A COMPARATIVE STUDY OF NUCLEAR POWER RISK PERCEPTIONS WITH SELECTED TECHNOLOGICAL HAZARDS

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ABSTRACT

How people perceive risk or threats is important to many disciplines that seek to assist policy makers in developing policies, regulations and laws. Using the previous work of Slovic et al. (Fischhoff, Slovic, Lichtenstein, Read and Combs, 2000; Slovic P., 1992; Slovic, Fischhoff, and Lichtenstein, 2000) in development of the psychometric paradigm, a sample of residents (n=600) from a region with a large number of nuclear reactors was surveyed. The question set was expanded to include demographic questions to determine if they impact risk perception. Two aspects of risk perception were examined, perception of overall risk and perception of riskiness along specific dimensions of concern identified previously in the literature. For both risk and riskiness, respondents' perceptions of nuclear power were compared to three other perceptions of technologies including use of modern farming methods using chemicals, railroad transportation and coal-generated electricity. The recent increase in public concern about nuclear power following the meltdowns at the Fukushima Dai-ichi nuclear power plant led to the expectation that nuclear power would be rated higher in overall risk and riskiness than the other three technologies consistent with Slovic's earlier work on risk perception. This expectation was generally supported although respondents tended to perceive modern farming methods using chemical as similar in overall risk and riskiness to nuclear power.

The research specifically tested five hypotheses concerning the impact of five demographic factors: gender, race, income, education and political orientation on the overall perception of risk and riskiness. Subsequent analysis using analysis of

variance and linear regression found that select demographics only explained 2% of the risk perception for nuclear power generation.

DEDICATION

I wish to thank the three people in my life for being extremely understanding and tolerant of me while I was completing this dissertation. My sons, David Duff II and Daniel Duff, were understanding and let me have some time to work on this paper. They also provided me with ample opportunity to take a break from writing and to just be a father.

In addition, there was one other person that motivated and pushed me when I needed it most to complete this study. For that support, help, and most importantly friendship, I wish to say thank you to First Lieutenant Denise A. Caspers, USAF. She truly gave me the motivation to complete this portion of my life and begin the next phase.

Thank you to Denise, David and Daniel who gave me their love, support and an occasional swift kick to keep me focused on the final goal.

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CHAPTER ONE. INTRODUCTION

On March 11th, 2011, a devastating earthquake (9.0 on the Richter scale) and tsunami rocked the physical, social and political structure of Japan, killing people, disrupting transportation, manufacturing and destroying property across a broad area. The damage done to the Japanese nation was magnified by the impact of the tsunami on the six reactor, nuclear power plant known as Fukushima Dai-ichi. Power to the cooling systems and other safety mechanisms was lost and a partial core meltdown occurred in reactor one, reactor three and reactor four due to a probable hydrogen gas explosion within the reactor buildings. This disaster released radiation into the atmosphere and into the water leading to mandatory evacuation zones of at least twenty kilometers and restrictions on the sale of animals and produce from the Fukushima Prefecture. While this event was initially rated as a Level 5-Accident with Wide Consequences, on the International Nuclear Event Scale by the Japanese government, it was later changed to a rating of Level 7-Major Accident which is the most severe (BBC News, 2011).

Following earlier, severe nuclear accidents such as Three Mile Island and Chernobyl, there was extensive research performed on the public's perception of risk associated with nuclear power generation, but the amount of research has diminished over time. The notion that the planet requires additional energy resources as it continues its cycle of modernization has increased the demand for nuclear power in many areas of the world, even after the recent accident in Japan. Given this

resurgence of interest in nuclear power, the researcher believed that it was an opportune time to reexamine the public's perception of risk of nuclear power.

The research presented in this paper is based on the social psychological tradition of psychometric evaluations as established by Paul Slovic et al. (Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000; Slovic, 1992; Slovic, Fischhoff, Lichtenstein, 2000). Slovic's model focuses on the public's perception of risk and the perceived benefit as well as the dread or fear caused by such a threat. In his past work, Slovic and his colleagues have shown that the risk perception of laypeople does not correspond to the perception of risk as seen by technical specialists, that there is an inverse relationship between how people perceive the risk and expected benefit and that the perceived threat laypeople associate with nuclear power was uniquely extreme when compared to other threats.

The research presented in this paper will replicate some of the prior work done by Slovic and his colleagues, by using a large regional survey of a densely populated area that is associated with multiple reactors located within the region. The goals of this research paper are the following: a) to examine the extent to which people's perceptions of risk concerning nuclear reactors remains extreme when compared to other risks; b) to extend some of the work of Slovic et al. by further evaluating Slovic's measures of risk perception by testing five hypotheses measuring the impact of respondent's demographic characteristics on measures of risk

perception and riskiness for all four technologies; and c) to compare the pattern of results across other technical hazards.

CHAPTER TWO. LITERATURE REVIEW

The present study offers several key contributions to the literature on risk perception. Slovic's risk perception research paradigm has produced measures that have been shown to be both reliable and valid. His measures have been applied to a wide variety of risks including the risk associated with the use of nuclear power. In order to incorporate Slovic's research on risk perception within the field of emergency management, it is necessary to evaluate the impact that the demographics have on perceived risk for a high impact low probability events such as a reactor breach at a nuclear power facility. This will allow us to apply what Slovic has learned about risk perception to what emergency managers need to know about factors affecting people's attitudes to perceived threat. It is hoped that this knowledge might assist emergency managers to develop demographic profiles to create targeted messages for at risk populations.

Second, while the present study focused on perceptions of risk associated with nuclear power and how those perceptions were affected by the various social dimensions of the sample, it also measured risk perceptions associated with three other technologies which have also been studied by Slovic et al. These other technologies include modern farming using fertilizers and pesticides, railroad transportation, and electricity generated from coal burning plants. These three additional technologies are both similar and dissimilar to nuclear power.

All four threats were similar in the fact that they are human created threats, yet they are dissimilar in the extent to which people understand the threats, sense control over them, perceive the threats to be probable and/or to have emotive responses (e.g. dread) in response to these perceived threats. Placing the present study's focus on nuclear power in the context of these other technological risks sets the stage for exploring the extent to which a link between demographic factors and risk perception of nuclear power may be generalizable to other types of technology. All of the hazards are salient to the targeted region, given the presence of many nuclear power plants, intense farming, railroad networks and power generation requirements, so their salience was likely to have permeated the region's social structure, albeit in different degrees dependent on one's demographic location. However, given that Slovic et al. found such high degrees of dread related to nuclear power, the extreme perception of dread may negate the impact of the demographic factors.

Third, Slovic's original research model while impressive and productive has methodological weaknesses. While there has been some extension of Slovic's research to explore the extent to which these weaknesses threaten Slovic's overall findings, it is hoped that the present study may provide additional insight. The two weaknesses addressed by the present study, when compared to the original 1978 model, republished in 2000 (Fischhoff, Slovic, Lichtenstein, Read and Combs, 2000), include the following: a) Slovic et al. have primarily focused on the cognitive aspects of risk perception while there is a need to add a social contextual profile to Slovic's

risk perception literature; and b) some of the independent variables (demographics in this study) have not been as thoroughly investigated as others in relation to his rich perception measures. In this study, the demographic variables are proxy measures for respondents' positions in the social structure. This study used a large sample (N=600) of participants who responded via the internet. The independent variables included race, gender, income, age, education, and political identification. These methodological changes allowed the present study to incorporate analyses not done within Slovic's typical data collection efforts, thus allowing for an examination of social structural factors in risk perception. In addition, the fact that the respondents are in their natural residential settings allowed for the selection of a region where nuclear reactors are present and likely to be salient. Thus, the present study expands research in several directions. The literature review to follow examines each of the potential contributions identified above by examining the pertinent literature and highlighting the gaps in that literature which the present study addressed.

Modernity

The damage to the reactor at Fukushima has served as a strong signal to many in the world that people should now perceive the potential risk of nuclear power plant operation as far outweighing the positive impact of the power it generates for modern society. The events in Japan may have led many around the world to perceive nuclear power plants and the spent fuel from these plants as more risky. Reacting to this high risk-low probability event in Japan, the German government has decided to begin

planning for the closure of all nuclear power plants within its borders (Breidthardt, 2011). In contrast, other nations such as United Kingdom, France and the United States did not react to the event in Japan with plans to shutter operable plants within their borders (Fineren and Cutler, 2011). These latter nations appear to have placed greater emphasis on the evidence provided by technical specialists within the field of nuclear energy. The technological prowess of the human race has developed many wonderful things to expand our ability to survive in comfort while at the same time creating potential risks and threats that some deem to be unacceptable. Ulrich Beck has written on this concept of the risk of modernity, noting that as we continue to expand our technological capabilities humans are also creating more potential hazards (Beck, 1992).

The ability or willingness to accept certain types and levels of risk apparently varies from country to country given the expected benefit derived from the operations of nuclear power plants, but this perception of risk is only a reflection of how different people perceive risk which may vary from person to person as well as from risk type to risk type. As humanity has continued to adapt to natural surroundings to better address perceived needs, we have also enhanced old risks and created new risks to which we must now adjust. This can be seen in some of Beck's and Giddens' writings concerning a "new modernity" (Beck, 1992; Giddens 1990).

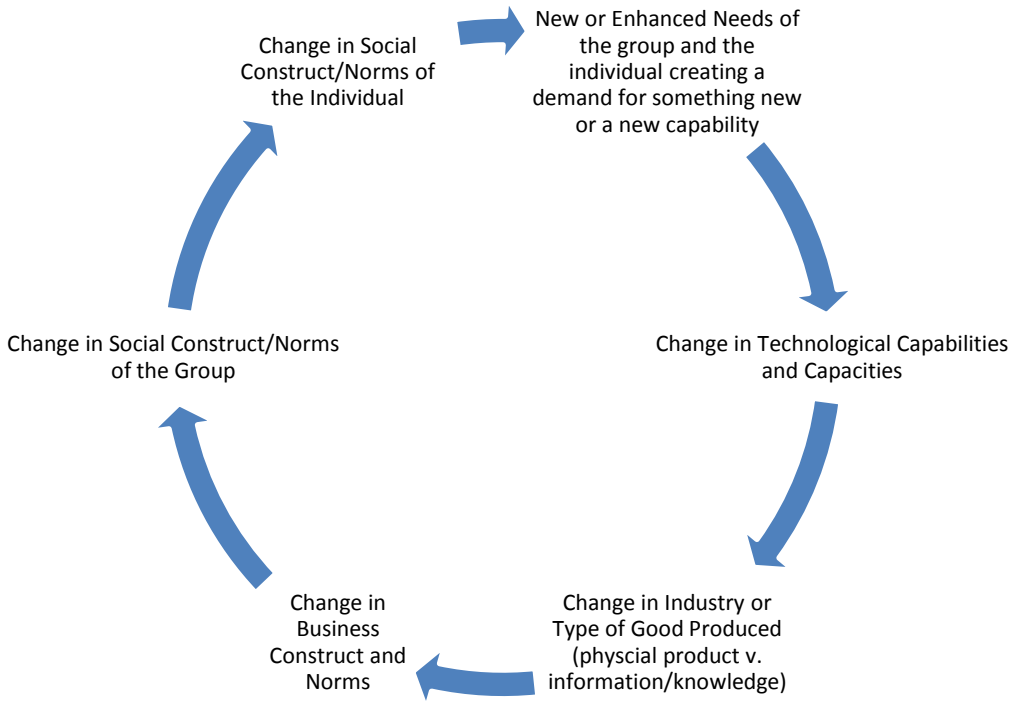

Figure 1. Cyclic Nature of Ulrich Beck's Modernity. Graphic representation of Beck's modernity concept, taken from an unpublished paper (Duff, 2008).

Beck suggests that modern society is in a constant feedback loop; this loop consists of industry, research capabilities/capacities, the norms of society as a whole, and the evolving norms of the family or individual. Figure 1 provides a visual representation of Beck's model taken from an unpublished paper by Duff (2008). This concept of the cycling of society provides a picture of how the modern society is internally reflexive to influences and changes from within. As new technology comes on-line society and family units adapt to the potential threats presented by technology in-order to mitigate the potential harm that may be incurred from them.

The Unseen Threat

A recurrent threat that modern society must deal with is the potential for release of hazardous materials from either an operating nuclear power plant or waste storage sites of nuclear power plants. An explosion or a radiation release from such a location has the ability to impact many people within a large radius surrounding the plant. There have been only a few such accidents, but those have created a sense of lingering fear. Perhaps the underlying nature of the fear reflects the nature of radiation as a threat that cannot be seen, has no odor and no color but yet may make an area uninhabitable and unusable for many years. There is a stigma attached to the use of nuclear power that has grown through the years which many technical specialists fail to understand (Erickson, 1994). Within the nuclear power industry, many of the engineers and scientists see the use of nuclear power as a safe green power source that can provide the power needs for a large portion of the population.

There have been only a few nuclear power plant failures but these failures have been of such significance that their names have become rallying cries for those opposed to nuclear power. Those names include Three Mile Island in the United States, Chernobyl in Ukraine, and the recent being Fukushima Dia-ichi plant in Japan. These accidents have become what Birkland (1997, 2006) refers to as focusing events or triggering events for public policy change. But to what extent policies change is dependent upon many factors such as input from technical specialists, government regulators, special interest groups and the concerns of residents the location and operation of nuclear power facilities.

This study focused on how people in a modern society perceive the risk or level of threat of a low probability, high impact nuclear power plant disaster. There have been a variety of studies performed in the past on how technical hazards are perceived. These studies have been completed by various researchers with extensive backgrounds in risk perception, such as Lyndell, Perry, Kunreuther, Kaprinsky, Slovic, and Renn. These researchers have focused on various risks and threats which have evolved with the modern world including but not limited to the following: hazardous materials, radiation risks, economic risks, use of medication in society, drug abuse, insurance implications, societal risk taking, the impact of seat belts, chemical manufacturing, long term radioactive material storage. One of the most significant authors in this research field has been Paul Slovic. The intent of this research was to extend the previous modeling performed by Slovic to reevaluate the current perception of a risk that people have concerning nuclear power. In addition this study used demographic attributes as independent variables to identify possible respondent profiles. The literature review therefore focuses on the previous work that Slovic has done concerning the perception of risk related to nuclear power facilities (many of these articles have been republished and are cited with the most recent publishing date). For summary purposes, these articles are listed in chronological order in Appendix A.

Slovic et al. Early Work

Slovic has spent decades evaluating the risk-based decision making and risk perceptions associated with various topics including the following: leadership,

economic decision making, healthcare, pharmaceuticals, nuclear power, safety belts in cars, railroads, farm hazards, etc. In one of his early papers (Edwards and Slovic, 1965) Slovic performed a small study to understand information seeking associated with decision making. He found that "information should be sought only if the expected cost is less than the expected gain from it" (Edwards and Slovic, 1965, p. 188). He found that the ability to make a decision with incomplete information was due to the people doing "a good job of intuitively sizing up strategies in relatively complex tasks of information seeking" (Edwards and Slovic, 1965, p. 196). Edwards and Slovic also found that those people who were more cautious in a given scenario would most likely continue to be so in another similar situation. Individuals who were more risk adverse would seek additional information prior to making a decision. Thus respondents in the present study can be expected to process different aspects of incompletely understood technologies differently.

