and estimating the potential for this unique class of impacts" (Loux 2000, 4). Since 1986 the State of Nevada and, more recently, some of the counties and cities in southern Nevada have commissioned studies that have explored the potential impact of risk perceptions.

During the same period, the DOE kept abreast of the research reported by the State of Nevada and sponsored its own research efforts, primarily through Argonne National Laboratory. These efforts resulted in an annotated bibliography (Nieves et al., 1990) of the literature regarding socioeconomic impacts associated with perceived risks, as well as several research reports and articles prepared by scientists at Argonne National Laboratory.

In the mid-1990s two summaries of what social scientists knew at that time about the potential impacts of risk perceptions appeared. Both projects were independent of DOE.

- In 1995 the Nuclear Waste Technical Review Board (NWTRB) produced one of the summaries, drawing upon NWTRB staff resources as well as the results of a 2-day meeting with ten social scientists who had researched risk perceptions related to radioactive materials. The NWTRB, which Congress established in the NWPA to evaluate the technical and scientific validity of site characterization activities, wanted to develop a better understanding of the relevant issues and questions and to ascertain if they adequately could be addressed and assessed in the context of the potential repository at Yucca Mountain (NWTRB 1995b, 6-7).

- In 1997, Doug Easterling, who had participated in a number of the State of Nevada's research efforts, produced the second summary of the potential impacts of risk perceptions. He published in *Risk Analysis* a review of studies produced by the State of Nevada and others.

The NWTRB and Easterling reviews established a baseline, as of 1997, of the available research in the field of perception-based impacts and stigma effects. This report will draw upon their findings as well as the results from more recent work.

During the scoping process for the Draft EIS, DOE received comments on the need to address perception-based impacts and stigma effects in the EIS. Guided by the conclusions reached by the NWTRB summary and the Easterling article, and by its own research, DOE decided at that time that, while the possibility of such negative impacts cannot be dismissed as entirely impossible, the state of the science was not sufficiently advanced to anticipate and measure the occurrence or extent of such impacts with any reasonable degree of accuracy. Therefore, results of these types of analyses would be so uncertain or speculative that they would not provide any meaningful input for decision-makers.

Because of the nature of the comments received on the Draft EIS and the Supplement to the Draft EIS, DOE has elected to reexamine the relevant literature and assess the state of the research into perception-based impacts and stigma effects.

## 1.2 Purpose

The purpose of this paper is to summarize the research on perception-based impacts and stigma effects and to use this research to assess qualitatively the likelihood that perceptions of danger and of stigma, regardless of whether they are based on accurate scientific assessments, could result in adverse socioeconomic impacts on Nevada, particularly the Las Vegas area.

## 1.3 Data

This report does not involve the collection of new data gathered specifically for this effort. The author reviewed the available literature, including work supported by DOE, the State of Nevada, and others.

## 1.4 Scope and Organization

After the introductory section, Section 2 describes the research literature related to possible effects from perceptions. The section reviews two documents that summarize findings (the 1995 NWTRB report and the 1997 Easterling article) and significant research published since those summary works.

Then, Section 3 assesses the ability of social scientists to estimate the likelihood, based upon the literature, that people in Nevada would feel threatened by the repository if it is constructed and operated at Yucca Mountain. Also, the section assesses possible risks related to transportation of spent nuclear fuel and high-level radioactive waste along transportation corridors. Do social scientists know enough to estimate risk perception impacts with a high level of certainty? Based upon what we do know, what levels of risk perceptions seem most likely?

Section 4 assesses the likelihood that people who view the repository as risky and who say they would feel threatened would actually change their behavior because of fears of the repository. This is the link between expressed attitudes and behavior. Are social scientists certain that current expressed attitudes are good predictors of future behavior? In summary, can social scientists estimate with a high degree of confidence the impacts of the repository on risk perceptions, behavior, and the Nevada economy in general as well as on selected sectors such as tourism and gaming? Based upon what we do know, are significant impacts from perceptions likely?

Next, Section 5 assesses the likelihood of stigmatization of the region as a result of the repository and transportation of spent nuclear fuel and high-level radioactive waste, again using the NWTRB and Easterling work as baseline scholarship as well as drawing on more recent work. Do social scientists know enough to estimate the probability of stigmatization with a high level of certainty? Are people who are likely to stigmatize the region also likely to act upon their views? Based upon what we do know, is stigmatization likely? If stigmatization happens, will individuals change their behavior? What will be the most likely impacts on the economy as a whole, on particular sectors, and on property values along transportation routes? Based upon what we do know, are significant impacts likely?

Finally, Section 6 describes what the state-of-the-art of perception-based impacts allows us to conclude about these impacts and with what degree of certainty. Is quantitative risk assessment possible? What can we conclude about the likely impacts of perceptions about the repository program?

## 2.0 The Research Literature

### 2.1 Summaries Published in 1995 and 1997

This section first reports the findings from two documents, a 1995 NWTRB report and a 1997 article by Doug Easterling, that were not directly supported by funding from DOE. The authors of these documents sought to summarize what social scientists know about the possible effects of perceptions about the proposed repository and the shipment of spent nuclear fuel and high-level radioactive waste in the future. Then, the section reviews selected studies written since those summaries.

NWTRB Report to the U.S. Congress and the Secretary of Energy

On May 23 and 24, 1995, the NWTRB held a "Joint Meeting of the Panels on Risk and Performance Analysis and the Environment and Public Health" to discuss "Perceptions of Risk and Social and Economic Impacts" (NWTRB 1995b). Ten distinguished social scientists (Gilbert Bassett, Doug Easterling, Hank Jenkins-Smith, Stephen Kraus, Warner North, James Opaluch, Howard Schuman, Paul Slovic, Elaine Vaughan, and Lee Wilkins) examined the link between risk perception and socioeconomic impacts. These scholars represented a diverse range of social science disciplines and experience including economics, journalism, political science, psychology, sociology, and survey research. Some had received funding directly from DOE, some from the State of Nevada, and some from neither organization. The NWTRB sought to "ventilate the methodological, empirical, and analytic issues, the technical questions that would have to be addressed to reach a grounded and sound conclusion on the validity of the proposition" (NWTRB 1995b, 7) that "perceptions of risk associated with a repository lead to significant adverse social and economic effects" (NWTRB 1995b, 6).

Garry Brewer, chairperson of the NWTRB panels on Risk and Performance Analysis and the Environment and Public Health, ran the sessions that contributed to the NWTRB's annual *Report to the U.S. Congress and the Secretary of Energy* (NWTRB 1995a). He asked the social scientists to comment on the sequence that must occur in order for perceptions to lead to impacts that can be identified and mitigated or avoided. Brewer posited that, " ... the chain … begins with risk and risk perception, and works its way through behavior, and from behavior to impact, and from impact, in social and economic terms, to mitigation and compensation" (NWTRB 1995a, 3). The *Report* concluded:

- "What are the origins of risk perceptions?

  There is a strong understanding of what factors (attitudinal, demographic, cultural, knowledge) influence risk perceptions. Very little consensus has emerged about the relative importance of those factors" (NWTRB 1995a, 43).