In the 1976 (republished in 2000), Slovic, Fischhoff and Lichtenstein focused on nuclear power as the technological hazard to be evaluated. The authors believed that policy decisions for this field were made with limited information which was most often only extrapolations of the limited data sets the technical specialists had before them, as the Three Mile Island, Chernobyl or Fukushima accidents had yet to occur. The authors reviewed the issues facing policy makers who must act with little understanding as to how the public may respond. Following a review of existing risk perception research at the time, Slovic et al. (2000) suggested that social

psychology's work on the availability heuristic may help policy makers predict how the public will respond.

The availability heuristic suggests that the more recent a hazard/accident has occurred, or the more attention that is given to the subject by the media, the greater the level of perceived threat within the sample. Today with the expansion of news sources and social media on the internet, the availability heuristic must be considered. While it is three years since the disaster at Fukushima Dai-Ichi, the massive media coverage of this disaster compared to any events involving farming with chemical fertilizers, herbicides, and pesticides, railroad accidents and coal-generated electric power plant accidents leads to the expectations that the threat of nuclear plant disaster is likely to be more "available" then these other technological threats.

The Slovic, Fischhoff and Lichtenstein (2000) suggest that risk-benefit analyses may be the best course of action. The problem occurs when there may be competing levels of risk acceptance by the population and policy makers. Asking the question "how safe is safe enough," will trigger varying responses amongst respondents given their various levels of risk aversion when compared to possible future benefits derived from taking said risk. One of the goals of this study was to see if there was a meaningful relationship between risk perception and the respondents' demographics.

In 1978, Fischhoff, Slovic, Lichenstein, Read and Combs (republished in 2000) once again took up the risk-benefit issue. They highlight the need for policy

makers to consider not just cost-benefit based decisions, but also risk-benefit decisions. Fischhoff et al. then provide a description of their use of a psychometric survey to study perceived risk and perceived benefit. In this study they used a list of thirty different activities or technologies including the four technologies covered in this present study. In the first task, the study participants were broken in to groups, with one group being asked about perceived total benefit and the other group being asked about perceived total risk. The second task asked both groups "to judge the acceptability of the level of risk associated with each item" (Fischhoff et al. 2000, p. 86). The third task involved measures of variables the authors expected to be related to perceived benefit and/or risk (pages 86-87):

1. Voluntariness of risk-is the hazard voluntary or involuntary;
2. Immediacy of impact/risk of death;
3. Personal knowledge concerning the risk- do the respondents feel that they are knowledgeable and well informed on the potential hazard;
4. Knowledge/understanding of the risks by science;
5. How much personal control does the participant have to avoid death-do the respondents feel that through some action of theirs they have the ability to control some aspect of the level of risk that the hazard creates;
6. Newness of risks-are these threats familiar or new, novel risks;
7. Chronic v. Catastrophic risk in which people die one at a time or is there a large number of fatalities at once;

8. Common risk v. Dread inducing risk-does the risk create a sense of dread or foreboding in the respondents;
9. Severity of consequence or the likeliness that an incident involving the risk will be fatal.

Of special relevance to the present study, a consistent pattern emerged for the above measures across the four technologies of nuclear generated electric power; farming with chemical fertilizers, herbicides, and pesticides (CFHP); coal-generated electric power and railroad transportation. Across the nine measures listed above, nuclear generated electric power was perceived as the most extreme technology on eight measures with CFHP farming consistently in second place. Specifically, nuclear generated electric power was seen as the least voluntary, the most unknown to the public, the least known to the scientific community, the most difficult to control, the most catastrophic in impact, the most likely to cause death, the most likely to be viewed with a sense of dread, and the threat with the most severe consequences of a disaster. CFHP was perceived to be the next in line. Only on perceived immediacy was there a slight deviation in this pattern with nuclear power and CFHP switching the top two spots. Perceptions of coal generated electric power and railroads alternated across the nine measures in the remaining two spots. Thus, the results revealed differential perceptions of these technologies, opening the door for the differential impact of socio-demographics on the perceived risk of each technology.

Rating the Risks

The following year, 1979, Slovic, Fischhoff and Lichtenstein (republished in 2000) once again address the issue of the availability heuristic. This inferential rule basically says that people are more likely to believe that an event is more likely to occur if that event is more memorable, easy to recall or has recently occurred. Therefore the more one hears about a risk or disaster the more likely that members of the population will believe that the probability for it to recurr is quite high. This is a significant issue when dealing with low probability-high impact events such as nuclear power plant failures, weapons of mass distruction, etc., as "the very discussion of any low probability hazard may increase the judged probability of that hazard regardless of what the evidence indicates" (Slovic, Fischhoff, and Lichtenstein, 2000, p. 107).

Slovic Fischhoff and Lichtenstein, (2000) proceed to discuss the process to better understand perceived risk, citing some of their previous work. They believe that it is important to include a more qualitative component within the questions on risk perception. To better understand how people determine the risk of a particular event or technology, the authors compared perceived risks ratings they had obtained with estimates of the annual frequency of death. They found that the technical specialists closely linked perceived risk with frequency of death but this did not hold true for the other groups. As a result the authors concluded that "risk may not be synonymous with fatalities" (Slovic, Fischhoff, and Lichtenstein, 2000, p. 113).

When Slovic, Fischhoff and Lichtenstein (2000) expanded the question set given to four study groups to include the nine descriptive questions from their 1978 work concerning voluntariness, dread, severity of consequences, etc., "ratings of dread and of the severity of consequences were found to be closely related to laypersons' perceptions of risk." While, the "experts' judgments of risk were not related to any of the nine qualitative risk questions" (Slovic, Fischhoff, and Lichtenstein, 2000, p. 118)." This finding is similar to what Kai Erickson (Erickson, 1994) found in his work where the invisible hazard led to an increased level of dread for those potentially impacted by the hazard.

The Slovic, Fischhoff, Lichtenstein (2000) summarized their findings concerning the fallibility of judgment:

1. Cognitive limitations, coupled with the anxieties generated by facing life as a gamble, cause uncertainty to be denied, risks to be distorted and statements of fact to be believed with unwarranted confidence.
2. Perceived risk is influenced (and sometimes biased) by the imaginability and memorability of the hazard. People may, therefore, not have valid perceptions even for familiar risks.
3. Our expert's risk perceptions correspond closely to statistical frequencies of death. Laypeople's risk perceptions were based in part on frequencies of death, but there were some striking discrepancies. It appears that for laypeople the concept of risk includes qualitative aspects such as dread

and the likelihood of a mishap being fatal. Laypeople's risk perceptions were also affected by catastrophic potential.

4. Disagreements about risk should not be expected to evaporate in the presence of 'evidence.' Definitive evidence, particularly about rare hazards, is difficult to obtain. Weaker information is likely to be interpreted in a way that reinforces existing beliefs (Slovic, Fischhoff, and Lichtenstein, 2000).

Extending the Slovic et al. Risk Paradigm

Slovic, Fischhoff and Lichtenstein continued to fine tune their understanding perceived risk of various hazards by extending their hazard set from thirty to ninety (Slovic, Fischhoff and Lichtenstein, 2000). In this extended study they used the risk perception questions from the study they completed in 1978, (Fischhoff, Slovic, Lichtenstein, Read, and Combs 2000) but then added additional risk characteristics to the study. One of the more interesting findings of this study was that just as in the previous study, "perceived risk could be predicted from knowledge of an item's judged dread and severity" (Slovic, Fischhoff and Lichtenstein, 2000, p.143).

Another interesting finding was in dealing with the issue of voluntary versus involuntary exposure to the risk. While at first it might appear that being involuntarily subjected to a risk would increase perceived risk, the authors noted that if the factors such as dread or catastrophic consequence were the true driving factors for perceived risk, "society's apparent aversion to involuntary risks may be mostly an

illusion, caused by the fact that involuntary risks are often noxious in more important ways, such as being inequitable or potentially catastrophic" (Slovic, Fischhoff and Lichtenstein, 2000, p. 148).

Catastrophic potential appears to play a much larger role in risk perception, especially when it is based around a low probability, high impact event such as an accident at a nuclear reactor. Their past research showed that the sample members believed that nuclear power posed a greater risk of death then the other hazards, and that "further research linked this perception to the perceived potential for disaster" (Slovic, Fischhoff, and Lichtenstein, 2000, p.148).

Slovic et al. on Public Perceptions

In "Perceptions of Risk" by Paul Slovic, originally published in 1987 and reissued in Slovic, (2000), Slovic begins his discussion using the argument that technological progress brings along with it potential hazards as well. Slovic notes that the public's general knowledge of these threats is nominally limited to information bits from the news media, "which rather thoroughly document mishaps and threats occurring throughout the world" (Slovic P. , 2000, p. 220). He also discusses how the general sense of the public within industrialized nations today is that they face an increased level of risk today, more so than in the past and, that potential future risks will only increase. This compares well to Beck's cycle of modernity (see Figure 1, page 8), which basically states that as people acquire more modern technologies, the hazards will increase, driving them to seek other technology

to minimize the hazards. Slovic then provides the reader with a summary of some of his past work on various aspects of revealed and expressed preferences as well as the psychometric paradigm.

Within the psychometric paradigm, Slovic noted that peoples' risk perceptions were strongly influenced by two specific categories, the first one being the dread or fear that the technology creates within the subject due to its potential impact in the event of an accident. The second is the degree to which the technology has some level of unknown or unseen quality about it which the respondents do not readily grasp or comprehend. The potential toxicity of the event as mentioned by Erickson (1994) creates a sense of dread, as people may have no way of using their senses to recognize the presence of the threat.

Slovic then shifts into a discussion on forecasting public acceptance or the lack of acceptance of risks. He uses nuclear power as an example; people perceive the nuclear power plants provide little benefit to society while the risk that the nuclear power plants pose is rated as being unacceptable. "Nuclear power risks occupy extreme positions in psychometric factor spaces, reflecting people's views that these risks are unknown, dread, uncontrollable, inequitable, catastrophic and likely to affect future generations" (Slovic, 2000, p. 229), whereas the technical experts view such negative perceptions as being not grounded in the scientific research and knowledge. Slovic's interpretation of this is that risk perception research shows the experts that the general population's anxiety is driven by "extensive unfavorable media coverage

and a strong association between nuclear power and the proliferation and use of nuclear weapons" (Slovic, 2000, p.229-230).

Peters and Slovic: Can We Accept Some Risk?

The willingness to accept a reasonable level of risk concerning nuclear power was considered in a study by Peters and Slovic in (1996). This study considered affect-laden imagery as well as worldviews and political leanings in measuring the levels of acceptance that respondents would have to nuclear power. Peters and Slovic's study of the worldviews of their respondents was based on some previous work by Dake in articles from 1991 and 1992, which Peters and Slovic summarize as "people's identities and world views are mediated by their social relations to groups, as well as by the extent of social prescriptions that constrain their behavior" (Peters and Slovic, 1996, p.1430). The way that people view themselves, how they fit into and interact with society and the role that they believe society should have strongly influences how people perceive risk. Specific to this study, Peters and Slovic found that the more individualistic or hierarchist a person was, the more likely they were to support nuclear power, whereas the more people supported government egalitarianism, the less likely they were to support nuclear power. "This study tests and supports the hypothesis that worldviews and affect-laden imagery are highly predictive of perceptions of risk from nuclear power and support for that technology" (Peters and Slovic, 1996, p. 1427).

Review of Demographic Impacts on Risk Perception

The previous articles show Slovic et al. used a cognitive approach to risk perception. Other researchers have looked at the social aspects of risk perception concerning nuclear power and many of these authors have found that there are patterns linked to demographics while others counter that attitudes concerning the generation of nuclear power do not vary according to such characteristics as age, gender, education or income. This inconsistency is one that was addressed in the present study by the research done analyzing both the psychometric model as well as specific demographic data in a multiple regression analysis.

There are several authors that have found that respondents' demographics play a role in how people perceive the risk of nuclear power. In a chapter from the book *Cross-Cultural Risk Perception* (Slovic, Flynn, Mertz, Poumadere, and Mays, 2000), Slovic et al. do a comparative study on how the risk of nuclear power is perceived between France and the United States. One of their first conclusions is that there is a gender difference in the acceptance of nuclear power, with women showing a greater anxiety leading to opposition to nuclear power. This finding adds to the finding that Flynn, Slovic and Mertz (1994) made revealing that white males had the tendency to be more accepting of nuclear power and its benefits. Flynn, Slovic and Mertz found that there were no significant differences between all other males and females. Slovic et al. refer to an article by Peters and Slovic (1996) which points out that the white male respondents tend to have a more individualistic attitude and trusting of technical specialists, while others are more egalitarian and hold nuclear power in less esteem.

This was also a finding by Savage (1993, p. 8) where he found that the "leading explanation of the relationship between demographic factors and dread of a hazard is the perceived personal exposure to the hazard. Women, blacks, the young and those with lower levels of income and schooling feel both heightened personal exposure to risks and have more dread of them."

This white male effect was mentioned in several other articles as well. Finucane et al. (2000) suggest that men and people of Caucasian ancestry judge risks as being lower than women and non-Caucasians perceive them to be. In performing multiple regression analysis on their data set, Finucane et al. "showed that gender, race and 'white male' remained highly significant predictors of the hazard index, even when the other variables were controlled statistically" (Finucane et al. 2000, p. 169). Similarly, in the Flynn, Slovic and Mertz (1994) articles it was noted that the "white male effect" was linked to about 30% of the population which judged the risks to be extremely low. Slovic notes in his 1999 article republished in 2000, that "when compared to the remainder of the sample, the group of white males with the lowest risk perception scores were better educated (42.7% college or post graduate degree v. 26.3% in the other group), had a higher household incomes (32.1% above $50,000 v 21.0%), and were politically more conservative (48% conservative v. 33.2%)" (Slovic, 2000, p. 399). This is further supported by Covello's review of earlier work (Covello, 1983) in reviewing risk perception articles which he summarized as, "the debate about nuclear power is also colored by social class—people with lower socioeconomic status are less supportive of nuclear power than those with higher

socioeconomic status; by sex—women are less supportive of nuclear power than men are" (Covello, 1983, p. 290). Thus some researchers have found that there is a relationship between several demographic factors and how their respondents' perceive the risk associated with nuclear power. More specifically, the gender of the respondents, the levels of income, the education levels and political orientation impact how people perceive risks associated with nuclear power.

Whereas there is some support for specific social demographic impact on risk perception, other researchers such as Sjoberg (2000) would like to see a broader analysis of risk perception. The psychometric model is cognitive and based on the function of the threats; the cultural theory of risk perception relies, on the social context of the threat, but Sjoberg proposed an approach using attitude, specific fear and risk sensitivity as a better model of risk. Whitfield et al. (2009) furthered the concept that attitudes are important in risk perception. They suggest that attitudes are a function of risk and that "both attitudes and risk perception are a function of values, beliefs and trust in the institutions that influence nuclear policy" (Whitfield et al. 2009, p. 425). In their research, they found that values are predictive of the attitudes people hold towards nuclear power, "individuals with more traditional values have greater support for, while those with altruistic attitudes have greater opposition to nuclear power. Nuclear attitudes do not vary by gender, age, education, income, or political orientation, though nonwhites are more supportive than whites" (Whitfield et al. 2009, p. 425). These findings would seem to agree in one part with the Peters and Slovic (1996) article that found the hierarchist or individualist would be more

supportive of nuclear power and the more egalitarian would be less supportive. But, it does seem to disagree with Covello (1983), Finucaine et al. (2000), Flynn, Slovic and Mertz (1994) and Slovic, Flynn, et al. (2000) where we just saw the white male effect to be important for risk perception.

We have seen in comparing the earlier work of Slovic et al. in the development of the psychometric paradigm with some of the later works by Slovic and authors from various disciplines that there is a great deal of potential that this tool has to offer to researchers. Slovic et al. have focused on the dread that the risk produces as being an important component of the perception of risk, while others have looked at demographic factors as being the important component impacting risk perception. Risk perception is a complex topic that is not limited to dread and fear, but may have varied components which include socio-demographic factors.

The present study focused specifically on Slovic et al. measures assessing severity of consequences for four technologies: nuclear power, modern farming using chemicals, fertilizers and pesticides, railroad transportation and coal-generated power. The data analysis in this research involved the testing of hypotheses involving five independent variables identified in the literature review: gender, race, income, education, and political orientation (Covello 1983; Savage 1993; Flynn, Slovic, and Mertz, 1994; Peters and Slovic 1996; Slovic P., Flynn, Mertz, Poumadere, and Mays, 2000; Finucane et al. 2000) and six dependent variables of risk perception

representing severity of riskiness for each of the four identified technical hazards. Specifically the hypotheses are stated as follows:

- Hypothesis 1: Females will perceive the risk and riskiness of nuclear power to be greater than males perceive the risk and riskiness of nuclear power.
- Hypothesis 2: Non-white respondents will perceive the risk and riskiness of nuclear power to be greater than white respondents perceive the risk and riskiness of nuclear power.
- Hypothesis 3: Lower income respondents will perceive the risk and riskiness associated with nuclear power to be greater than respondents with higher income.
- Hypothesis 4: Respondents with lower levels of education will perceive the risk and riskiness of nuclear power to be greater than respondents with higher levels of education perceive the risk and riskiness of nuclear power.
- Hypothesis 5: Respondents that identify as having extremely liberal or liberal political orientation will perceive the risk and riskiness of nuclear power to be greater than respondents that identified as having extremely conservative or conservative political orientation.

The primary focus is on the role of socio-demographic factors in the perception of nuclear power risk. The focus on nuclear power relative to other technologies reflects the "availability" of nuclear power as a threat in recent years and the finding that nuclear power, by Slovic et al., triggers the most fear along multiple

dimensions of the perceived consequences of technological accidents. The focus on the potential role of socio-demographic characteristics in perceptions of nuclear power reflects the debate in the literature over the importance of these factors as predictors of fear. To pursue these dual foci, the present study compared perceptions of nuclear power with three other technologies and does so along six dimensions of perceived consequences. These measures included a) overall risk, b) dread, c) probability, d) immediacy of impact, e) certainty of fatalities, and f) catastrophic impact. The impacts of socio-demographic factors on these dimensions for all four identified technologies were examined to determine cross technological patterns of socio-demographic impacts.

CHAPTER THREE. RESEARCH METHODS

Technology allows society to transform the environment into more hospitable settings but these changes impact the level of potential threats that humans face either by placing us in closer context with areas more prone to natural hazards or by the placement of modern manufacturing and energy production closer to human habitations. In order to more closely identify how people perceive the general hazards of modernity and the specific hazard of a nuclear power plant within their societies, the following research methodology was developed using the baseline psychometric survey model developed by Paul Slovic et al. (Fischhoff, Slovic, and Lichtenstein, 2000; Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000; Slovic, 2000; Slovic, 1992; Slovic, Fischhoff, and Lichtenstein 2000), and then incorporating questions specifically related to the social setting and structure of the survey respondents.

This chapter describes the methodology used for this risk perception research project. The following sections will address the population and sample, the sampling procedures and data collection methods, the specific measures of riskiness, and the limitations of this study. In developing this survey instrument several pretests of the tool were performed. These pretests were completed by emergency management students of North Dakota State University in order to identify potential format problems, comprehension issues and to determine what the average completion time for the survey.

Sampling Approach

The sample for this study included 600 individuals who were empanelled by the Qualtrics Survey Group (www.Qualtrics.com) for this internet based survey. In order to focus the geographic region for the survey on areas served by nuclear power facilities, the maps of operating nuclear power reactors (United States Nuclear Regulatory Commission, 2012; United States Nuclear Regulatory Commission, 2013) were obtained. Regions were then identified on the map that contained multiple reactor sites that were clustered together with high population density. It was thought the salience of this topic would be more significant to the areas that have both high population density and high density of nuclear reactors.

The Midwest area encompassing the counties of Southern Wisconsin and Northern Illinois was selected for the following reasons. There are several modern hazards in this area that include large railroad transportation lines and hubs, nuclear power plants, other forms of power generation, manufacturing facilities, and modern farming using various herbicides and pesticides. The salience of the research topic to this population was thought to be important.

The population surveyed for this study was focused in three ways. First, all participants had to be over the age of 18 years old. Second, to closely mirror the US population as defined by the 2010 US Census, a 50/50 +/- 1% gender split was sought with representation by age group proportionate to the 2010 Census figures. Third, the participants had to come from the northern counties of Illinois and the southern

counties of Wisconsin (see Table 1 for a list by state of which counties were included) as this was an area that had a large concentration of nuclear reactors.

Figure 2. A Map Showing Commercial Nuclear Power Reactors Located Within the United States. (United States Nuclear Regulatory Commission, 2012)

Table 1
Counties Within Each State in Which the Survey Sample Was Drawn

Illinois	Wisconsin
Hancock, McDonough, Fulton, Tazewell, McLean, Ford, Iroquois, Kankakee, Livingston, Woodford, Marshall, Peoria, Knox, Warren, Henderson, Mercer, Rock Island, Henry, Stark, Bureau, Putnam, LaSalle, Grundy, Will, Cook, Kendall, DeKalb, DuPage, Lake, McHenry, Kane, Boone, Lee, Ogle, Winnebago, Stephenson, Carroll, Jo Daviess, Whiteside	Crawford, Richland, Sauk, Columbia, Dodge, Washington, Ozaukee, Grant, Iowa, Lafayette, Green, Middleton, Dane, Walworth, Kenosha, Waukesha, Racine, Milwaukee, Jefferson, Rock

Sampling Procedures

The survey sampling was done through the internet based survey company Qualtrics.com. This company was chosen given their available software suite and because they offer the availability of various panels covering the United States. In order to better understand how this was accomplished, several written questions were submitted to a representative of Qualtrics.Com, Angie Irion (Irion, 2013). A summary of the questions and answers concerning the use of survey panels follows.

How does Qualtrics access the panel members to participate in various surveys? Qualtrics stated that while they do have panel respondents, they recruit them through partner companies. Those partner companies then generally identify the potential participants and ask them to participate in the survey. The panel companies have basic information from the participants which they use to meet the demographic or other screening requirements for the surveys. The partner companies with whom Qualtrics contracts, sent out invitations to participate in the surveys via e-

mail to those that meet initial screening requirements. The companies also post information on the panel company's website concerning available surveys. Participants are provided with some modest forms of compensation. Angie Irion stated that "most of our panel partners compensate respondents by allowing them to build up points and redeem them through some kind of gift card. The amount they are compensated depends entirely on how difficult of a target you are trying to reach. General Population samples can be compensated anywhere from $1-$5. Others are more expensive (medical field samples, for example)" (Irion, 2013).

Several screening questions were placed at the beginning of each survey as well. These additional questions served to fine tune the screening process, insuring that the people within this convenience sample meet the requirements of the researchers. The screening requirements specified that all participants must be over the age of 18 years, the participants must live within a defined geographic area, and that the distribution by age and gender must parallel the percentages seen in the 2010 US census.

To address the issue of non-response, Qualtrics excludes the participant from the total results presented to the researcher and continues to seek additional participants. The researcher only pays for completed responses from qualified participants. The data from incomplete responses can also be obtained if the researcher so desired.

The sample had the following demographic distributions: Male=50% (300) and Female=50% (300); the age distribution was 18-24yrs=13% (78), 24-44yrs=35% (209), 45-64yrs=35% (211) and 65+yrs=17% (104); the income distribution was ≤$24,999=13% (79), $25000-$49,999=24% (145), $50,000-$74,999=24% (145), $75,000-$99,999=16% (96), ≥$100,000=16% (95), rather not say=7% (40); the education distribution was high school or less=16% (97), some college=36% (213), college degree=30% (180) and graduate school/graduate degree=18% (110); and the distribution by political orientation was extremely liberal=5% (31), liberal=12% (70), moderately liberal=15.5% (93), middle of the road=24.5% (147), moderately conservative=16.6% (100), conservative=14.5% (87), extremely conservative =5% (31), prefer not to answer=6.8% (41).

Study Measures

Appendix C contains the survey instrument used in this study. The instrument was based on the Psychometric Survey Model designed by Slovic et al. and then expanded for this study to include measures concerning specific demographics. Part one of the survey uses the previously mentioned psychometric model. Part two of the survey requested baseline demographic data to assist in categorizing the responses.

Originally, 30 natural and technological hazards were identified and the respondents were then asked to complete the psychometric profile for each identified hazard. The pretests that were performed on this survey tool indicated a need to dramatically shorten the survey in order to improve the general response rate. The

number of hazards used in the final survey tool was four. Those hazards were nuclear power plants, railroad transportation, coal-based power plants and, modern farming methods using chemical pesticides and fertilizers.

Psychometric Hazard Profiles

Participants were asked to answer the psychometric questions for each of the identified hazards by rating them on a scale of one to seven with higher scores nominally reflecting a higher perception of risk. In a few cases response options were "yes" or "no." Each survey question is listed in Appendix B, which identifies where the questions originated from Slovic's literature as well as the few other questions that were developed by the researcher or from other sources.

Independent Measures

The independent variables in the present study are the demographic factors reported in prior research with the Slovic risk perception paradigm. There measures were race, gender, income, education (high school or less, some college, undergraduate degree, some graduate school/graduate degree) and political orientation (extremely liberal, liberal, moderately liberal, middle of the road, moderately conservative, conservative and extremely conservative). The questions and response formats for these demographic measures are presented in Appendix C.

Dependent Measures

The dependent measures include multiple aspects of risk perception as developed by Slovic et al. The measures are of two general types. First, the questions assessed respondents' view of the severity of possible consequences for each technology. These measures included the following: a) perceived impact or risk of death, b) perceived dread or fear, c) perceived probability of an accident, d) perceived severity of consequences, and e) perceived potential for catastrophic deaths. Each of these dependent variables was measured with a seven point Likert scale. Second, an overall measure of risk perception was also included and ultimately is the primary dependent variable. The question and response formats for the perception measures are provided in Appendix B.

Ethical Issues

Prior to the start of the study, the research team completed the requirements of the North Dakota State University Institutional Review Board (IRB). The research tool (protocol #HS14137, Risk Perception and Nuclear Power) was reviewed and approved by the IRB as an exempt category two protocol in accordance with Code of Federal Regulations, Title 45, Part 46, Protection of Human Subjects (Appendix D).

Each participant was assured of confidentiality prior to their beginning the survey (Appendix C). Also, given the use of the Qualtrics sample group, the researchers receive no personally identifying information from the survey respondents.

Methodological Limitations

The potential limitations within the sample come from many sources. The primary limitation of this survey is the method of sampling, given that the sample population is limited to those that have internet access and are willing to participate in research studies, although that might be offset as the sample was designed to closely mirror the 2010 census percentages by age and sex. Another potential limitation was that the sample set was focused on a specific location within the country. However, this limitation reflected the desire for a sample where the specified threats would likely be salient to the sample members.

CHAPTER FOUR. FINDINGS: DATA ANALYSIS I

This chapter provides an overview for the dependent variables for this study, to determine which hazards are perceived as the greatest risk. For convenience, six Likert scale variables measuring various aspects of risk perception were selected from the original nine variables. The selected variables used in the analysis were: overall perception of risk of an accident, immediacy of impact of an accident, the sense of dread created by the threat of an accident, the probability of an accident occurring, the certainty of fatalities from an accident, and the potential for catastrophic death and loss from an accident. For each of these six Likert variables presented here, N=600. The six Likert variables are presented separately in Tables 2-7. Each table presents the mean Likert rating for one perceptual variable in rank order by highest hazard mean first. In addition, the percentage distribution for each hazard is also presented. The 7-point Likert scale was recoded into three categories of Low (1, 2, 3), Midpoint (4), and High (5, 6, 7). This recode was done to provide a more efficient and direct interpretation of the percentages.

Technically, the use of significance tests for this data set is inappropriate, as this is not a true random sample. But the use of the significance tests was done as if the sample were random in order to have a criterion that is independent of subjective decision making processes. This allowed a non-subjective evaluation to be performed to determine if the results were significant or not significant.

Table 2 presents data on overall risk perception. The Likert item that stated "On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving . . . ?" Each Likert question concluded with a referent to a specific hazard; these included nuclear generated electric power plant, farming with the use of chemical fertilizers, herbicides and pesticides (CFHP), coal-generated electric power plant, and railroad transportation.

Table 2
Means and Percentages of Overall Perceived Risk for Technical Hazards

Hazard	Average (Std. Dev.)	Low	Midpoint	High	Total %
Nuclear	5.1 (1.62)	15%	23%	62%	100%
CFHP	5.0 (1.54)	16%	20%	64%	100%
Coal	4.1 (1.56)	31%	33%	36%	100%
Railroad	4.0 (1.58)	39%	25%	36%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the overall risk perception scale, nuclear generated electric power received the highest average of 5.1; followed by CFHP at 5.0; coal generated electric power at 4.1; and railroad transportation at 4.01. The mean scores and the percentage data show that the first two hazards are virtually identical in accident risk perception. The same holds true for coal-generated electric power and railroad transportation which have nearly identical means of accident risk perception although their percentage distribution varies somewhat.

The remaining tables present data on various specific measures of riskiness. Table 3 presents data on the Likert item that stated, "On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact or risk of death from an incident, what do you believe is the accident potential for . . ."

Table 3
Means and Percentages of Perceived Risk of Immediacy of Impact and Death for Technical Hazards

Hazard	Average (Std Dev.)	Low	Midpoint	High	Total %
Nuclear	5.1 (1.58)	14%	22%	64%	100%
CFHP	4.3 (1.58)	30%	26%	44%	100%
Railroad	4.2 (1.55)	31%	30%	39%	100%
Coal	3.8 (1.49)	38%	34%	28%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the immediacy of impact and death scale, nuclear generated electric power received the highest average of 5.1; followed by CFHP at 4.3; railroad transportation at 4.2; and coal generated electric power at 3.8. The mean scores and the percentage data show that the nuclear generated electric power creates a much greater perception of immediacy of impact and death than the other three hazards. Specifically the percentage distribution for nuclear generated electric power shows a larger percentage in the high category then the other three hazards, with a "high" percentage of 64%; while CFHP, the next highest mean score, had a "high" percentage of 44%.

Table 4 presents data on the Likert item that stated, "On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident involving . . ."

Table 4
Means and Percentages of Overall Perceived Dread for Technical Hazards

Hazard	Average (Std. Dev.)	Low	Midpoint	High	Total %
Nuclear	4.4 (1.80)	27%	24%	49%	100%
CFHP	4.0 (1.76)	36%	25%	39%	100%
Coal	3.3 (1.72)	49%	26%	25%	100%
Railroad	3.2 (1.70)	53%	26%	21%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the dread scale, nuclear generated electric power received the highest average of 4.4; followed by CFHP at 4.0; coal-generated electric power at 3.3; and railroad transportation at 3.2. The mean scores and the percentage data show that the first two hazards are similar in dread risk perception. The same holds true for coal-generated electric power and railroad transportation which have nearly identical means and similar percentage distributions.