- "What is the link between attitudes and behaviors?

  There appears to be only a modest link between attitudes, such as risk perceptions, and consequent behaviors" (NWTRB 1995a, 43). At the meeting, Brewer summarized, " ... it's very, very difficult, tenuous, risky, absent a real sensitive understanding of context, to go from one's best measured sense of risk perception to predicting behavior" (NWTRB 1995b, 64). Stephen Kraus agreed, "The bottom line is I came up with 80 or 90 studies that seemed to be good, fairly methodologically sound tests of this question, of do attitudes predict behavior, and the answer seems to be a definitive, sometimes" (NWTRB 1995b, 89).

- "How do individual behaviors translate into socioeconomic impacts?

> The relationship between individual behaviors and socioeconomic impacts has almost exclusively been inferred from anecdotal or case study evidence. Should another anecdote or case suggest a contradictory conclusion, no basis currently exists for distinguishing among different interpretations.... Moreover, other environmental, economic, and social conditions or trends could influence the socioeconomic well-being of southern Nevada, making isolating the impacts associated with a future repository very difficult" (NWTRB 1995a, 43).

- "How are impacts evaluated? How can they be compensated for or mitigated?

  > At the core of the compensation and mitigation issue are three questions: How do you know if some response is needed, especially for a project that will be implemented over the next century? How can any harm experienced be quantified in monetary terms? Are there certain types of harm that intrinsically cannot be compensated for or mitigated against either because of their nature or their magnitude? The social sciences have not yet provided very determinative answers to those questions" (NWTRB 1995a, 43).

The NWTRB concluded that, "Standard socioeconomic impacts have been analyzed in a variety of contexts using relatively standard methodologies.... Special socioeconomic effects, caused by perceptions of risk, are much more difficult to predict. Substantial theoretical, methodological, and conceptual obstacles need to be overcome before much confidence can be given to predictions of more than a few years" (NWTRB 1995a, 44).

Doug Easterling, "The Vulnerability of the Nevada Visitor Economy to a Repository at Yucca Mountain"

In 1997 *Risk Analysis* published Easterling's review of the "… studies commissioned by the Nevada Nuclear Waste Project Office to estimate the economic impact of a high-level nuclear waste repository at Yucca Mountain" (Easterling 1997, 635). The purpose of his article was to review the:

> "… socioeconomic research program undertaken by the NWPO [Nevada Nuclear Waste Project Office], outlining the research questions, methods, and findings from a variety of studies that examine the potential for visitor impacts. In general, these studies explore the question of whether a repository at Yucca Mountain would influence the decision to visit Nevada for a vacation, meeting, or convention.… Three distinct methodologies have been used to investigate visitor impacts: case studies, elicitation of behavioral intent, and theory testing…. The primary purpose of this paper is to describe what is known and what is not known and to help establish an agenda for future socioeconomic studies" (Easterling 1997, 636).

In addition to studies supported by the State of Nevada, the review recognized research commissioned by DOE, as well as research not sponsored by stakeholders.

Easterling describes the research commissioned by the State of Nevada as focused on three theories of visitor impact: risk-avoidance, negative imagery, and stigmatization. The "risk-avoidance" model is based on the standard theories of self-protective behavior; i.e., "… people avoid destinations they perceive to be risky" (Easterling 1997, 637). This model suggests that Nevada could suffer economic losses "… if potential visitors view the repository as a major hazard" (Easterling 1997, 637). Furthermore, the risk-avoidance theory suggests that "... the potential for economic losses increases if the repository is plagued by mishaps or mismanagement" and the effects might be compounded "... if repository-related concerns are highlighted by the media or interest groups" (Easterling 1997, 637). Regarding the construct of "negative imagery," Easterling states that researchers have assumed that the repository will work its way into the "image set" of places in the vicinity. "In other words, when people think of the prospect of visiting Las Vegas, the repository will become one of the images that comes to mind. The theory assumes

that this image will be highly aversive for the typical individual, and as such, will reduce the decision-maker's preference for visiting Las Vegas" (Easterling 1997, 637). Easterling points out that the risk-avoidance and negative-imagery models represent independent and complementary pathways to influence visitor decisions. That is, the negative imagery model suggests that visitors might avoid any place they feel has an unpleasant or noxious image, regardless of whether they perceive that location to be risky. The risk-avoidance and negative-imagery models both suggest that impacts on visitor decisions would be exacerbated by serious repository-related accidents with extensive coverage by the media.

The third theory, "stigmatization" is characterized as "... the extreme case of either the risk-avoidance or negative-imagery process" (Easterling 1997, 638). Easterling notes that "Stigmatization is likely to require a rather extreme initiating event" such as a "... radiation release as extreme as the Chernobyl accident ... but stigmatization is less likely under more benign scenarios" (Easterling 1997, 638). However, "... even if stigmatization does not occur, the repository could marginally increase the perceived risk and/or imagery associated with the state, which might still impact visitor behavior" (Easterling 1997, 638).

In his review of the historic research, Easterling summarizes both the "Nevada studies" and the "counter-evidence studies" and indicates that the research commissioned by the State of Nevada "... suggests that there are instances in which nuclear facilities have led to losses in the visitor economy of nearby communities" (Easterling 1997, 639), but the counter-evidence studies imply that there is little cause to anticipate visitor impacts. Easterling explains,

> "Some of this contrast stems from a difference in what the researchers were intending to demonstrate. Namely, the Nevada studies specifically sought out cases where economic losses had occurred in order to show that repository-induced impacts were within the range of possibility, whereas Metz [William Metz, Argonne National Laboratory] selected a set of nuclear-weapons facilities that he thought would provide a best-guess estimate of the consequences of a repository" (Easterling 1997, 639).

In other words, the Nevada studies have focused on case studies of accidents that might result in risk avoidance, negative imagery, and/or stigmatization, while the counter-evidence studies have examined the average long-term performance of nuclear facilities. Easterling concludes that the "... primary lesson to draw from the case-study approach is that the impact of a nuclear facility on the local economy depends almost completely on the severity of the events that occur over the lifetime of the facility" (Easterling 1997, 639).

The second element of research examined in the article looks at studies of intended behavior. The State of Nevada sponsored a series of surveys designed to elicit statements of intended behavior from a variety of groups (e.g., the general public, persons who vacation in Nevada, convention planners and attendees). The intent of these studies was to assess possible repository-related effects on respondents' behavior by asking them to "... consider a variety of repository scenarios and indicate how they would behave" (Easterling 1997, 640). These studies invariably found that, based on statements of intended behavior, Nevada would become a less desirable place to visit, start a business, relocate, invest, etc. As Easterling observes, however, "Still, one must acknowledge that the link between stated intent and subsequent behavior is far from perfect" (Easterling 1997, 642). The long period between conducting the survey and opening the repository increases disparities between stated intentions and actual behavior.

Finally, the article turned to the third component of the research commissioned by the State of Nevada: studies to understand visitation decisions. The intent of this research was to test the three theories of visitor impact—risk avoidance, negative imagery, and stigmatization—to the degree possible in the

absence of an operating repository. The research examined several propositions associated with these theories:

- Does perceived risk influence behavior?
- Would a repository increase perceived risk for Nevada?
- Does imagery influence visitation decisions?
- Is negative imagery associated with a repository?
- Will repository imagery be aligned with Nevada?