Table 5 presents data on the Likert item that stated, "On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves. . ."

Table 5
Means and Percentages of Overall Perceived Probability of an Accident for Specified Technical Hazards

Hazard	Average (Std. Dev.)	Low	Midpoint	High	Total %
Nuclear	4.3 (1.57)	28%	29%	43%	100%
CFHP	4.2 (1.62)	32%	27%	41%	100%
Railroad	3.7 (1.57)	46%	27%	27%	100%
Coal	3.6 (1.50)	45%	30%	25%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the probability of an accident scale, nuclear generated electric power received the highest average of 4.3; followed by CFHP at 4.2; railroad transportation at 3.7; and coal generated electric power at 3.6. The mean scores and the percentage data show that the first two hazards are virtually identical in perceived probability of an accident. The same holds true for coal generated electric power and railroad transportation which have nearly identical means and similar percentage distributions.

Table 6 presents data on the Likert item that stated, "On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident would be fatal, what do you believe is the severity of consequences of an accident occurring which involves . . ."

Table 6
Means and Percentages of Overall Perceived Risk for Certain Fatalities from an Accident Involving Specified Technical Hazards

Hazard	Average (Std. Dev.)	Low	Midpoint	High	Total %
Nuclear	5.3 (1.45)	8%	23%	69%	100%
Railroad	4.3 (1.49)	26%	32%	42%	100%
CFHP	4.2 (1.47)	29%	30%	41%	100%
Coal	4.1 (1.48)	31%	36%	33%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the risk of certain fatality scale, nuclear generated electric power received the highest average of 5.3; followed by railroad transportation at 4.3, CFHP at 4.2 and; coal-generated electric power at 4.1. The mean scores and the percentage data show that the nuclear generated electric power creates a much greater perception that an accident involving it would create certain fatalities, much more so then the other three hazards. The percentage distribution for nuclear generated electric power also shows a larger percentage in the high category then the other three hazards, with "high" percentage at 69%; while railroad transportation, the next highest mean score, had "high" percentage of 42%. Railroad transportation and CFHP have nearly identical means and similar percentage distributions and while coal-generated electric power also has a similar mean, the percentage distribution is more evenly distributed across the low, midpoint and high rankings.

Table 7 presents data on the Likert item that stated, "On a scale from 1 to 7, with 1 being an accident were there are no deaths occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving. . ."

Table 7
Means and Percentages of Overall Perceived Risk for Catastrophic Death and Loss for Specified Technical Hazards

Hazard	Average (Std. Dev.)	Low	Midpoint	High	Total %
Nuclear	5.2 (1.50)	10%	26%	64%	100%
Railroad	4.0 (1.41)	33%	32%	35%	100%
CFHP	3.9 (1.52)	38%	28%	34%	100%
Coal	3.8 (1.44)	38%	35%	27%	100%

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

For the catastrophic death and loss scale, nuclear generated electric power received the highest average of 5.2; followed by railroad transportation at 4.0; CFHP at 3.9 and; coal-generated electric power at 3.8. The mean scores and the percentage data show that the nuclear generated electric power creates a much greater perception that an accident involving it would create catastrophic levels of loss, much more so then the other three hazards. The percentage distribution for nuclear generated electric power also shows a larger percentage in the high category then the other three hazards, with "high" percentage at 64%; while railroad transportation, the next highest mean score, had a "high" percentage of 35%. Railroad transportation and CFHP have nearly identical means and similar percentage distributions and while coal-generated electric power also has a similar mean, the percentage distribution is distributed across the low, midpoint rankings more so then the high rankings.

Analysis of Tables 2-7 shows that nuclear was the top rated hazard for all 6 of the perceptual measures. CFHP was second ranked for four of the six perceptions while railroad transportation had two of the second rank mean scores. Each of the three remaining hazards, CFHP, railroad transportation and coal-generated electric power each held two positions in the third ranked position, while coal-generated electric power generation was fourth in four of the six perceptions and railroad transportation had the remaining two, fourth ranked positions.

Now we will focus the analysis on a more direct comparison of the mean scores from Tables 2-7. Table 8 provides a slightly different view of the data from Tables 2-7. Table 8 provides a matrix that shows which hazards were top rated, second rated, third rated and rated fourth for each perceptual measure in one master matrix table. Table 8 provides the template to establish if the paired *t*-test comparisons of the mean scores show a statistically significant difference.

Table 8
Rank Order of Mean Response Scores by Technical Hazard

Risk Perception Question	Column 1 Top Hazard Mean Score	Column 2 2nd Ranked Hazard Mean Score	Column 3 3rd Ranked Hazard Mean Score	Column 4 4th Ranked Hazard Mean Score
Fatal	5.3 Nuclear	4.3 Railroad	4.2 CFHP	4.1 Coal
Catastrophic	5.2 Nuclear	4.0 Railroad	3.9 CFHP	3.8 Coal
Impact-Immediate Death	5.1 Nuclear	4.3 CFHP	4.2 Railroad	3.8 Coal
Risk	5.1 Nuclear	5.0 CFHP	4.1 Coal	4.0 Railroad
Dread	4.4 Nuclear	4.0 CFHP	3.3 Coal	3.2 Railroad
Probability	4.3 Nuclear	4.2 CFHP	3.7 Railroad	3.6 Coal

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

Table 8 shows that of the identified hazards, nuclear power ranks highest in risk perception. Table 9 presents the findings from the paired *t*-test calculations

prepared form the mean scores presented in Table 8. The paired *t*-test was used to determine if the difference between the means in adjacent columns of Table 8 are significant.

The data for nuclear power shows that there was a statistically significant difference for four comparisons. The comparisons include the severity of consequence/fatal accidents comparing nuclear generated electric power to the second rated railroad transportation mean. The second significant comparison also involved comparing nuclear generated electric power to railroad transportation in considering the question which asked about the wholesale impact of an incident causing large numbers of fatalities. The third significant comparison involved nuclear generated electric power and CFHP. People were significantly more sensitive to the immediate impact potential of an event involving nuclear power.

Table 9
Paired t-Test of Mean Response Scores

Risk Perception Question	**Paired *t*-test Column 1 & 2 from Table 8**	**Paired *t*-test Column 2 & 3 from Table 8**	**Paired *t*-test Column 3 & 4 from Table 8**
Fatal	.000	.211	.015
Catastrophic	.000	.090	.211
Impact-Immediate Death	.000	.127	.000
Risk	.336	.000	.204
Dread	.000	.000	.140
Probability	.097	.000	.430

Significance determined at $p \leq .05$
CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

The final significant comparison involved the means for nuclear generated electric power and CFHP in relation to the question about dread. Once again the difference between nuclear generated electric power and CFHP was significant in the

paired *t*-test. In summary, we see that the comparison of means between columns one and two shows that nuclear power generation was indicative of higher perceived riskiness but not overall risk.

In looking at the results of the paired *t*-test between Columns 2 and 3 from Table 8 we see that there are three significant comparisons. The first question which showed sensitivity between the means in this set of paired *t*-tests was in response to the question concerning overall risk. In this comparison we see that there was a difference between the means of CFHP and coal-generated electric power. This is pertinent as the mean for CFHP was similar to nuclear power for how people perceive the risk of these modern hazards. The drop in the mean value for coal-generated electric power is indicative of the lower perceived risk of that hazard when compared to nuclear generated electric power and CFHP.

The next item to show sensitivity for the difference between means was CFHP and coal-generated electric power in relation to the question concerning the perceived level of dread that the modern hazard creates. This shows that there was a difference in the level of dread caused by these two hazards. In addition, as previously noted there was also a significant difference between dread related to nuclear generated electric power and CFHP.

The final risk perception question to show significant difference between Columns 2 and 3 was for the one that considered the probability of an accident occurring. In this question we see that the differences in the mean scores for CFHP

and railroad transportation from Table 8 are significant. This is the only set of means which showed a significant difference for the question related to probability of an accident occurring. But as with the question concerning risk perception of the hazards this is important as there was little difference between nuclear generated electric power and CFHP.

The final column of Table 9, displays the significance of the differences of the observed means between Columns 3 and 4 located in Table 8. The difference of the means only had two questions which showed significant difference. The first one related to the question which asked the respondents to consider the potential of the identified hazards to lead to fatalities. The difference between the hazard mean scores for CFHP and coal generated electric power revealed a significant difference.

The only other item to show a significant difference of the mean hazard scores was for the immediacy of impact and death. This showed that there was a significant difference between the hazard mean scores for railroad transportation and coal-generated electric power. Respondents' perceptions of the immediacy of coal-generated electric power's perceived impact are quite lower than the other hazards evaluated in this study.

Summary

The perceived risk of nuclear generated electric power is the most highly rated threat across most risk dimensions of the hazards identified in this study. The scores that nuclear power received were significantly higher when it comes to the perceived

risk, potential to cause catastrophic levels of destruction, to have an immediate impact causing death and having a high dread factor. For the two questions (perceived risk and perceived probability of an accident occurring involving the identified hazard) where nuclear generated electric power had similar mean response score to a second hazard, the second hazard was CFHP which in turn was significantly different from the next hazard. This analysis indicates that people perceive nuclear power as an extreme risk that could have a negative impact on society.

The analysis in this chapter suggests that nuclear power is not only seen as the riskiest technology of those identified in this study, but it is also seen as the riskiest in terms of its consequences. In addition the means and the significance tests suggest that overall perceived risk and probability of risk of farming do not differ from nuclear.

CHAPTER FIVE. FINDINGS: DATA ANALYSIS II

In this chapter, the focus shifts to analysis of variance (ANOVA) test for the six identified dependent variables to determine the extent to which socio-demographic factors significantly impact the dimensions of risk for each technology. These dependent variables include the six Likert scale variables dealing with hazard risk perception or riskiness. The number of cases, unless otherwise noted for each of the six Likert variables presented is N=600.

The reasoning behind doing the ANOVA tests were threefold. First, these ANOVA tests allow an in-depth view of the role each demographic plays across the multiple dimensions of perceived risk that were investigated by this study. Second, the ANOVAs also allow for the comparison of the impact that the demographics have across the four technologies; and third, performing the ANOVAs identify what demographic variables deserve more attention in overall comparative analysis of the impact of these demographic factors on overall perceived risk using multiple regression. Specifically, the final analysis of the paper will focus only on respondents' overall perception of risk for each technology.

Regardless of a factor's affect on specific dimensions of riskiness, ultimately it is the factor's affect on overall perceived risk that reflects the factor's importance. This analysis will include all socio-demographic factors where one-way ANOVAs have shown a given factor to significantly impact overall risk perception. Where two

or more factors affect overall risk perception for a given technology, the multiple regression analysis will reveal the relative impact of these factors.

Table 10
Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Gender

Gender	Male N=300 Mean (SD)	Female N=300 Mean (SD)	F	*p*
CFHP: Death/Immed	4.2 (1.6)	4.4 (1.5)	.872	.515
CFHP: Fatalities	4.2 (1.5)	4.5 (1.4)	.622	.712
CFHP: Probability	4.2 (1.6)	4.3 (1.7)	.714	.639
CFHP: Catastrophic	4.0 (1.6)	3.9 (1.5)	.389	.886
CFHP: Dread	3.9 (1.8)	4.1 (1.7)	.539	.779
CFHP: Risk	4.9 (1.6)	5.1 (1.5)	.962	.450
Coal: Death/Immed	3.8 (1.6)	3.9 (1.3)	3.243	.004
Coal: Fatalities	3.9 (1.5)	4.2 (1.4)	2.396	.027
Coal: Probability	3.6 (1.6)	3.7 (1.4)	3.280	.004
Coal: Catastrophic	3.7 (1.5)	4.0 (1.4)	1.513	.171
Coal: Dread	3.3 (1.7)	3.4 (1.6)	1.133	.341
Coal: Risk	4.0 (1.6)	4.2 (1.4)	4.155	.000
Rail: Death/Immed	4.2 (1.6)	4.2 (1.5)	1.141	.337
Rail: Fatalities	4.3 (1.5)	4.3 (1.5)	.428	.860
Rail: Probability	3.7 (1.6)	3.7 (1.5)	.195	.978
Rail: Catastrophic	4.0 (1.4)	4.0 (1.4)	.898	.496
Rail: Dread	3.3 (1.7)	3.2 (1.7)	.968	.446
Rail: Risk	4.1 (1.6)	3.9 (1.5)	.999	.425
Nuclear: Death/Immed	5.1 (1.6)	5.2 (1.6)	.802	.569
Nuclear: Fatalities	5.2 (1.5)	5.4 (1.4)	1.011	.417
Nuclear: Probability	4.1 (1.6)	4.5 (1.5)	2.686	.014
Nuclear: Catastrophic	5.1 (1.5)	5.3 (1.5)	1.165	.323
Nuclear: Dread	4.3 (1.8)	4.5 (1.8)	.650	.691
Nuclear: Risk	5.0 (1.7)	5.2 (1.5)	1.154	.329

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides
SD=Standard Deviation

The impact of gender on the five dimensions of perceived riskiness and the overall perceived risk for each of the four technologies was examined using analysis

of variance (Table 10). The respondents' gender did not significantly impact any of the dimensions of risk nor did it impact respondents' perception of overall risk in two of the identified technologies, farming with chemical fertilizers, herbicides and pesticides (CFHP) and railroad transportation (Table 10). In contrast, respondents' gender did impact both coal powered electricity generation and nuclear powered electricity generation. Coal powered electricity generation was significantly impacted in three of the perceived riskiness dimensions (i.e. perceived immediacy of death, probability of fatalities and probability of an accident occurring) and overall risk perception. For nuclear power the only significant gender effect was for the perceived probability of an accident occurring. For each significant difference, females perceived risk to be higher than did males. Gender was significant for the overall risk perception for coal powered electric power plants and so will be included in subsequent analysis of factors affecting perceived risk for coal powered electric power plants.

The impact of race on the five dimensions of perceived riskiness and the overall perceived risk for each of the four technologies also was examined using analysis of variance (Table 11). In order to more easily interpret the results race was recoded into white and non-white. Respondents' identification as white or nonwhite did significantly impact dimensions of perceived riskiness across all four technologies (Table 11) and in all cases, non-whites perceived risk and/or riskiness to be higher than did whites. Specifically, identification as white or nonwhite impacted five of the perceived riskiness dimensions for CFHP (i.e., perceived immediacy of death,

perceived probability of fatalities, perceived probability of an accident occurring, perceived catastrophic potential of an accident, and the perceived dread that a disaster involving CFHP would create in the respondents). However, racial identification as white or nonwhite did not significantly impact overall perceived risk and therefore will not be included in subsequent analysis.

Respondents' identification as white or nonwhite also significantly impacted four dimensions of perceived riskiness for coal-generated electric power (i.e., perceived immediacy of death, perceived probability of an accident occurring, the potential for catastrophic impact and perceived dread). Racial identification also significantly impacted the overall perceived risk of coal-generated electric power, so it will be included in further analysis.

Respondents' identification as white or nonwhite also significantly impacted perceptions of railroad transportation across three dimensions of perceived riskiness (i.e., perceived probability of an accident occurring, the potential for catastrophic impact and perceived dread). However, racial identification for railroad transportation does not significantly impact overall perceived risk and thus will be excluded from subsequent analysis of factors affecting perceived risk.

Table 11

Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by White/Nonwhite

Race White/Nonwhite	White N=482 Mean (SD)	Nonwhite N=118 Mean (SD)	F	*p*
CFHP: Death/Immed	4.2 (1.6)	4.5 (1.5)	3.840	.001
CFHP: Fatalities	4.1 (1.5)	4.6 (1.4)	2.521	.020
CFHP: Probability	4.1 (1.6)	4.7 (1.6)	2.402	.027
CFHP: Catastrophic	3.8 (1.5)	4.4 (1.4)	4.341	.000
CFHP: Dread	3.9 (1.8)	4.4 (1.8)	2.475	.023
CFHP: Risk	5.0 (1.5)	5.0 (1.7)	2.078	.054
Coal: Death/Immed	3.7 (1.5)	4.2 (1.5)	2.167	.045
Coal: Fatalities	4.0 (1.5)	4.3 (1.5)	1.104	.359
Coal: Probability	3.5 (1.5)	4.2 (1.5)	4.678	.000
Coal: Catastrophic	3.7 (1.4)	4.4 (1.5.)	5.501	.000
Coal: Dread	3.1 (1.7)	4.2 (1.7)	6.502	.000
Coal: Risk	4.0 (1.5)	4.6 (1.6)	3.349	.003
Rail: Death/Immed	4.1 (1.5)	4.4 (1.5)	1.279	.265
Rail: Fatalities	4.3 (1.4)	4.5 (1.6)	1.546	.161
Rail: Probability	3.6 (1.5)	4.2 (1.6)	3.126	.005
Rail: Catastrophic	3.9 (1.4)	4.4 (1.5)	4.114	.000
Rail: Dread	3.1 (1.6)	4.0 (1.8)	5.357	.000
Rail: Risk	3.9 (1.6)	4.3 (1.6)	1.995	.064
Nuclear: Death/Immed	5.1 (1.6)	5.3 (1.5)	1.392	.215
Nuclear: Fatalities	5.3 (1.4)	5.3 (1.5)	.975	.441
Nuclear: Probability	4.2 (1.6)	4.7 (1.5)	2.268	.036
Nuclear: Catastrophic	5.2 (1.5)	5.2 (1.6)	1.044	.395
Nuclear: Dread	4.3 (1.8)	5.1 (1.6)	3.709	.001
Nuclear: Risk	5.0 (1.6)	5.2 (1.6)	1.376	.222

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides
SD=Standard Deviation

Respondents' identification as white or nonwhite for race did significantly impact nuclear generated electric power across two dimensions of perceived riskiness (i.e., perceived probability of an accident occurring, and perceived dread). However,

racial identification for nuclear powered electric generation did not significantly impact overall perceived risk and thus will be excluded from subsequent analysis.

The ANOVAs for the four identified hazards compared against the independent variable for education are presented in Table 12. Respondents' level of education did not significantly affect any of the dimensions of perceived riskiness nor did it impact respondents' perceptions of overall perceived risk for three of the four technologies, CFHP, coal powered electric generation, and railroad transportation (Table 12). In contrast, respondents' education did significantly impact two dimensions of perceived riskiness for nuclear power (i.e., perceived immediacy of death and the perceived probability of fatalities), and marginally affected a third dimension (i.e., perceived catastrophic loss). However, education still did not significantly impact overall perceived riskiness of nuclear power. Thus, education will not be included in any subsequent analysis of factors affecting perceived risk of any of the four technologies.

The ANOVAs for the four identified hazards compared against the independent variable for income is presented in Table 13. Respondents' level of income did not significantly affect any of the dimensions of perceived riskiness nor did it impact respondents' perceptions of overall perceived risk for two of the four technologies, CFHP, and railroad transportation (Table 13).

Table 12

Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Education

Education	High School or Less N= 97 Mean (SD)	Some College N= 213 Mean (SD)	College Degree N= 180 Mean (SD)	Graduate School or Greater N= 110 Mean (SD)	F	*p*
CFHP: Death/Immed	4.1 (1.6)	4.4 (1.5)	4.3 (1.6)	4.4 (1.6)	.540	.655
CFHP: Fatalities	4.1 (1.5)	4.2 (1.5)	4.3 (1.4)	4.3 (1.5)	.800	.494
CFHP: Probability	4.0 (1.8)	4.2 (1.5)	4.4 (1.7)	4.2 (1.6)	1.323	.266
CFHP: Catastrophic	3.8 (1.7)	3.8 (1.5)	4.0 (1.5)	4.0 (1.5)	.916	.433
CFHP: Dread	3.9 (1.9)	4.0 (1.7)	4.0 (1.7)	4.0 (1.8)	.285	.836
CFHP: Risk	5.0 (1.6)	4.9 (1.6)	5.0 (1.5)	5.2 (1.4)	1.016	.385
Coal: Death/Immed	3.6 (1.4)	3.9 (1.5)	3.9 (1.4)	3.9 (1.6)	1.165	.323
Coal: Fatalities	3.9 (1.5)	4.0 (1.5)	4.1 (1.4)	3.6 (1.6)	.549	.649
Coal: Probability	3.4 (1.4)	3.7 (1.5)	3.7 (1.5)	3.6 (1.6)	.765	.514
Coal: Catastrophic	3.8 (1.3)	3.9 (1.5)	3.9 (1.4)	3.8 (1.4)	.353	.787
Coal: Dread	3.3 (1.7)	3.4 (1.7)	3.3 (1.7)	3.3 (1.9)	.022	.996
Coal: Risk	3.9 (1.4)	4.1 (1.5)	4.2 (1.6)	4.2 (1.6)	.989	.397
Rail: Death/Immed	4.1 (1.5)	4.1 (1.6)	4.3 (1.5)	4.2 (1.7)	1.013	.386
Rail: Fatalities	4.0 (1.3)	4.3 (1.6)	4.5 (1.4)	4.4 (1.5)	2.012	.111
Rail: Probability	3.6 (1.4)	3.7 (1.6)	3.7 (1.5)	3.7 (1.6)	.165	.920
Rail: Catastrophic	3.9 (1.4)	4.0 (1.4)	4.2 (1.4)	4.0 (1.4)	1.717	.162
Rail: Dread	3.3 (1.6)	3.2 (1.7)	3.3 (1.7)	3.1 (1.7)	.676	.567
Rail: Risk	4.0 (1.5)	4.0 (1.5)	4.2 (1.6)	3.8 (1.6)	1.186	.314

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides

SD=Standard Deviation

Table 12. ***Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Education (continued)***

Education	High School or Less N= 97 Mean (SD)	Some College N= 213 Mean (SD)	College Degree N= 180 Mean (SD)	Graduate School or Greater N= 110 Mean (SD)	F	*p*
Nuclear: Death/Immed	5.0 (1.6)	5.0 (1.6)	5.2 (1.5)	5.5 (1.5)	3.557	.014
Nuclear: Fatalities	5.3 (1.5)	5.1 (1.6)	5.4 (1.4)	5.7 (1.3)	3.106	.026
Nuclear: Probability	4.4 (1.5)	4.4 (1.5)	4.3 (1.6)	4.3 (1.7)	.100	.960
Nuclear: Catastrophic	5.1 (1.5)	5.0 (1.6)	5.2 (1.4)	5.4 (1.4)	2.365	.070
Nuclear: Dread	4.5 (1.8)	4.4 (1.7)	4.4 (1.8)	4.4 (2.0)	.113	.952
Nuclear: Risk	4.9 (1.7)	5.1 (1.6)	5.1 (1.6)	5.1 (1.6)	.558	.643

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides
SD= Standard Deviation

Table 13

Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Income

Income	<$24,999 N=79 Mean (SD)	$25,000 - $49,999 N=145 Mean (SD)	$50,000 - $74,999 N=145 Mean (SD)	$75,000- $99,999 N=96 Mean (SD)	>$100K N=95 Mean (SD)	F	*p*
CFHP: Death/Immed	4.5 (1.6)	4.2 (1.6)	4.2 (1.6)	4.4 (1.6)	4.3 (1.6)	.505	.804
CFHP: Fatalities	4.4 (1.5)	4.2 (1.4)	4.0 (1.4)	4.3 (1.5)	4.4 (1.5)	.351	.909
CFHP: Probability	4.3 (1.7)	4.2 (1.6)	4.1 (1.6)	4.4 (1.6)	4.2 (1.6)	.622	.713
CFHP: Catastrophic	4.0 (1.6)	3.8 (1.5)	3.8 (1.4)	4.2 (1.6)	4.0 (1.6)	.484	.820
CFHP: Dread	4.2 (1.9)	4.0 (1.7)	3.9 (1.7)	4.1 (1.7)	3.9 (1.8)	.430	.859
CFHP: Risk	5.1 (1.8)	5.0 (1.5)	5.0 (1.5)	5.1 (1.5)	5.1 (1.5)	1.197	.306
Coal: Death/Immed	3.8 (1.7)	3.8 (1.4)	3.7 (1.5)	4.0 (1.6)	3.8 (1.4)	.1530	.166
Coal: Fatalities	4.1 (1.7)	4.0 (1.4)	4.1 (1.5)	4.1 (1.5)	4.0 (1.5)	1.887	.081
Coal: Probability	3.6 (1.7)	3.7 (1.5)	3.6 (1.6)	3.8 (1.5)	3.5 (1.4)	1.422	.204
Coal: Catastrophic	4.0 (1.7)	3.9 (1.4)	3.7 (1.5)	4.0 (1.3)	3.6 (1.3)	2.802	.011
Coal: Dread	3.7 (1.8)	3.1 (1.7)	3.3 (1.7)	3.5 (1.8)	3.2 (1.7)	.566	.757
Coal: Risk	4.1 (1.6)	4.2 (1.6)	4.0 (1.5)	4.1 (1.7)	4.1 (1.4)	1.592	.147
Rail: Death/Immed	4.2 (1.7)	4.1 (1.5)	4.2 (1.6)	4.4 (1.5)	4.2 (1.5)	.339	.916
Rail: Fatalities	4.6 (1.6)	4.3 (1.5)	4.2 (1.5)	4.4 (1.4)	4.2 (1.5)	1.681	.123
Rail: Probability	3.7 (1.6)	3.8 (1.5)	3.5 (1.6)	3.9 (1.7)	3.5 (1.3)	1.228	.290
Rail: Catastrophic	4.2 (1.5)	4.0 (1.4)	3.9 (1.4)	4.3 (1.5)	3.9 (1.4)	1.678	.124
Rail: Dread	3.4 (1.7)	3.2 (1.7)	3.2 (1.6)	3.4 (1.8)	3.0 (1.6)	.279	.947
Rail: Risk	4.0 (1.6)	4.0 (1.6)	3.9 (1.5)	4.1 (1.6)	4.1 (1.5)	.445	.848

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides, Sample N=560

SD=Standard Deviation

Table 13. ***Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Income (continued)***

Income	<$24,999 N=79 Mean (SD)	$25,000 - $49,999 N=145 Mean (SD)	$50,000 - $74,999 N=145 Mean (SD)	$75,000- $99,999 N=96 Mean (SD)	>$100K N=95 Mean (SD)	F	*p*
Nuclear: Death/Immed	5.1 (1.7)	5.1 (1.5)	5.0 (1.7)	5.1 (1.5)	5.5 (1.5)	1.279	.265
Nuclear: Fatalities	5.3 (1.6)	5.4 (1.5)	5.3 (1.5)	5.2 (1.3)	5.4 (1.3)	1.850	.087
Nuclear: Probability	4.6 (1.6)	4.3 (1.6)	4.3 (1.6)	4.5 (1.5)	4.0 (1.5)	2.430	.025
Nuclear: Catastrophic	5.2 (1.7)	5.3 (1.4)	5.1 (1.6)	5.1 (1.3)	5.2 (1.4)	1.445	.195
Nuclear: Dread	4.6 (1.8)	4.3 (1.8)	4.3 (1.9)	4.3 (1.7)	4.5 (1.8)	.821	.554
Nuclear: Risk	5.2 (1.7)	4.9 (1.7)	5.2 (1.6)	5.1 (1.4)	5.0 (1.6)	1.915	.076

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides, Sample N=560
SD=Standard Deviation

Table 14

Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Political Orientation

Political Orientation	Extreme Liberal N=31 Mean (SD)	Liberal N=70 Mean (SD)	Moderately Liberal N=93 Mean (SD)	Middle of the Road N=147 Mean (SD)	Moderately Conservative N=100 Mean (SD)	Conservative N=87 Mean (SD)	Extremely Conservative N=31 Mean (SD)	F	*p*
CFHP: Death	4.8 (1.7)	4.2 (1.4)	4.4 (1.5)	4.2 (1.4)	4.4 (1.6)	4.2 (1.8)	3.9 (1.9)	1.990	.065
CFHP: Fatalities	4.74 (1.7	4.3 (1.4)	4.4 (1.3)	4.1 (1.3)	4.3 (1.4)	4.1 (1.5)	3.6 (2.0)	3.383	.003
CFHP: Probability	4.8 (1.6)	4.2 (1.6)	4.5 (1.7)	4.1 (1.4)	4.2 (1.5)	4.1 (1.7)	3.7 (2.0)	1.889	.081
CFHP: Catastrophic	4.3 (1.7)	4.1 (1.4)	4.0 (1.5)	3.9 (1.5)	3.9 (1.4)	3.8 (1.5)	3.5 (1.9)	1.860	.086
CFHP: Dread	4.4 (1.9)	3.9 (1.6)	4.1 (1.8)	4.0 (1.6)	4.0 (1.8)	4.0 (1.8)	3.6 (2.3)	1.410	.208
CFHP: Risk	5.6 (1.6)	4.8 (1.6)	5.3 (1.4)	4.9 (1.4)	5.0 (1.4)	5.0 (1.6)	5.0 (1.5)	1.366	.226

CFHP=Farming with Chemical Fertilizers, Herbicides and Pesticides, SD= Standard Deviation

Table 14. ***Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Political Orientation (continued)***

Political Orientation	Extreme Liberal N=31 Mean (SD)	Liberal N=70 Mean (SD)	Moderately Liberal N=93 Mean (SD)	Middle of the Road N=147 Mean (SD)	Moderately Conservative N=100 Mean (SD)	Conservative N=87 Mean (SD)	Extremely Conservative N=31 Mean (SD)	F	*p*
Coal: Death/ Immed	4.3 (1.6)	4.1 (1.6)	3.9 (1.5)	3.8 (1.3)	3.8 (1.5)	3.5 (1.6)	3.5 (1.8)	2.751	.012
Coal: Fatalities	4.4 (1.7)	4.3 (1.4)	4.1 (1.5)	4.0 (1.3)	4.0 (1.5)	3.9 (1.6)	3.8 (1.8)	1.888	.081
Coal: Probability	4.1 (2.2)	3.9 (1.5)	3.7 (1.6)	3.6 (1.3)	3.6 (1.5)	3.3 (1.5)	3.5 (1.8)	2.422	.026
Coal: Catastrophic	4.2 (1.8)	4.1 (1.4)	3.8 (1.3)	3.7 (1.3)	3.8 (1.5)	3.7 (1.6)	3.5 (1.8)	2.613	.017
Coal: Dread	3.3 (1.9)	3.7 (1.9)	3.3 (1.7)	3.4 (1.6)	3.2 (1.6)	2.9 (1.7)	2.9 (2.1)	1.433	.200
Coal: Risk	4.2 (1.9)	4.3 (1.6)	4.3 (1.6)	4.1 (1.4)	4.1 (1.5)	3.9 (1.6)	3.5 (1.9)	1.797	.098