Easterling indicates that the answer to each of these propositions probably is affirmative. There is evidence that suggests risk perceptions influence behavior, perceived risk has remained high for the repository during the period of the studies, imagery does appear to influence visitation decisions, and the imagery associated with a repository largely is negative.

Easterling suggests caution, however, before accepting the proposition that reduced tourism and fewer conventions will occur because of negative imagery from the repository and shipments of spent nuclear fuel. If those individuals who already hold a negative image of Nevada (based on negative attitudes toward legalized gambling, for instance) are also disproportionately the same people who will develop a negative imagery of Nevada because of the repository, "... then we might see only a further alienation of Nevada among the state's detractors, not avoidance among persons who currently visit the state" (Easterling 1997, 645).

Easterling also urges caution regarding the last proposition, that people will necessarily associate the repository with Nevada. Now, when asked about their image of Nevada or Las Vegas, few respondents associate the repository with Nevada, perhaps because the facility has not yet been built. He also notes that the long history of the Nevada Test Site does not appear to be a "... prominent part of the public's mental landscape of Nevada, which calls into question the proposition that people will associate a Yucca Mountain repository with Nevada" (Easterling 1997, 644).

The conclusion of Easterling's review focuses on many of the uncertainties inherent in the studies that he evaluated. He notes that the studies have shown that a "... repository at Yucca Mountain could have a negative impact on Nevada's visitor economy, but this is a possibility rather than an inevitability" (Easterling 1997, 645). He observes that the case studies of analogous facilities have shown that visitors sometimes avoided areas near nuclear facilities, particularly following a well-publicized incident involving radioactive contamination, but those studies do not allow a reliable assessment of when such impacts occur or the magnitude of the impacts. Easterling states, "... the studies of intended behavior provide reason to believe that visitation decisions will be influenced by a repository (at least under severe scenarios), but these studies are subject to substantial imprecision" (Easterling 1997, 645). Regarding the tests of visitor-behavior theories, studies "... support the possibility of a repository leading to avoidance behavior, but uncertainties remain. We know that the perceived risk and imagery associated with a place have an influence on a person's likelihood of visiting that place, but we don't know how a repository at Yucca Mountain will influence the perceived risk and imagery associated with Nevada" (Easterling 1997, 645).

Easterling summarizes his review, "The bottom-line conclusion from these studies is that repository-induced impacts are possible, but uncertain. Furthermore, much of this uncertainty is irreducible" (Easterling 1997, 645). Under a benign scenario, with incident-free operation of the facility and dissipation of controversy, "... the repository would likely have a benign impact on decision-making. On the other hand, if one assumes a severe repository scenario—with a set of high-publicity accidents and controversies—there is a very real potential for significant visitor impacts, in the extreme stigmatizing Nevada as a contaminated place to be avoided. If two researchers make different assumptions about how

the repository will perform, they will inevitably arrive at competing economic forecasts" (Easterling 1997, 645).

The conclusions of both independent reviews—the NWTRB Report and the Easterling article—are consistent. The researchers seem in agreement on several points:

- While the body of research, both directly associated with a potential Yucca Mountain repository and unrelated studies, is extensive, significant uncertainties regarding the crucial questions of the effects of public perceptions remain.

- The evidence suggests that there is some understanding of how perceptions are formed, that those perceptions might influence individual behavior, and that those individual behaviors collectively might in some instances lead to socioeconomic impacts. The understanding of those relationships, however, is limited and contextual.

- The repository and transportation of spent nuclear fuel and high-level radioactive waste would not necessarily have either substantial or negative socioeconomic effects from perceptions, although it is possible to conceive of circumstances that would bring about significant negative socioeconomic effects.

- Social scientists have a quite limited capability to measure accurately the occurrence, timing, and extent of socioeconomic effects from future perceptions. There is great uncertainty about (1) the nature and intensity of future perceptions related to the repository and the transportation of spent nuclear fuel and high-level radioactive waste if DOE built the repository, (2) the link of such perceptions to individual behavior, and (3) the link between individual behavior and socioeconomic impacts.

The next sections describe the research since 1997 to report fresh insights and to examine whether the conclusions of 1995 and 1997 require revision.

## 2.2 Description of Research Since 1997

Most of the research related to risk perceptions published since the Easterling article in 1997 is only tangentially related to the possible socioeconomic impacts of a repository and transportation of spent nuclear fuel and high-level radioactive waste. Much of the research has focused on developing a better understanding of the etiology of perceived risk. Scholars have looked to cultural theory (e.g., Shrader-Frechette 1997; Sj`berg 1998a; Marris, Langford, and O'Riordan 1998; Brenot, Bonnefous, and Marris 1998; Grendstad and Selle 2000; Langford et al. 2000), trust (e.g., Sj`berg and Drottz-Sj`berg 1997; Earle and Cvetkovich 1998; Peters, Covello, and McCallum 1998; O'Connor, Bord, and Fisher 1998; Greenberg and Williams 1999; Slovic 1999; Siegrist 2000; Siegrist and Cvetkovich 2000; Siegrist, Cvetkovich, and Roth 2000; Sj`berg 2001), the role of worry in risk perception (e.g., Sj`berg 1998b; Baron, Hershey, and Kunreuther 2000), and how perceptions of benefits influence risk perceptions (e.g., Slovic 2000; Finucane, et al. 2000). Other research has focused on risk communication (e.g., Long and Fischhoff 2000; Siegrist and Cvetkovich 2001; Chess 2001), the willingness to pay for "zero risk" (e.g., Burger et al. 1997; Nakayachi 1998), and how risky experiences change perceptions (e.g., Rogers 1997).

The authors of five studies published since the Easterling article intended their work to address issues of the socioeconomic effects of perceptions of the proposed repository. This section will review each of those studies in turn.

William Metz and David Clark, "The Effect of Decisions about Spent Nuclear Fuel on Residential Property Values"

In an article funded by DOE and published in the same 1997 issue of *Risk* Analysis as the Easterling article, William Metz and David Clark attempt to determine if property values in the vicinity of two nuclear power plant sites were affected by decisions at the facilities regarding spent nuclear fuel storage and extension of the permit to operate the reactors (Metz and Clark 1997). The data used in the study "... represent individual single-family residential property sales that took place between 1990 and 1994 within 15 miles of the Rancho Seco and Diablo Canyon nuclear plants" (Metz and Clark 1997, 574). The authors report their results: "... decisions and announcements about spent nuclear fuel storage activities have not affected the local residential property market to the extent predicted by surveys of attitudes and images. Our hedonic model results indicate that this finding of no property value effect is the case regardless of whether a plant is operating or closed or whether the high-level waste is to be placed in dry-cask storage facilities immediately or as part of a future action" (Metz and Clark 1997, 581). The authors do note, however, that "... these findings reflect only the current residential property value situation around the two California plant sites; we made no attempt to determine whether there were effects on residential property values at the time of the reactors' siting announcements and construction" (Metz and Clark 1997, 581).

The authors conclude that predictions based on surveys of public perceptions and images might overestimate negative economic effects as reflected in residential property values.

Hank Jenkins-Smith, "Modeling Stigma: An Empirical Analysis of Nuclear Images of Nevada

In 2001 Hank Jenkins-Smith published a chapter in *Risk, Media, and Stigma: Understanding Public Challenges to Modern Science and Technology,* edited by James Flynn, Paul Slovic, and Howard Kunreuther. Funded by DOE, Jenkins-Smith designed and implemented one survey with a national sample and a second survey with a longer questionnaire with residents of Phoenix, Arizona. He wanted to focus "on the processes by which individuals acquire images of different kinds, give value to them, and rely on them in development of preferences" (Jenkins-Smith 2001, 108). He sought to examine a general proposition:

> "… different kinds of individuals are quite likely to acquire and use distinct bundles of images. If this proposition is correct, when new kinds of images (e.g., nuclear ones) are introduced about that place, they are likely to be more readily acquired by some people than others, and once acquired are likely to be valued differently. If so, whether a new image will stigmatize to a place depends on how readily that image is acquired, how it is valued, and how it is attached to preferences for the place by individuals who would otherwise be attracted to that place" (Jenkins-Smith 2001, 108).

The findings of this study are important and worth quoting at length:

- "Some people are more likely to acquire nuclear images of Nevada than others….
- …. the valences attached to images about a place are very strong predictors of vacation preferences for that place. Thus, the more positive the valance of one's images about a place, the more likely it is that one will want to vacation there.
- The valances attached to images of a 'high level nuclear waste repository' appear to be reasonably valid measures of the positive and negative affect that people hold about a nuclear waste repository.

- Despite the implication of some scholars (e.g., Weart 1988) that nuclear imagery is overwhelmingly dread-filled, the valences that people attach to nuclear images of nuclear facilities have considerable variation, ranging from quite positive to quite negative.

- The valences that people attach to nuclear images are related to their cultural and ideological predispositions. Egalitarians and self-described liberals tend to have more negative nuclear image valences, and conservatives and fatalists tend to have more positive ones.

- Nuclear images are part of a broader set of images about Nevada, and the valences of nuclear images are correlated with the valences of other Nevada image categories. Those with more negative valences for nuclear images also tend to have more negative images about gambling, prostitution and entertainment.

- Valences of both nuclear and gambling images appear to be influenced by cultural biases. Egalitarians tend to give more negative valences to both gambling and things nuclear, while fatalists give more positive valences" (Jenkins-Smith 2001, 129).

Jenkins-Smith summarizes,

> "If a new and negative type image is widely introduced into the image sets of a place, the effect of that image on such activities as vacationing, relocating, and retiring will be in part dependent on how the new image is associated with images in the pre-existing image sets. If the new image (e.g., a nuclear image) is negatively associated with the valences of images that previously had served to attract people to the place (e.g., a pristine environment), then the nuclear image is likely to lead to greatest reduction in vacation preferences among precisely those people who used to be most attracted to the place. The wide dispersion of such an image might well result in a stigmatization among those people who used to be attracted to that place. If, on the other hand, the new image (e.g., a nuclear image) is positively associated with the valences of those images that previously had attracted people to the place (e.g., gambling), then the nuclear image will be most positive (or least negative) for those who are most likely to vacation in that place. Those who were least likely to vacation in the place before (those who assigned negative valences to gambling) are the ones for whom the new images will be most negative. In that case, people who didn't want to vacation there before will now want to vacation there even less" (Jenkins-Smith 2001, 130-131).

Louis Berger Group, Inc., Assessment of the Hazards of Transporting Spent Nuclear Fuel and High Level Radioactive Waste to the Proposed Yucca Mountain Repository Using the Proposed Northern Las Vegas Beltway

In 2000 the Louis Berger Group issued a report, *Assessment of the Hazards of Transporting Spent Nuclear Fuel and High Level Radioactive Waste to the Proposed Yucca Mountain Repository Using the Proposed Northern Las Vegas Beltway,* designed to assess quantitatively the economic impacts of high-level nuclear waste transportation. The study commissioned by the City of North Las Vegas states that the transport of spent nuclear fuel and high-level radioactive waste "... along the Northern Beltway could result in significantly lower levels of economic activity and property values in year 2020. These results are based on a comparison between a base forecast of employment and business activity in year 2020 and an assumption that the hazardous waste transport will alter the land use and industry in the study area" (Berger Group 2000, E-3). The assumption used to estimate the economic impacts is that, as a result of the perceived risks and stigma effects associated with radioactive waste transportation, "... no office development will take place in the study area" (Berger Group 2000, 94). The study projects demographic

losses in population and related employment; economic losses for reduced sales activities and employment earnings; and losses in property, sales, and state business taxes. The Berger report also asserts that the economic losses in North Las Vegas would result in larger losses in Clark County through a multiplier effect. Such losses would be reflected in reduced sales activities, employment earnings, collections of Nevada State Business Tax, and sales taxes (Berger Group 2000, E-4).

Urban Environmental Research, LLC, Property Value Impacts from the Shipment of High-Level Nuclear Waste through Clark County, Nevada (2000), Clark County Property Value Report on the Effects of DOE's Proposal to Ship High Level Nuclear Waste to a Repository at Yucca Mountain (2001)

In 2000 Urban Environmental Research, LLC (UER) issued a report prepared for the State of Nevada. In 2001 UER expanded the 2000 report by adding a review of the literature on the effects of "adverse environmental conditions" on property values. The purpose of this research by UER was to estimate potential property value effects associated with transporting radioactive waste through Clark County. The design involved interviewing Clark County residents who live near potential transportation routes and a small number of experts involved in lending for real estate investments in southern Nevada. The public survey (subcontracted to the University of Nevada at Las Vegas) asked residents their views on property values, how shipments of radioactive waste might affect these values, and whether residents who did not own property would consider buying near such routes. The other survey asked a small number of professional appraisers and bankers their opinion about how shipments of radioactive waste would influence their behavior and what they estimated would be the effects on property values near routes used for the shipments.

Residents, appraisers, and bankers all expect property values to decline near routes used to transport spent nuclear fuel and high-level radioactive waste. UER concludes, based on the residential survey:

> "Nuclear waste transportation is highly likely to significantly and adversely impact property values at least up to 3 miles from the routes. The reluctance to purchase residential properties near shipment routes by most of the Clark County population will not only result in property values declining but also may adversely effect (sic) the housing industry in the Las Vegas Valley and the level of revenue flow to local governments" (UER 2001, 71).

The conclusion from the survey of appraisers and bankers is that the value of residential properties within one mile of the route might be anticipated to decrease from 2.0 to 3.5 percent while the value of commercial and industrial properties might be anticipated to decline from 0.5 to 3.0 percent. The numbers would be much higher if there were transportation accidents.

These survey findings are typical of those of earlier work that most people say they prefer not to locate near anything nuclear, including transportation routes. The specific UER figures, however, are similar to the findings of the research on actual property values for one of the three counties studied by Gawande and Jenkins-Smith, as noted below.