SD= Standard Deviation

Table 14. ***Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Political Orientation (continued)***

Political Orientation	Extreme Liberal N=31 Mean (SD)	Liberal N=70 Mean (SD)	Moderately Liberal N=93 Mean (SD)	Middle of the Road N=147 Mean (SD)	Moderately Conservative N=100 Mean (SD)	Conservative N=87 Mean (SD)	Extremely Conservative N=31 Mean (SD)	F	*p*
Rail: Death/ Immed	4.6 (1.7)	4.3 (1.5)	4.1 (1.6)	4.1 (1.5)	4.3 (1.6)	4.0 (1.5)	4.1 (1.6)	.808	.564
Rail: Fatalities	4.4 (1.9)	4.3 (1.4)	4.5 (1.5)	4.3 (1.4)	4.3 (1.4)	4.1 (1.6)	4.2 (1.6)	.450	.845
Rail: Probability	3.9 (2.2)	3.5 (1.6)	3.9 (1.7)	3.6 (1.3)	3.7 (1.5)	3.6 (1.7)	3.7 (1.7)	.738	.619
Rail: Catastrophic	4.0 (1.7)	4.1 (1.4)	4.0 (1.4)	4.1 (1.3)	4.2 (1.4)	3.8 (1.4)	4.0 (1.6)	.309	.932
Rail: Dread	3.2 (2.1)	3.3 (1.7)	3.2 (1.6)	3.4 (1.5)	3.2 (1.8)	3.0 (1.8)	3.1 (2.0)	.402	.878
Rail: Risk	4.0 (1.9)	4.0 (1.5)	4.1 (1.7)	4.0 (1.5)	4.0 (1.5)	4.0 (1.6)	4.0 (1.7)	1.522	.169

Table 14. ***Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk by Political Orientation (continued)***

Political Orientation	Extreme Liberal N=31 Mean (SD)	Liberal N=70 Mean (SD)	Moderately Liberal N=93 Mean (SD)	Middle of the Road N=147 Mean (SD)	Moderately Conservative N=100 Mean (SD)	Conservative N=87 Mean (SD)	Extremely Conservative N=31 Mean (SD)	F	*p*
Nuclear: Death/Immed	5.5 (2.0)	5.3 (1.3)	5.5 (1.6)	5.2 (1.5)	5.0 (1.5)	4.9 (1.7)	4.9 (1.7)	2.259	.037
Nuclear: Fatalities	5.8 (1.9)	5.3 (1.3)	5.6 (1.4)	5.4 (1.4)	5.3 (1.3)	5.0 (1.5)	5.0 (1.7)	2.808	.011
Nuclear: Probability	4.8 (2.0)	4.5 (1.6)	4.5 (1.6)	4.3 (1.4)	4.1 (1.4)	4.0 (1.7)	4.0 (1.9)	2.574	.018
Nuclear: Catastrophic	5.6 (1.8)	5.2 (1.4)	5.5 (1.3)	5.2 (1.4)	5.1 (1.2)	4.9 (1.7)	4.7 (1.7)	2.496	.022
Nuclear: Dread	4.7 (2.1)	4.5 (1.6)	4.6 (1.8)	4.6 (1.6)	4.3 (1.7)	4.1 (1.9)	3.7 (2.3)	2.087	.053
Nuclear: Risk	5.7 (1.9)	5.2 (1.4)	5.3 (1.7)	5.2 (1.5)	5.0 (1.4)	4.7 (1.7)	4.4 (2.0)	4.358	.000

SD= Standard Deviation

Table 15

Summary of Significant Findings from Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk

	Gender	Race	Education	Income	Political Orientation
CFHP: Death/Immed		X			X*
CFHP: Fatalities		X			X
CFHP: Probability		X			X*
CFHP: Catastrophic		X			X*
CFHP: Dread		X			
CFHP: Risk		X*			X*
Coal: Death/Immed	X	X			X
Coal: Fatalities	X			X	X*
Coal: Probability	X	X			X
Coal: Catastrophic		X		X	X
Coal: Dread		X			
Coal: Risk	X	X			

Note. "X" identifies a significant affect and "X" with an asterisk identifies a marginally significant affect.

Table 15. ***Summary of Significant Findings from Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk (continued)***

	Gender	Race	Education	Income	Political Orientation
Rail: Death/Immed					
Rail: Fatalities					
Rail: Probability		X			
Rail: Catastrophic		X			
Rail: Dread		X			
Rail: Risk		X*			
Nuclear: Death/Immed			X		X
Nuclear: Fatalities			X	X*	X
Nuclear: Probability	X	X		X	X
Nuclear: Catastrophic			X		X
Nuclear: Dread		X			X*
Nuclear: Risk				X*	X

Note. "X" identifies a significant affect and "X" with an asterisk identifies a marginally significant affect.

Respondents' level of income did significantly impact one dimension of perceived riskiness for coal powered electric power (i.e., perceived riskiness of a catastrophic event). However, income did not impact overall perceived risk for coal powered electric generation, thus income will not be included in any subsequent analysis for perceived risk in the context of these three technologies (i.e., CFHP, railroad transportation, and coal generated electric power). In contrast, respondents' with higher reported income did significantly impact one dimension of perceived riskiness for nuclear power (i.e., the perceived probability of an accident occurring), and marginally affected overall perceived risk. Thus, income will be included in subsequent analysis of overall perceived risk for nuclear power generation.

The ANOVAs for the four identified hazards compared against the independent variable of political orientation are presented in Table 14. The political orientation of the respondents' did not significantly affect any of the dimensions of perceived riskiness nor did it impact respondents' perceptions of overall perceived risk for the technical hazard of railroad transportation (Table 14). In contrast, respondents' political orientation did significantly impact one dimension of perceived riskiness for CFHP (i.e., perceived potential for fatalities). Also, political orientation significantly impacted three dimensions of perceived riskiness for the technical hazard of coal generated electric power (i.e., perceived probability of immediacy of death, perceived probability of an accident, and perceived potential for catastrophic impact). However, political orientation did not significantly impact overall perceived riskiness of CFHP, railroad transportation and coal generated electric power. Thus,

political orientation will not be included in any subsequent analysis of factors affecting perceived risk of any of these three technologies.

However, political orientation did significantly impact four dimensions of perceived riskiness for nuclear power (i.e., perceived immediacy of death, perceived probability of fatalities, perceived probability of an accident, and the perceived probability of catastrophic loss). Also, political orientation did significantly impact overall perceived riskiness of nuclear power. Thus, political orientation with concern for nuclear power generation will be included in subsequent analysis.

The summary of the significant findings from the ANOVA tests performed (Table 15) create an interesting pattern which shows that race plays some role in risk perception in all of the hazards, but most strikingly in CFHP, coal-generated electricity and railroad transportation. The non-white respondents tended to have an increased perception of risk and riskiness for the technical hazards of CFHP, railroad transportation and coal-generated electric power. The other demographic variable that has a similar impact, although marginally in many cases, is political orientation. Political orientation significantly affects the risk perception of nuclear power, coal generated electricity and marginally CFHP. Respondents that identified themselves as being extremely liberal and liberal tended to find the technical hazards as having increased risk and riskiness. From this initial analysis it would appear that there may be some support for the race basis of the white component of the white-male effect as well the political orientation of the respondents.

Regression Analysis

Overall perceived risk was the primary dependent variable for each of the technological hazards. Despite numerous significant and marginally significant effects across measures of perceived riskiness for all technologies, the number of socio-demographic effects on overall perceived risk of a given technology was limited. The data from tables 10-14 showed that there was only significance for overall risk for coal generated power for the perceived riskiness variables race and gender. Nuclear power generation only had a significant finding for the dependent variable overall risk with the perceived riskiness variable political orientation and marginally impacted by the perceived riskiness variable for income. Multiple regression analysis was performed on each of the identified independent variables (i.e., for coal nonwhite/white and gender and for nuclear power political orientation and income) and the dependent variable for no risk/high risk.

With both gender and race affecting the perceived risk of coal-generated electric power, it is reasonable to test for the "white-male" effect found in past research (Finucane, Slovic, Mertz, Flynn and Satterfield, 2000). The "white-male" effect suggests and interaction of gender and race. The findings are presented Table 16.

Table 16
Regression Analysis of Gender/Race Interaction (White Male Effect) on Risk Perception for Coal-Generated Electric Power

Variable	β	t
Gender/Race Interaction	-.036	-.235
Gender	-.019	-.203
White/Nonwhite	-.122	-.966
R^2	.019*	
F	4.968	

*p<.05

The overall model is significant, but the R^2 is not very large, explaining roughly 2% of the variation in the dependent variable. Furthermore, neither the interaction factor nor the separate independent variables in this study are significant. The male/white interaction found in prior research is not present in the current data. Thus, this interaction factor was dropped to just focus on gender and race.

Table 17 shows the results of the linear regression analysis of overall perceived risk of coal-generated electric power with the independent variables of gender and race.

Table 17
Regression Analysis of Gender and Race Impacting Risk Perception of Coal Generated Electric Power

Variable	β	t
Gender	-.038	-.934
Race	-.150	-3.709*
R^2	.021*	
F	7.437	

*p<.001

The overall model remains with a small R^2 explaining only about 2% of the variation in the dependent variable. Gender is still not significant, but race is when controlled for gender.

Table 18 shows the analysis of how income and political orientation impact the respondents' risk perception of nuclear generated electric power. These two independent variables were the only ones to significantly impact nuclear power risk perception.

Table 18
The Regression Analysis of Income and Politics Impacting Risk Perception of Nuclear Generated Electric Power

Variable	β	t
Income	.006	.147
Political Views	-.178	-4.123*
R^2	.028*	
F	8.521	

*p<.05

The overall model is significant per the R^2 of about .028. The R^2 is not very large, explaining only about 3% of the variation in the dependent variable. This minimizes the substantive importance which would indicate that there is a need to explore more than just the social demographic factors. The statistical significance of the separate independent variables in this study show that income is no longer significant when controlled for political orientation; but the independent variable of political orientation is significant when controlling for income.

In addition, political orientation has a significant effect. To understand this effect, a post-hoc *t*-test (Tukey's HSD) was performed to compare overall risk

perception means by political orientation to find the break point among means. The relevant information can be found in Table 19.

Table 19
Post Hoc t-test Using Tukey's HSD to Compare Means of Risk Perception of Nuclear Power by Political Orientation

Political Orientation Comparison		Difference of Means	Std. Error
Extreme Liberal	Conservative	.988*	.332
Extreme Liberal	Extreme Conservative	1.290*	.403

*$p \leq .05$

The results show that the difference in political orientation was only significant when comparing those at either extreme of the political spectrum. Those at the conservative end perceived significantly less risk than those at the extreme liberal end of the political spectrum.

Summary

The results of this study indicate that certain demographics can only explain about 2%-3% of the risk perception of coal generated power and nuclear power. This would indicate that socio-demographic factors play a very minor role at most in risk perception of the four technologies and that there is much more to be assessed to obtain a clearer picture of risk perception when it comes to these changing modern hazards.

The results of the ANOVA studies showed that there was no consistent pattern of significant effects across all four of the hazard technologies except for race and

political orientation. The ANOVAs for the independent variables race and gender impacted the dependent variable overall risk perception with the technical hazard of coal powered electricity generation. Regression analysis performed included the creation of a gender-white/race variable to test for the white male effect. The regression analysis showed that there was nothing significant when these three variables were run together (Table 15). Then dropping the gender-race variable a second regression was run (Table 16) allowed for the effect of white/nonwhite to emerge as having a statistically, albeit it small at 2%, significant predictor of the overall perceived riskiness of coal generated electric power.

The next set of ANOVA results were the independent variables political orientation and the independent variable for income, there was marginal significance for the dependent variable overall risk perception with the technical hazard of nuclear power generation. Regression analysis performed (Table 17) showed that the independent variable political orientation emerged, explaining about 3% of the perceived risk of nuclear power. To test where the differences in political orientation existed, a Tukey's HSD test was performed. The resultant information (Table 18) showed that the differences were statistically significant between those that identified themselves as being extremely liberal and those that identified themselves as being conservative or extremely conservative.

The results of the analysis, suggests that the hypotheses identified earlier (Chapter 2) concerning the impact of socio-demographic factors, do not provide much

explanatory power of the overall perceived risk or riskiness of the respondents. On the other hand, there is a consistent pattern in Table 15, the Summary of Significant Findings from Means and ANOVA Results for Dimensions for Perceived Riskiness and Overall Perceived Risk. In Table 15 we see that there is a pattern of significant and marginally significant findings for the socio-demographic factors of race and political orientation. This consistent pattern would suggest that these results are not solely change results but may indicate that those respondents that perceive a reduced level of risk from the technologies may have a reduced level of exposure to the risks inherent to many modern technologies potentially due to status, power, income or social role.

CHAPTER SIX. CONCLUDING DISCUSSION

The point of this research was to see if demographic profiles could be found that would assist emergency management personnel in their communications with residents in their jurisdictions. What was found in Chapter 4 of this study, was that, as occurred in earlier studies by Slovic and his colleagues, perceptions of nuclear power in relation to other technologies generated the greatest level of perceived riskiness and overall risk while farming with the use of chemical fertilizers, herbicides and pesticides was also rated highly for perceived riskiness and overall risk. Even with the expanded sample size these items have remained consistent from the studies of Slovic and his colleagues to this current application of the psychometric paradigm. In summary, looking at the results, significant patterns have emerged but there is not much in the way of substantive findings. The explanatory paradigm still requires development to better address basic attitudes. The respondents view the overall potential for risk associated with nuclear power generation and modern farming practices as being high, emergency management professionals may not be able to learn much more on how to better use socio-demographic information as leverage in marketing and information dissemination tools.

Immediately after the accident at Fukushima Dai-Ichi the perceived acceptability of nuclear power decreased. World media attention to this focusing event led to a shift in public policy concerning the continuation or expansion of the use of nuclear power. The most notable was Germany, which altered its energy policy by canceling the extension of operating licenses for their nuclear power plants.

While the Japanese government temporarily shut down the nuclear plants in Japan, it is still seen as a valuable piece of their energy sector, not just in terms of energy production, but also in terms of exports of nuclear power technology and expertise to other countries. Countries such as South Korea, China, India and Japan still see this as a needed component to their internal energy needs. This would indicate that even where some see risk of using nuclear power as being too high, others view the benefits in energy production, reduction of carbon emissions and, the reduction of dependence on petroleum imports as important components of their energy production profiles as their economies and populations continue to grow and demand more products that require the use of power.