Gawande and Jenkins-Smith, "Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks"

Rather than depend solely on survey data, Kishore Gawande and Hank Jenkins-Smith collected data on 9,432 real estate transactions in three South Carolina counties to model the effects of a series of highly publicized shipments of spent nuclear fuel to a storage facility at DOE's Savannah River Site. The study, funded by DOE and forthcoming in the *Journal of Environmental Economics and Management*, addressed the question of whether shipments of spent nuclear fuel reduced residential property values. Along with the data of actual real estate sales, Gawande and Jenkins-Smith designed and implemented a

survey that showed that many South Carolinians thought that a train accident and the rupture of spent fuel containers was likely. A majority thought that, if an accident occurred, "the nuclear fuel containers would break open and allow radiation to escape" (Gawande and Jenkins-Smith 2001, 7). The conclusions of the study indicate mixed results regarding property values:

> "Our analysis indicates that property values have reacted in different ways to the shipments in the three counties. No declines were evident in predominantly rural Berkeley and Aiken Counties, while an economically and statistically significant decline was evident in more populous Charleston County" (Gawande and Jenkins-Smith 2001, 2).

In Charleston County, "After the shipments began, the net gain in value associated with being five miles away from the route relative to a property on the route was nearly 3% of the average home value" (Gawande and Jenkins-Smith 2001, 22). There were no discernable results in the two more rural counties. Based on the different results for the three counties, the authors urge caution when making generalizations about the effect of spent nuclear fuel shipments on housing values. Gawande and Jenkins-Smith conclude, "Our results, if confirmed in further studies, indicate that there may be important distributional consequences of such shipments that should be considered in policy making. These consequences include suppressed property values when the shipments are highly publicized, controversial, and the focus of claims about extreme risk, as occurred in South Carolina" (Gawande and Jenkins-Smith 2001, 23).

## 2.3 Conclusions Regarding the Research Conducted Since 1997

The research since the summary article by Doug Easterling in 1997 has not challenged the conclusions he reached. Little new evidence has been developed since 1997 to address the fundamental uncertainties and improve our ability to anticipate accurately the occurrence, timing, or extent of those effects. Significant uncertainties regarding the crucial questions of the effects of public perceptions remain. We do not have a good understanding of the linkages among attitudes, individual behavioral decisions, and socioeconomic impacts. We cannot conclude that negative socioeconomic effects from perceptions regarding a repository and transportation of spent nuclear fuel are likely, although we cannot totally rule out negative effects. Many of the hypotheses involve assumptions that the proposed repository is unique and that tragic accidents would occur at the facility or with transportation. Data are not available to test these hypotheses because the facility is not open. Therefore, although additional research can tantalize and suggest possibilities, it cannot directly address the fundamental uncertainties of possible perceptual effects from the repository and the transportation of spent nuclear fuel and high-level radioactive waste.

Scholars supported by both DOE and the State of Nevada seem in agreement that the limitations and uncertainties noted by Easterling in his review still exist. During the November 1999 public hearing on DOE's water rights applications for the Yucca Mountain Site Characterization Project, James Flynn, formerly the project manager for the State of Nevada's study team, addressed whether Easterling's claims remain valid. Testifying for the State of Nevada as an "expert in risk, stigmatization and social amplification of risk," Flynn confirmed that Easterling's conclusions remain valid: Perception-based impacts and stigma effects associated with the proposed repository at Yucca Mountain are possible but not inevitable, and much of the uncertainty is irreducible (State of Nevada Department of Conservation and Natural Resources 1999, 150, 195-8).

Some of the work since 1997 assumes adverse effects and tries to tally the cost. The Berger Group study (2000) is an example of this type of work. The major limitation of the Berger Group study is that their assumption that no office development would take place near the Northern Beltway begs the question of what would be the impact of the selection of the Northern Beltway as a transportation route. The report assumes that the stigmatization of the Northern Beltway would be so intense that no businesses would be

willing to locate near the road. Assumptions are useful only to the degree that they reflect a basis in reality. While the Berger report provides a review of the perception-based impacts literature, the report provides little basis for the assumption that no office development will take place in the study area. Businesses (including business services, health services, communications, financial institutions, and legal, engineering, and management services) that serve a regional market and do not have to locate near a specific client or set of clients have the flexibility to choose a site based on the desire to avoid a stigmatized transportation artery. Still, there is no evidence in the literature that businesses would consider only the assumed stigma in making business office location decisions

The second problem with the Berger report is its overstatement of losses even if there were no new development in the transportation corridor. The study's baseline projections for 2010 and 2020 are based on land use master plans for the Northern Beltway area (Berger Group, Inc. 2000, 67) and a reasonable assumption that the types and mix of businesses attracted to the Northern Beltway area will be similar to those located near the recently completed Southern Beltway (Berger Group 2000, 75-76). While not explicitly stated in the report, some portion of the growth in the Northern Beltway area must be due to relocation of people and businesses from other parts of Clark County. This conclusion emerges from three lines of reason.

First, some of the people who will move to the Northern Beltway area are certain to come from elsewhere in Clark County. The Berger report projects a population increase of approximately 138,000 persons living within 2 miles of the Northern Beltway from 2010 to 2020 (Berger Group 2000, Tables 7-2 and 7-3). During the same period, Clark County and the University of Nevada, Las Vegas projects a total county population increase of approximately 331,000 (Riddel and Schwer 2000, p. 3). The Berger projected population increase along the 13-mile sector of the Northern Beltway is approximately 42 percent of the total projected population increase in the county. An increase in population for such a small area that contains such a large portion of the total increase in the county population does not appear to be reasonable unless it includes substantial relocation from other areas of Clark County.

Second, some of the new businesses along the Northern Beltway are certain to come from elsewhere in Clark County. Table 7-9 of the Berger Group report shows that many businesses in the Southern Beltway area had relocated from elsewhere in Clark County. There is no reason to assume that the same relocation activity pattern will not occur along the Northern Beltway. Such an activity is consistent with business location decisions to take advantage of new infrastructure.

A third reason for the overestimation of losses, even given the assumption that no firms would locate near the Northern Beltway, is that the report's conclusions require that businesses that decide not to locate near the Northern Beltway also not locate elsewhere in Clark County. The analysis and identification of losses (such as reduced tax revenues) are dependent on the assumption that businesses do not locate anywhere in the region where they would pay such taxes. Even if stigmatization of the transportation routes were to occur, businesses would still locate in Clark County. In such an instance, stigmatization would come into play only in terms of the selection of the specific site within the region.

In summary, the Berger Group report takes a worst-case assumption regarding stigma effects, an assumption not supported by any transportation-related stigma event in history. Within this scenario the report then overestimates negative impacts by ignoring the in-county nature of many individual and business location decisions.

The UER work also has limitations, although they are quite different from those of the Berger Group study. The major problem of the UER survey is with accepting the stated intentions as good predictors of behavior (and lower property values). One reason to expect a large attitude/behavior gap is the several years between the survey response and the actual transportation of radioactive waste if the repository

were to be built. The longer the time between expressing an attitude and having the opportunity to act upon it, the weaker is the predictive capability of the attitude. Finally, although there are no systematic studies of the effects on transporting radioactive waste on residential property values (with the exception of the 2001 Gawande and Jenkins-Smith study), there is much evidence of high property values near nuclear facilities (see, for example, Metz, 1994). It is not obvious why Nevadans would act differently.

Social science research on perception effects has had some important advances since 1997. Jenkins-Smith (2001) has made an impressive start toward elaborating the stigma model developed initially by Slovic et al. (1991). Jenkins-Smith shows that a repository and shipments of radioactive waste are less likely to bring negative socioeconomic effects through stigma than the earlier model had suggested. The people most likely to stigmatize Las Vegas because of its proximity to Yucca Mountain are the same people who already stigmatize Las Vegas for other reasons. They have no intention of relocating to southern Nevada with or without the repository. Still, more research on how different people make risk perceptions salient is needed.

Another advance is the work of Gawande and Jenkins-Smith (2001), the first systematic study of impacts on property values from the transportation of spent nuclear fuel. Highly publicized shipments of foreign spent nuclear fuel apparently did depress housing prices near the train tracks in an urban county, but had no effect in two rural counties. This is an important case study that calls for replication in other communities where DOE transports spent nuclear fuel, and for validation of the duration of the depression on housing prices. The policy implications for compensation and mitigation could be significant, particularly if the depression was of long-lasting effect.

The work of Metz and Clark (1997) also contributed to a better understanding of effects related to perception-based impacts by studying actual cases. Their study and the Gawande and Jenkins-Smith article (2001) indicate that economic impacts in the form of effects on property values can occur in some, but by no means all, situations.

## 3.0 Risk Perceptions of the Repository and Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste

This section is a qualitative assessment, based upon the literature discussed above as well as studies cited only in this section, of the likelihood that people would feel threatened in Nevada, and particularly the Las Vegas area, by the repository and transportation of spent nuclear fuel and high-level radioactive waste through southern Nevada.

In assessing the likelihood that Nevadans would feel threatened by the repository or the transportation of spent nuclear fuel and high-level radioactive waste, a number of observations are relevant:

- **Although a large proportion of people, when asked, report negative images of nuclear facilities and say they are risky, there is only weak and problematic evidence that people would feel threatened by a radioactive waste repository 90 miles away.**

One problem with testing hypotheses regarding whether people would be fearful of vacationing or living 90 miles away from a high-level radioactive waste repository is that there is no such repository anywhere that would allow social scientists to gather data to test perceptual hypotheses. The best we can do is to ask people to imagine how they might feel and to reason from analogies.

When social scientists ask people what they think of a radioactive-waste disposal facility, many report negative images related to risk (e.g., Slovic et al. 1991). This finding is by no means the same as a finding that many people would feel threatened by the repository if it were to open. There are two criteria

that must be met before people would feel threatened by the repository. First, the Yucca Mountain Repository would have to become salient so that people would accept information about it and care about that information. Second, the information about the repository would have to engender beliefs that the repository threatens them.

Regarding the salience criterion, Yucca Mountain seems likely to become salient to neither Nevadans nor potential vacationers. The Nevada Test Site has not been and is not now a salient part of the way most people think about southern Nevada. The proposed repository is not, despite extensive press coverage in Nevada and across the nation, part of the way most people think about southern Nevada. It is unclear why the operation of the proposed repository would necessarily make the repository salient to the people of Nevada and to potential vacationers.

Even if the repository becomes salient, survey data show that not everyone will necessarily become fearful of adverse effects from a facility that is 90 miles away (Jenkins-Smith, 2001). Analogues also show that nuclear facilities are by no means necessarily disincentives to investors or to businesses and people considering relocation to the area. The closest analogues we have to the proposed repository are low-level waste facilities, Federal nuclear reservations (e.g., Hanford), the Waste Isolation Pilot Project (WIPP), and nuclear power plants. Communities are thriving well within 90 miles of these facilities. Similarly, there is little evidence that these facilities have frightened actual or potential tourists. Disneyland is 35 miles from San Onofre, which has at-reactor storage of spent nuclear fuel. There is no evidence that this situation has either frightened tourists or deterred them from visiting Anaheim.

Unless there is a major accident (e.g., an explosion with a significant release of ionizing radiation bringing about exposures downwind, some cases of radiation poisoning, and deaths) or periodic smaller accidents (e.g., damaged canisters with some releases of ionizing radiation), there is little reason to expect a repository to be salient to more than a small minority of southern Nevada residents and visitors. Many people might continue to say that a repository is risky when asked, but a repository will not be a salient part of their thinking and they will not feel threatened.

- **Different people react to information about nuclear facilities differently. The people who visit Las Vegas now are disproportionately less likely to attend to information about the repository and be concerned than are people who choose to vacation elsewhere.**

The Jenkins-Smith study (2001) shows that not everyone is equally disposed to fear a repository. Las Vegas vacationers are disproportionately predisposed neither to attend to information about the repository nor to feel threatened by radioactive waste. The implication of this finding is that the tourist industry of southern Nevada is less vulnerable to adverse socioeconomic impacts from a radioactive waste repository than other places would be.

- **Although a large proportion of people, when asked, report negative images of shipments of spent nuclear fuel and high-level radioactive waste, it is not clear that a substantial number of people would feel threatened by such shipments.**

Social scientists have devoted less energy to studying perceptions regarding the transportation of spent nuclear fuel and high-level radioactive waste than regarding the proposed repository. Nevertheless, both Flynn et al. (1997) and Gawande and Jenkins-Smith (2001) provide strong evidence that people think a transportation accident both is likely to happen and, if there was an accident, likely to bring harm to the people who live near the location of the accident. These attitudes suggest a possibility that many people along transportation routes might feel threatened by the shipments, but this scenario is not inevitable. As with threatening feelings about a repository, there are two criteria that must be met to turn questionnaire responses that shipments of spent nuclear fuel and high-level radioactive waste are risky into perceptions

that those shipments are threatening. First, the situation with routes and shipments would have to become salient so that people would attend to information about it and care about that information. Second, the information about the shipments would have to engender beliefs that the shipments are threatening.

Regarding the salience criterion, why transportation of spent nuclear fuel and high-level radioactive waste would necessarily become salient is not obvious. In the past 40 years, over 2,500 shipments of spent nuclear fuel have taken place around the country, most with little attention. Publicized disputes have occurred related to some shipments of radioactive waste, specifically those involving transuranic waste to the WIPP and foreign spent nuclear fuel. These shipments are probably the closest analogues to the Nevada situation. In the WIPP situation, incident-free shipments seem to have minimized both the salience and threat perceptions related to transportation of transuranic waste among residents along corridors (Thrower, Portner, and Holm, 2001). In the case of foreign spent nuclear fuel shipped to the Savannah River site, as noted in Section 2.2, there is evidence that many residents in the Charleston area of South Carolina did feel threatened by the shipments.

One interpretation of the data regarding transportation of radioactive waste draws heavily on the Charleston area study (Gawande and Jenkins-Smith, 2001). This understanding of risk perceptions regarding transportation is that, early in the operation of the repository, transportation could be salient to many residents who could also feel threatened. With incident-free shipments, over time these residents along transportation corridors can be expected to forget about the issue. A second interpretation of the data gives more weight to the ongoing experience of frequent shipments around the country with little public concern and views the Charleston area case study as an aberration. This second understanding of risk perceptions regarding transportation is that few people along the routes are likely to notice or to care.