Kai Erickson (1994) in his sociological profiles of people exposed to disasters or continuing events which have the cumulative impact of disaster seeks to understand the impact these events have on daily life. When Erickson examines the impact of "toxic emergencies," he finds that they "are often harder to deal with than natural ones because they are not framed by distinct beginnings or ends" (Erickson, 1994, p. 106). This may help to explain some of the issues experienced by those in Japan after the Fukushima Dai-ichi where they had to deal with the fallout from the destruction of the nuclear reactors. The Fukushima accident has impacted the land and the ocean for possibly an extended time, and this leads to Erickson's unseen dread concept. Erickson suggests that accidents like the one in Japan are somewhat continuous in nature as it "involves agents that are all the more dreaded because they cannot be detected by the usual human senses" (Erickson, 1994, p.109). The

potential impact that this agent that cannot be recognized by the human senses extends beyond the physical impact, into the psychological impact as fear or dread begins to shape the opinions and actions of people in the impact zone and also by those that are determined to take up this cause as a policy issue to forward part of their agendas.

The present study had four general goals. First, considerable time has passed since Slovic and his associates initiated a series of studies examining the perception of various risks, including technological risks. A major finding by Slovic et al. was the degree to which the overall risk of nuclear power was perceived to be much greater than any other technology except for the use of farm chemicals. The latter two technologies may be perceived similarly because they are associated with hazardous consequences that are often unseen and/or are slow in developing, but potentially severe in nature. The present study sought to determine whether there has been any change in the ranking of the perceived risk of nuclear power and farm chemicals relative to two other technologies, railroad transportation and coal-generated electric power. While differences over time can be confounded with a variety of other factors (e.g. differences in samples studied), exploring the issue is still of interest. A sample was selected in a region of the United States where all four technologies are interconnected within a densely settled region. The results are consistent with Slovic et al.'s prior findings. The overall risks of these technologies cluster in two groups. The perceived risk of nuclear power and the use of farm chemicals is the same and the perceived risk of railroad transportation and coal

generated electric power is the same; but the perceived risk of the first group is significantly higher than is the perceived risk of the second group. Despite the absence of any major nuclear reactor problems in the United States for nearly four decades and few headline events associated with farm chemicals, both technologies are still feared. The recent Japanese reactor disaster may explain the continued fear of nuclear power, in part, but not the continued fear of farm chemicals. These fears may simply be inherent in the nature of these risks.

Second, the present study wished to determine whether the four technologies ranked as Slovic et al. found them to rank along previous dimensions of perceived riskiness. These dimensions included: immediacy of impact/death, probability of fatalities, probability of incident, probability that the incident would be catastrophic, the level of dread the incident would create, and the overall perceived risk of an incident. Once again, nuclear power stood out alone, independent of the other three technologies including farm chemicals. The perceived riskiness of nuclear power was significantly greater than all other technologies on three dimensions of perceived severity (fatalities, catastrophic impact, and immediacy of impact/death) as well as dread. Farm chemicals were perceived as significantly less risky than was nuclear power, but significantly more risky along several dimensions of riskiness then were the other two technologies. These findings generally replicated Slovic et al.'s earlier findings and were consistent with overall perceptions of risk.

Third, an effort was made to extend Slovic's early research into a real life setting where respondents are surrounded by these technologies and examine the role of the respondents' socio-demographic characteristics in their perceptions of riskiness and overall risk. Past research has identified several factors to be predictive of risk perceptions within Slovic's research paradigm, while other studies have failed to support such findings (Flynn, Slovic and Mertz, 1994; Peters and Slovic, 1996; and Finucane et al. 2000). Nevertheless, the present study offered five hypotheses describing the expected relationships between gender, race, income, education and political orientation with perceived riskiness and risk. The present study's findings found two general patterns of effects. The most persistently significant effects across dimensions of perceived riskiness were for race and political orientation. The relationships revealed that non-white respondents had a higher perception of riskiness than did white respondents, and that the difference in political orientation was only significant when comparing those at either extreme of the political spectrum. Those at the conservative end perceived significantly less risk than those at the extreme liberal end of the political spectrum. In addition, while there were a number of effects for the various demographic factors on perceived riskiness, there were not many effects on the overall perception of risk.

Fourth, the limited number of demographic effects on overall perceptions of risk was examined using multiple regression analysis. The results of the study were limited to the finding that overall risk perception remained high for CFHP and nuclear power. The regression analysis performed identified 2%-3% of the risk

perception was shown to be due to a sensitivity of risk to the impact of socio-demographics and the other hazards did not show statistically significant sensitivity for overall risk perception to the socio-demographics. The regression analysis results from this study suggest that socio-demographic factors do not play much of an explanatory role in perception of risk, but the consistent pattern identified in Table 15 suggest that there is some factor that extends beyond change results. But what this study brought to light is that there are many more aspects to perceived risk than we have researched here.

Finally, the present study can offer one or two insights into the current perceptions of nuclear power, the study's main focus. First, perceived riskiness and risk appear to be impacted by political orientation, with those on the extreme liberal and liberal end of the spectrum having a higher degree of perceived risk than those on the conservative, extremely conservative end of the spectrum. Second, race impacted the dread component of nuclear power, while political orientation only marginally impacted the dread component. Whereas dread was a significant finding in Slovic et al.'s prior studies, the means and percentages of overall perceived dread in this study were not as high as the other measures of perceived riskiness. This could indicate that people are more focused on other potential risks within their environs or that there is currently a greater level of acceptance of this power source. Nuclear power has a significant history in the United States with a predominately safe operating record. Therefore, the level of existing dread of this technology may remain lower than other riskiness factors, unless of course there would be another event within the

United States such as Chernobyl, Three Mile Island or Fukushima Dai-Ichi which would focus the attention of the population on this technical hazard.

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APPENDIX A. A CHRONOLOGIC LISTING OF PERTINENT ARTICLES BY SLOVIC ET AL.

Year	Primary Authors	Primary Topic	Survey Tools	Survey Population	Survey Size	Survey Issues
1965	Ward, Slovic	Reduce Risk of Decision Making	16 cell matrix	Undergraduate Students	10 male	Small sample
1976*	Slovic, Fischhoff, Lichtenstein	Cognitive Process and societal risk taking (anchoring bias), Availability Heuristic	Review of previous work	N/A	N/A	N/A
1978* How Safe is Safe Enough? Psychometric Study Attitudes towards technological risks/benefits	Fischhoff, Slovic, Lichtenstein, Read, Combs	Early Psychometric study of attitudes towards tech risks and benefits 9 characteristics of risk	Perceived risk v Perceived Benefit Nine question survey tool for each hazard	Eugene Oregon League of Women Voters	52 female, 24 male	Limited sample size, limited variability in population, probably homogeneous in socio-political beliefs, economics
1979* Rating the Risks	Slovic, Fischhoff, Lichtenstein	1.Availability Heuristic 2.Judgments of risk 3.Fallibility of Judgment, 4.Dread and Severity of consequences (catastrophic potential) greatest impact to lay person risk perception	Review of Risk Perception, Rating risks, how are risks assessed			

* Indicates that the article was republished in an edited book by Paul Slovic (Slovic P. , The Perception of Risk, 2000). This will be the standard citation date for this paper.

Year	Primary Authors	Primary Topic	Survey Tools	Survey Population	Survey Size	Survey Issues
1979*	Slovic, Fischhoff, Lichtenstein	1.Acceptability of risks, 2.Weighing the risks	N/A			
1980* Facts and Fears, Understanding Perceived Risk	Slovic, Fischhoff, Lichtenstein	Extended study of risk perception Used 90 hazards	1.Original 18 risk characteristics which we condensed down 2.Used 100 point scale for perceived risk of death and perceived benefits	1.Only college students 2.Looked at voluntary v. involuntary exposure to risk 3.Catastrophic Potential and weighing catastrophes		Results showed that dread, familiarity and exposure account for most interrelations among the 18 characteristics
1987* Perception of Risk Accidents as Signals	Slovic	Expressed Preferences using the Psychometric Paradigm Discusses accidents as signals (focusing events) Risk means more to people than expected number of fatalities	Uses previous data from technical experts, college students and League of Women Voters	Uses previous data from technical experts, college students and League of Women Voters		Provides ordering comparison for 30 technological hazards among the 3 populations
1991* Perceived Risk, Trust and Politics of Nuclear Waste	Slovic, Flynn, Layman	Framing Issues concerning the location of waste depository Unseen threats Public v. Scientists	Review of multiple surveys Uniformly negative opinion of waste repository	Imagery impacts perception, people keep seeing the post impact photos of nuclear weapons		

Year	Primary Authors	Primary Topic	Survey Tools	Survey Population	Survey Size	Survey Issues
1994 A Psychological Study of the Inverse Relationship Between Perceived Risk and Perceived Benefit	Alhakaml, Slovic	High Risk Activities are Judged as Providing Low Benefit	Asked about risk benefit of 40 technologies	University of Oregon Students	100	Entry level psych class only—not very representative, but a good convenience sample
1995* Technological Stigma	Gregory, Flynn, Slovic	Stigmatization of technology Viewing certain technologies as toxic, violating that which is normal Technology has both good and bad sides to it, this links well with Beck's concept of modernity.	N/A	N/A	N/A	N/A
1996* Perception of Risk from Radiation	Slovic	uncontrollable, dread, catastrophic, lethal and inequitable in their distribution of risks and benefits Comparison is one of better ways to help people understand risk but people are still resistant to change	Review of past information, lit review	N/A	N/A	N/A
1996 The Role of Affect and Worldviews as Orienting Dispositions in the Perception of Nuclear Power	Peters Slovic	Worldviews/Political Leanings and affect laden imagery are predicative of risk perception concerning nuclear power	National Telephone	National Survey, Random dial -155 questions- 50.7% response rate	1512 with 50.7% response rate	N/A

APPENDIX B. SURVEY QUESTIONS MATRIX

Question	Question Type	Answer Type	Derived From
On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving hazard X?	Dependent Variable	7pt Likert, No Risk-High Risk	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , Perception of Risk, 2000)
On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact or risk of death from an incident, what do you believe is the accident potential for hazard X?	Dependent Variable	7pt Likert, No Impact or risk of death from an incident-High Potential for immediate impact from or risk of death from an incident	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , The Perception of Risk, 2000)
On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident involving hazard X makes you feel.	Dependent Variable	7pt Likert, No Dread, Fear or Foreboding Feeling-Strong Dread, Fear or Foreboding Feeling	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , The Perception of Risk, 2000)

Generalized questions (i.e. no specific threat provided) showing from which point in the literature the questions were drawn.

Question	Question Type	Answer Type	Derived From
On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident would be fatal, what do you believe is the severity of consequences of an accident occurring which involves hazard X?	Dependent Variable	7pt Likert, Certain not fatal-Certain fatal	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , The Perception of Risk, 2000)
On a scale from 1 to 7, with 1 being an accident were there are no deaths occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Hazard X would cause?	Dependent Variable	7pt Likert, zero deaths-Catastrophic numbers of deaths/injuries	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , The Perception of Risk, 2000)
On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves hazard X?	Dependent Variable	7pt Likert, No Probability-High Probability	(Fischhoff, Slovic, Lichtenstein, Read, and Combs, 2000) (Slovic P. , The Perception of Risk, 2000)

Generalized questions (i.e. no specific threat provided) showing from which point in the literature the questions were drawn.

Question	Question Type	Answer Type	Derived From
Please indicate the highest level of education completed.	Independent Variable	Less than High School-various doctoral level degrees	Researcher
What is your gender?	Independent Variable	Male/Female	Researcher
Please indicate your current household income in U.S. dollars	Independent Variable	Under $24,999 $25,000 - $49,999 $50,000 - $74,999 $75,000 - $99,999 Over $100,000 Rather not say	(Bishop, 2005)
How old are you?	Independent Variable	Number	Researcher
What is your race?	Independent Variable	White/Caucasian, African American, Hispanic, Asian, Native American, Pacific Islander, Other	Qualtrics Question Bank
In general, how would you describe your political ideals or beliefs?	Independent Variable	7pt Likert, Extremely Liberal-Extremely Conservative, Have not thought much about Politics	(Bishop, 2005)
Number of people (by age) that reside at this address at least half-time	Independent Variable	0-4 years old 5-10 years old 11-18 years old 19-24 years old 24-35 years old 36-45 years old 46-60 years old More than 60 years old	Researcher

Grid format of demographic questions requested of the participants.

APPENDIX C. SURVEY TOOL

Informed Consent Form
Department of Emergency Management
North Dakota State University
NDSU Department 2351
P.0. Box 6050
Fargo, ND 58108-6050
(701) 231-5595I

Introduction: This study focuses on information about individual perception of potential risks and hazards that may be within your geographic area. You were chosen as a potential participant in this survey because you live in areas of urban, suburban and rural populations that face a variety of modern day risks or hazards.

Procedures: The research involves a questionnaire concerning risks and hazards. Questions are focused on how you perceive risks or threats based on your knowledge and past experience. The questionnaire is divided into three sections. The first section asks basic questions concerning how you receive news and other information. The second section consists of 5 modern hazards with questions for each hazard. The final section asks for demographic information about your household for classification purposes. It is expected that the complete survey may take from 10 to 20 minutes to complete.

Risks/Discomforts: There are no known risks associated with completing this survey.

Benefits: There are no direct benefits to you. However, it is expected that through your participation, researchers will learn more about how people perceive and respond to potential risks and threats which may lead to public safety benefits.

Compensation: The Qualtrics Group or their affiliates may provide some form of incentive for completing this survey in accordance with their survey panel protocols.

Confidentiality: All participant data will be kept confidential and will only be reported in an aggregate format (by reporting only combined results and never reporting individual ones). The survey will not collect personally identifiable information.

Participation: Participation in this research study is completely voluntary. You have the right to withdraw at anytime or refuse to participate entirely. If you desire to

withdraw, please close your Internet browser. Withdrawing without completing the survey may exclude you from receiving any compensation from the Qualtrics Group and their affiliates in accordance with their policies and procedures.

Questions about the Research: If you have questions regarding this study, you may contact (principal investigator), at 701.231.8925, David.Duff@My.NDSU.EDU or the head of the academic Emergency Management Department (Prof. Daniel Klenow) at 701.231.8925, Daniel.Klenow@NDSU.EDU

Questions about your Rights as Research Participants: You have rights as a research participant. If you have questions about your rights or complaints about this research, you may talk to the researcher or contact the North Dakota State University (NDSU) Human Research Protection Program at 1-855-800-6717, ndsu.irb@ndsu.edu , or by mail at: NDSU HRPP Office, NDSU Dept 4000, PO Box 6050, Fargo, ND 58108

I have read, understood, and I have the option to print this consent form. I freely consent to participate in this study.

- ❍ Yes
- ❍ No

Which methods of communication and/or news alerts are currently available to you?

	Select YES or NO	
	YES	NO
Television/Cable News	❍	❍
Email	❍	❍
Text Messaging	❍	❍
Cellular Phone	❍	❍
Smart Phone	❍	❍
Telephone/Land-line	❍	❍
NOAA Weather Radio	❍	❍
Radio	❍	❍
Facebook	❍	❍
Twitter	❍	❍
Instagram	❍	❍
Other Social Media	❍	❍
Other communication method not already listed	❍	❍

What other type of communication method is available to you?

Which method of communication and/or news alert is the first one you seek out in event of a crisis, emergency or disaster? Please identify the first preferred method with a number one, the second preferred method with a number two and the third preferred method with a number three.

_____ Television/Cable News
_____ E-Mail
_____ Text Messaging
_____ Cellular Phone
_____ Smart Phone
_____ Telephone/Land-line hard wired into your residence
_____ NOAA Weather Radio
_____ Radio
_____ Facebook
_____ Twitter
_____ Instagram
_____ Other Social Media
_____ Other Communication method not otherwise listed

The following questions concern how you view or perceive Modern Farming Methods within society.