## 4.0 Linking Risk Perceptions to Behavior

This section reviews the literature linking risk perceptions to behavior, with particular attention to assessing whether attitudes about the repository and the transportation of spent nuclear fuel and high-level radioactive waste are likely to influence individual decisions.

- **Attitudes are usually poor predictors of behavior.**

Sidney Kraus (1995) published a meta-analysis of studies relating attitudes to behavior. He concluded that, at best, attitudes only sometimes strongly relate to behavior. Attitudes are good predictors of behavior only when a number of specific criteria are realized. These criteria include great specificity of the attitude and behavior, a short time between the solicitation of the attitude and the behavior, and the high potency of the attitude.

"Which presidential candidate are you going to vote for in tomorrow's election?" will predict well; "Are you likely to move if, 4 years from now, the government puts in a hazardous-waste incinerator in the town?" is not a good predictor. The second question involves a considerable gap in time between the elicitation of the attitude and the decision. Also, voting is a low-cost decision whereas whether to move is more difficult.

High potency means that the attitude is strong and important to the respondent because of how it was acquired. Two people might give similar negative responses to questions about Health Maintenance Organizations (HMOs). One person reached that view because of comments from friends and late-night television comedians. The other person arrived at that same attitude because of numerous personal negative experiences with an HMO. The latter is much more likely to take action.

Questions that elicit attitudes that are socially desirable often fail to measure the attitude well or predict the behavior. "Are you going to contribute to the United Fund this year?" is notorious in that over twice the percentage of respondents respond positively than actually contribute. If nuclear images are overwhelmingly negative (Slovic et al., 1991), there might be a socially desirable element in responding negatively to questions related to nuclear facilities (Noelle-Neumann, 1993) regardless of actual opinions.

Even if the attitude measures are accurate, holding negative images of nuclear facilities is not a good predictor of decisions, in part because the attitude is neither potent nor salient to most people. The studies of intentions ask questions now about behavior years in the future. In the absence of accidents, there is little reason to expect attitudes about the repository and transportation of spent nuclear fuel and high-level radioactive waste to ever be salient to most Nevadans and to most people considering vacationing in southern Nevada.

- **People do not seek to minimize risks, but to avoid significant threats to their health and safety.**

In assessing public perceptions of a high-level radioactive waste repository or other technologies often viewed as risky among the general public, there is a tendency to assume that everyone's goal is to minimize risks. The reality is much more complex as people often prefer riskier activities (e.g., skiing, wilderness hiking) more than safer ones and more dangerous vacation destinations over safer places. There is a substantial literature explaining why some risks are acceptable and others unacceptable (e.g., Slovic, 1999). What matters in terms of motivating behavior are risk perceptions that oneself or one's family might actually be harmed, not any desire for the lowest possible level of risk *per se.* What is important is not whether people think a repository would be riskier for Nevadans than the No-Action Alternative, but whether they think there is a meaningful likelihood that the repository or the transportation of spent nuclear fuel and high-level radioactive waste will harm them.

- **The theory of the "social amplification of risk," as applied to the proposed repository and transportation of spent nuclear fuel and high-level radioactive waste, is that the consequences of an accident at Yucca Mountain or in transporting these materials would extend beyond the immediate victims. The theory is that an accident would result in people thinking about possible risks associated with the repository and transportation, and taking actions intended to reduce risks.**

Slovic et al. (1991) summarizes:

> "The informativeness or signal potential of a mishap, and thus its potential social impact, appears to be systematically related to the perceived characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused to the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear waste repository or a recombinant DNA laboratory, may have immense social consequences if it is perceived as a harbinger of future and possibly catastrophic mishaps" (1991, 685).

According to the theorists (Kasperson et al., 1988) who developed the theory of the "social amplification of risk," the mere existence of a facility such as a repository will neither raise fears nor influence decisions. An accident is needed to generate the process that amplifies risk perceptions and related behavior.

The theory of the "social amplification of risk" is only relevant to assessing the link between attitudes and behavior if there were to be an accident at Yucca Mountain or in transporting spent nuclear fuel and high-level radioactive waste. The theory provides a plausible explanation of how an accident could make attitudes salient and lead to behavior consistent with those attitudes.

- **"Stigma" theory, as applied to the proposed repository and transportation of spent nuclear fuel and high-level radioactive waste, is that the consequences of an accident at Yucca Mountain or in transporting these materials would lead to a widely-held negative stereotype of southern Nevada so that (1) many businesses and people would decide to locate elsewhere and (2) many erstwhile and potential vacationers to southern Nevada would also go elsewhere.**

Stigma is "… a social construction that involves at least two fundamental components: (1) the recognition of difference based on some distinguishing characteristic, or 'mark'; and (2) a consequent devaluation..." (Dovidio, Major, and Crocker 2000, 3). Slovic et al. (1991) argue that places as well as people can be stigmatized. They suggest that images of nuclear facilities are so negative that an accident at Yucca Mountain or during transportation would trigger such a high level of concern that the entire region would become stigmatized. Slovic, Flynn, and Gregory write, "… the theory put forth to predict impacts conditions such impacts on the occurrence of *key events* that trigger negative images that, in turn, motivate individual, social, and institutional responses" (1994, 775).

Easterling reiterates:

> "Is the prospect of this facility more aversive than will be true of the actual facility? The answer will depend on whether people grow accustomed to the repository (i.e., become desensitized to the current connotations) once the facility becomes a reality. This, in turn, will likely hinge on the track record of the repository once it becomes operational; an accident-prone facility would reinforce the pre-existing attributions, whereas an uneventful track record may defuse the fears that are currently associated with a repository" (Easterling 2001, 142).

Stigma theory is a variant of the "social amplification of risk." Both are relevant to assessing the link between attitudes and behavior only if there were to be an accident at Yucca Mountain or in transporting spent nuclear fuel and high-level radioactive waste. Stigma provides a plausible explanation of how an accident could make attitudes salient and lead to behavior consistent with those attitudes. As Slovic and Flynn write, "…our aim (with stigma research) was to demonstrate a *mechanism,* grounded in theory and data, by which substantial impacts could occur—just as they have occurred with some hazardous waste sites and some other events—such as the Tylenol scare" (1991, 701). If there are no significant accidents in the operation of the repository and with transportation, there is no reason for stigma to happen.

## 5.0 Linking Risk Perceptions and Behavior to Socioeconomic Impacts

This section links the perception and behavior research to socioeconomic impacts.

- **Perceptions about a repository and transportation of spent nuclear fuel and high-level radioactive waste are unlikely to engender behavior that will harm the Nevadan economy.**

The mainstay of the economy of southern Nevada involves tourism and other services in the Las Vegas area. Absent serious accidents, there is little reason to expect the repository program to discourage businesses and persons considering moving to southern Nevada, or vacationers.

Even if there is a serious accident, stigmatization might not happen. Hershey Park, a large amusement park 11 miles from Three Mile Island, continues to set attendance records. The area directly downwind of Three Mile Island has had the most economic growth of any Pennsylvania region since the 1979 accident.

The mere presence of radioactive waste does not necessarily discourage tourism. Disneyland is 35 miles from San Onofre, where at-reactor storage of spent nuclear fuel takes place. In 2000, 38 million tourists visited New York City, which is less than 90 miles from a nuclear power plant with at-reactor storage.

- **The eco-tourism segment of the southern Nevada economy appears most vulnerable to adverse socioeconomic impacts from perceptions.**

Eco-tourism is travel and visitation to relatively undisturbed natural areas in order to enjoy and appreciate nature in a manner that promotes conservation. Jenkins-Smith (2001) presents data that suggests that the people most likely not to visit Nevada because of the repository have values similar to eco-tourists. Absent accidents, therefore, the segment of the southern Nevada economy most vulnerable to perception impacts might be the eco-tourism industry. Eco-tourism at present does not appear to be a large component of the southern Nevada economy.

- **Both stigma and the social amplification of risk require a trigger (e.g., a major accident) to bring about behavioral changes and adverse socioeconomic impacts.**

If there are no serious accidents, there will be no stigma and no social amplification of risk.

- **The repository would not reduce property values.**

The closest analogies we have to the proposed repository are low-level waste facilities, Federal nuclear reservations (e.g., Hanford), the Waste Isolation Pilot Project, and nuclear power plants. There is little evidence of negative impacts on property values in the vicinity of nuclear facilities, even Three Mile Island, site of America's most publicized nuclear accident (Gamble, Downing, and Sauerlender, 1980; Gamble and Downing, 1982; Nelson 1981). Impacts that have occurred (e.g., the area of the Fernald weapons plant in Ohio) are linked to contamination, not the mere presence of nuclear facilities. Hunsperger (2001) and Feiertag (1992) suggest that contaminated Federal facilities have impacts similar to those of Superfund sites.

- **Perceptions might temporarily reduce property values along urban transportation corridors by approximately 3 percent, although other research shows that impacts might be negligible or nonexistent.**

The UER (2001) and Gawande and Jenkins-Smith (2001) studies suggest that, at least temporarily, residential property values in transportation corridors in urban areas may decline approximately 3 percent. Data from other transportation experiences (e.g., transuranic waste to WIPP) suggest that impacts on property values might be negligible or nonexistent.

## 6.0 Conclusions

There is a consensus among social scientists that a quantitative assessment of the potential impacts from risk perceptions of the proposed repository and the transportation of spent nuclear fuel and high-level radioactive waste is impossible at this time and probably unlikely even after extensive additional research. The implication is not that impacts would probably be large, but simply difficult to quantify. As the NWTRB noted in 1995, social scientists do not know enough to identify what would be the level of concern during the operation of a repository, if it does open. Similarly, we cannot specify the links

between those attitudes and individual decisions that would have socioeconomic impacts. Based upon what we do know from surveys and from analogues, we can assess qualitatively what outcomes seem most likely.

## 6.1 Effects from Perceptions of the Proposed Repository

Social scientists are loath to write that something in the future is impossible. Thinking like science fiction authors, social scientists can conjure sequences of extremely unlikely events that, taken together, can result in tragic consequences.

The answers to questions about socioeconomic impacts from perceptions vary by how the question is phrased. If the question asks if significant adverse socioeconomic impacts are possible if the repository were to open, the answer of course is affirmative, even without science fiction. The more useful question asks whether there is a reasonable likelihood that perceptions about an operating repository are likely to engender significant adverse socioeconomic impacts. In the absence of a large accident at the repository or a continuing series of smaller accidents, there is little reason to expect significant adverse effects:

- Although, when asked, many people report that they think of nuclear things as dangerous, these attitudes are usually not salient in people's lives and therefore do not influence personal decisions. People do not consider that spent nuclear fuel is stored at San Onofre when they decide whether to visit Disneyland.

- Yucca Mountain is not in Las Vegas, but a significant distance away in the desert.

- Studies show few indications of adverse socioeconomic effects (and many positive socioeconomic effects) in places that currently safely store or dispose of radioactive waste. As New Mexico has not become stigmatized as the "transuranic nuclear waste dump state," there is little reason to expect that Nevada would be stigmatized.

- People who choose to vacation in Las Vegas are less likely to be concerned about the repository than people who choose to vacation elsewhere. Opening the repository, if there is any impact, would be likely to re-enforce the preferences of people who do not intend to visit Las Vegas with or without an operating repository 90 miles away. People who do like to visit Las Vegas would likely pay little attention.

- If the repository would be such a powerful disincentive to investors, businesses considering relocating to southern Nevada, and retirees and others considering relocating in the area, some effects of those perceptions should already be apparent. It is widely known that Congress has ordered DOE to characterize Yucca Mountain for consideration for a repository and that key program documents suggest that the site might be acceptable. If a repository were such a powerful disincentive, prudent investors, facing a possible opening of a repository, would not be investing in southern Nevada. Similarly, we would see a decline in population in southern Nevada as businesses and people decide to settle elsewhere in anticipation of future risks and stigma. There is no evidence of this behavior.

The assessment that substantial adverse socioeconomic impacts from perceptions of the repository are quite unlikely assumes that operations at the facility will not have either a major accident (e.g., an explosion with a significant release of ionizing radiation bringing about exposures downwind, some cases of radiation poisoning, and deaths) or periodic smaller accidents (e.g., damaged canisters with some releases of ionizing radiation). These events would most likely raise fears about a repository, make a repository salient to people in southern Nevada, result in some social amplification of risk, and perhaps

even stigmatize the region. Adverse socioeconomic effects from perceptions of an accident-prone repository might be substantial even with the repository 90 miles away. Without nuclear accidents at Yucca Mountain, these effects are quite unlikely.

## 6.2 Effects from Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste

As with socioeconomic impacts from perceptions about a repository, the answers to questions about potential impacts from the transportation of spent nuclear fuel and high-level radioactive waste vary with how the question is posed. Are significant adverse impacts possible? Large impacts are possible if there are accidents with releases of ionizing radiation during the transportation of spent nuclear fuel and high-level radioactive waste. The social amplification and risk and stigma might become quite relevant after an accident that exposes neighborhoods to ionizing radiation.

A different question is whether there is a reasonable likelihood that perceptions about transporting spent nuclear fuel and high-level radioactive waste are likely to engender significant adverse socioeconomic impacts. Absent accidents, there is no reason to expect impacts for property owners in areas beyond the transportation corridors. Even absent accidents, however, some studies (UER 2001; Gawande and Jenkins-Smith 2001) report that, at least temporarily, a decline in residential property values of approximately 3 percent might be expected in transportation corridors in urban areas. Data from other transportation experiences (e.g., transuranic waste to WIPP) suggest that impacts on property values might be negligible or nonexistent. More research on whether property values have fluctuated, and for how long, with the transportation of radioactive materials would be beneficial, although the research would not allow analysts to know with certainty whether there would be any impacts from perceptions of shipments of spent nuclear fuel and high-level radioactive waste to a Yucca Mountain Repository.

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