On a scale from 1 to 7, with 1 being no benefit and 7 being high benefit to society, what is the overall benefit to society of Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?</P>

	1	2	3	4	5	6	7
No Benefit:High Benefit	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
No Risk:High Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being totally unwilling to accept risk and 7 being willing to accept the risk, what is your willingness to accept the risk, if any, given the overall societal benefit derived from Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?</p>

	1	2	3	4	5	6	7
Totally Unwilling to Accept Risk:Willing to Accept Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact and death from an incident, what do you believe is the accident potential for Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
No Impact or Risk of Death:High Potential Immediate Impact and Death	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides makes you feel.

	1	2	3	4	5	6	7
No Dread, Fear or Foreboding Feeling:Strong Dread, Fear or Foreboding Feeling	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
No Probability:High Probability	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident is fatal, what do you believe is the severity of consequences of an accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
Certain to NOT be fatal:Certain to be fatal	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident were there are a no deaths or injuries occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides would cause?

	1	2	3	4	5	6	7
No deaths or injuries:Catastrophic numbers of deaths and injuries	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being precisely known to science and 7 being completely unknown to science, what do you believe the level of knowledge is concerning Farming with the use of Chemical Fertilizers, Herbicides and Pesticides?

	1	2	3	4	5	6	7
Precisely known to science:Completely unknown to science	❍	❍	❍	❍	❍	❍	❍

On a scale of 1 to 7, with one being a completely new or novel potential hazard and 7 being a completely familiar potential hazard, how would you rank Farming with the use of Chemical Fertilizers, Herbicides and Pesticides?

	1	2	3	4	5	6	7
Completely New:Completely Familiar	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no control and 7 being highly controllable, if you were exposed to the risk created by Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides, to what extent do you have control over an incident where you can by preparation, personal skill or diligence avoid personal harm?

	1	2	3	4	5	6	7
No Control:Highly Controllable	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much personal preparation should be done to reduce the impact of a potential accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much preparation have you personally done to prepare for a potential accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion, how prepared do you believe the state is to respond to an accident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

	1	2	3	4	5	6	7
Not Prepared:Highly Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no prepared and 7 being highly prepared, in your opinion, how prepared do you believe that the company or farmer, that is using the Chemical Fertilizers, Herbicides and, Pesticides in your area/region, is to respond to an accident?

	1	2	3	4	5	6	7
Not Prepared:Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no knowledge and 7 being highly knowledgeable, please rate your level of knowledge concerning the potential risks, if any, that might be associated with Farming that uses Chemical Fertilizers, Herbicides and, Pesticides.

	1	2	3	4	5	6	7
No Knowledge on Topic:Highly Knowledgeable and Informed on Topic	❍	❍	❍	❍	❍	❍	❍

Have you ever been negatively impacted by a prior event involving modern farm practices that use Chemical Fertilizers, Herbicides and Pesticides?

- ❍ YES
- ❍ NO

Do you believe that there is an adequate notification system in place to alert you to an incident involving Farming with the use of Chemical Fertilizers, Herbicides and, Pesticides?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe
- ❍ Probably Yes
- ❍ Definitely Yes

Here is a list of information sources that could be used to share news/alerts or general information in the event of an incident involving Farming with the Use of Chemical Fertilizers, Herbicides and, Pesticides. Please rate the effectiveness of each method separately on a scale of 1 to 5 with 1 being not effective at all, 2 not very effective, 3 somewhat effective, 4 very effective, and 5 totally effective.?

	1. Not Effective at All	2. Not Very Effective	3. Somewhat Effective	4. Very Effective	5. Totally Effective
Radio	❍	❍	❍	❍	❍
Smart Phone	❍	❍	❍	❍	❍
Telephone/Land-line	❍	❍	❍	❍	❍
Cell Phone	❍	❍	❍	❍	❍
Text Messaging	❍	❍	❍	❍	❍
NOAA Weather Radio	❍	❍	❍	❍	❍
E-mail Alerts	❍	❍	❍	❍	❍
Television/Cable News	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍
Instagram	❍	❍	❍	❍	❍

The following questions concern how you view or perceive Railroad Transportation within society.

On a scale from 1 to 7, with 1 being no benefit and 7 being high benefit, what is the overall benefit to society of Railroad Transportation?

	1	2	3	4	5	6	7
No Benefit:High Benefit	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving Railroad Transportation?

	1	2	3	4	5	6	7
No Risk:High Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being totally unwilling to accept risk and 7 being willing to accept the risk, what is your willingness to accept the risk of a potential accident involving Railroad Transportation, if any, given the overall societal benefit derived from Railroad Transportation?

	1	2	3	4	5	6	7
Totally Unwilling to Accept Risk:Willing to Accept Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact and death from an incident, what do you believe is the accident potential for Railroad Transportation?

	1	2	3	4	5	6	7
No Impact or Risk of Death:High Potential for Immediate Impact and Death	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident involving Railroad Transportation makes you feel.

	1	2	3	4	5	6	7
No Dread, Fear or, Foreboding Feeling:Strong Dread, Fear or, Foreboding Feeling	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring involving Railroad Transportation in your area?

	1	2	3	4	5	6	7
No Probability:High Probability	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident is fatal, what do you believe is the severity of consequences of an accident involving Railroad Transportation in your area?

	1	2	3	4	5	6	7
Certain to NOT be fatal:Certain to be fatal	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident were there are a no deaths or injuries occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Railroad Transportation would cause?

	1	2	3	4	5	6	7
No deaths or injuries:Catastrophic number of deaths and injuries	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being precisely known to science and 7 being completely unknown to science, what do you believe the level of knowledge is concerning Railroad Transportation?

	1	2	3	4	5	6	7
Completely known to science:Completely unknown to science	❍	❍	❍	❍	❍	❍	❍

On a scale of 1 to 7, with one being a completely new or novel potential hazard and 7 being a completely familiar potential hazard, how would you rank Railroad Transportation?

	1	2	3	4	5	6	7
Completely New:Completely Familiar	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no control and 7 being highly controllable, if you were exposed to the risk created by Railroad Transportation to what extent do you have control over an incident where you can by preparation, personal skill or diligence avoid personal harm?

	1	2	3	4	5	6	7
No Control:Highly Controllable	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much personal preparation should be done to reduce the impact on you and/or your household of a potential accident involving Railroad Transportation?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much preparation have you personally done to prepare for a potential accident involving Railroad Transportation?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion how prepared is the state to respond to an accident involving Railroad Transportation?

	1	2	3	4	5	6	7
Not Prepared:Highly Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion, how prepared is the company, that owns the Railroad Transportation in your area, to respond to an accident?

	1	2	3	4	5	6	7
Not Prepared:Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no knowledge and 7 being highly knowledgeable, please rate your level of knowledge concerning the potential risks of Railroad Transportation?

	1	2	3	4	5	6	7
No Knowledge on Topic:Highly Knowledgeable and Informed on Topic	❍	❍	❍	❍	❍	❍	❍

Have you ever been negatively impacted by a prior event involving Railroad Transportation?

- ❍ YES
- ❍ NO

Do you believe that there is an adequate notification system in place to alert you to an incident involving Railroad Transportation?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe
- ❍ Probably Yes
- ❍ Definitely Yes

Here is a list of information sources that could be used to share news/alerts or general information in the event of an incident involving railroad transportation. Please rate the effectiveness of each method separately on a scale of 1 to 5 with 1 being not effective at all, 2 not very effective, 3 somewhat effective, 4 very effective, and 5 totally effective.

	1. Not Effective at All	2. Not Very Effective	3. Somewhat Effective	4. Very Effective	5. Totally Effective
Radio	❍	❍	❍	❍	❍
Smart Phone	❍	❍	❍	❍	❍
Telephone/Land-line	❍	❍	❍	❍	❍
Cell Phone	❍	❍	❍	❍	❍
Text Messaging	❍	❍	❍	❍	❍
NOAA Weather Radio	❍	❍	❍	❍	❍
E-mail Alerts	❍	❍	❍	❍	❍
Television/Cable News	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍
Instagram	❍	❍	❍	❍	❍

The following questions concern how you view or perceive the generation of electricity using Coal as a fuel source.

On a scale from 1 to 7, with 1 being no benefit and 7 being high benefit to society, what is the overall benefit to society of Coal Generated Electric Power?

	1	2	3	4	5	6	7
No Benefit:High Benefit	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving Coal Generated Electric Power Plant?

	1	2	3	4	5	6	7
No Risk:High Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being totally unwilling to accept risk and 7 being willing to accept the risk, what is your willingness to accept the risk of a potential accident involving Coal Generated Electric Power, if any, given the overall societal benefit derived from Coal Generated Electric Power?

	1	2	3	4	5	6	7
Totally Unwilling to Accept Risk:Willing to Accept Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact and death from an incident, what do you believe is the accident potential for Coal Generated Electric Power?

	1	2	3	4	5	6	7
No Impact or Risk of Death:High Potential Immediate Impact and Death	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident at a Coal fueled electric power plant makes you feel.

	1	2	3	4	5	6	7
No Dread, Fear or Foreboding Feeling:Strong Dread, Fear or Foreboding Feeling	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves Coal Generated Electric Power Production?

	1	2	3	4	5	6	7
No Probability:High Probability	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident is fatal, what do you believe is the severity of consequences of an accident involving Coal Generated Electric Power?

	1	2	3	4	5	6	7
Certain to NOT be fatal:Certain to be fatal	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident were there are a no deaths or injuries occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Coal Generated Electric Power would cause?

	1	2	3	4	5	6	7
No deaths or injuries:Catastrophic number of deaths and injuries	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being precisely known to science and 7 being completely unknown to science, what do you believe the level of knowledge is concerning Coal Generated Electric Power?

	1	2	3	4	5	6	7
Completely known to science:Completely unknown to science	❍	❍	❍	❍	❍	❍	❍

On a scale of 1 to 7, with one being a completely new or novel potential hazard and 7 being a completely familiar potential hazard, how would you rank Coal Generated Electric Power?

	1	2	3	4	5	6	7
Completely New:Completely Familiar	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no control and 7 being highly controllable, if you were exposed to the risk created by Coal Generated Electric Power to what extent do you have control over an incident where you can by preparation, personal skill or diligence avoid personal harm?

	1	2	3	4	5	6	7
No Control:Highly Controllable	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much personal preparation should be done to reduce the impact of a potential accident involving Coal Generated Electric Power?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much preparation have you personally done to prepare for a potential accident involving Coal Generated Electric Power?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion how prepared do you believe the state is to respond to an accident involving Coal Generated Electric Power?

	1	2	3	4	5	6	7
Not Prepared:Highly Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no prepared and 7 being highly prepared, in your opinion how prepared is the company, that operates the Coal Generated Electric Power Plant in your area, to respond to an accident?

	1	2	3	4	5	6	7
Not Prepared:Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no knowledge and 7 being highly knowledgeable, please rate your level of knowledge concerning the potential risks, that may or may not be created by Coal Generated Electric Power.

	1	2	3	4	5	6	7
No Knowledge on Topic:Highly Knowledgeable and Informed on Topic	❍	❍	❍	❍	❍	❍	❍

Have you ever been negatively impacted by a prior event involving Coal Generated Electric Power?

- ❍ YES
- ❍ NO

Do you believe that there is an adequate notification system in place to alert you to an incident involving Coal Generated Electric Power?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe
- ❍ Probably Yes
- ❍ Definitely Yes

Here is a list of information sources that could be used to share news/alerts or general information in the event of an incident involving Coal Generated Electric Power. Please rate the effectiveness of each method separately on a scale of 1 to 5 with 1 being not effective at all, 2 not very effective, 3 somewhat effective, 4 very effective, and 5 totally effective.

	1. Not Effective at All	2. Not Very Effective	3. Somewhat Effective	4. Very Effective	5. Totally Effective
Radio	❍	❍	❍	❍	❍
Smart Phone	❍	❍	❍	❍	❍
Telephone/Land-line	❍	❍	❍	❍	❍
Cell Phone	❍	❍	❍	❍	❍
Text Messaging	❍	❍	❍	❍	❍
NOAA Weather Radio	❍	❍	❍	❍	❍
E-mail Alerts	❍	❍	❍	❍	❍
Television/Cable News	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍
Instagram	❍	❍	❍	❍	❍

The following questions concern how you view or perceive Nuclear Power generation within society.

On a scale from 1 to 7, with 1 being no benefit and 7 being high benefit to society, what is the overall benefit to society of Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
No Benefit:High Benefit	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving a Nuclear Generated Electric Power Plant?

	1	2	3	4	5	6	7
No Risk:High Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being totally unwilling to accept risk and 7 being willing to accept the risk, what is your willingness to accept the risk, if any, given the overall societal benefit derived from this Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
Totally Unwilling to Accept Risk:Willing to Accept Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact and death from an incident, what do you believe is the accident potential for Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
No Impact or Risk of Death:High Potential Immediate Impact and Death	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident at a Nuclear Generated Electric Power Plant makes you feel.

	1	2	3	4	5	6	7
No Dread, Fear or Foreboding Feeling:Strong Dread, Fear or Foreboding Feeling	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves Nuclear Generated Electric Power Production?

	1	2	3	4	5	6	7
No Probability:High Probability	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident is fatal, what do you believe is the severity of consequences of an accident involving Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
Certain to NOT be fatal:Certain to be fatal	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident were there are a no deaths or injuries occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Nuclear Generated Electric Power would cause?

	1	2	3	4	5	6	7
No deaths or injuries:Catastrophic number of deaths and injuries	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being precisely known to science and 7 being completely unknown to science, what do you believe the level of knowledge is concerning Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
Completely known to science:Completely unknown to science	❍	❍	❍	❍	❍	❍	❍

On a scale of 1 to 7, with one being a completely new or novel potential hazard and 7 being a completely familiar potential hazard, how would you rank Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
Completely New:Completely Familiar	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no control and 7 being highly controllable, if you were exposed to the risk created by Nuclear Generated Electric Power to what extent do you have control over an incident where you can by preparation, personal skill or diligence avoid personal harm?

	1	2	3	4	5	6	7
No Control:Highly Controllable	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much personal preparation should be done to reduce the impact of a potential accident involving Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much preparation have you personally done to prepare for a potential accident involving Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion, how prepared do you believe the state is to respond to an accident involving Nuclear Generated Electric Power?

	1	2	3	4	5	6	7
Not Prepared:Highly Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no prepared and 7 being highly prepared, in your opinion how prepared is the company that operates the Nuclear Generated Electric Power Plant in your area (if any) to respond to an accident.?

	1	2	3	4	5	6	7
Not Prepared:Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no knowledge and 7 being highly knowledgeable, please rate your level of knowledge concerning the potential risks, that may or may not be created by Nuclear Generated Electric Power.

	1	2	3	4	5	6	7
No Knowledge on Topic:Highly Knowledgeable and Informed on Topic	❍	❍	❍	❍	❍	❍	❍

Have you ever been negatively impacted by a prior event involving Nuclear Generated Electric Power?

- ❍ YES
- ❍ NO

Do you believe that there is an adequate notification system in place to alert you to an incident involving Nuclear Generated Electric Power?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe
- ❍ Probably Yes
- ❍ Definitely Yes

Here is a list of information sources that could be used to share news/alerts or general information in the event of an incident involving Nuclear Generated Electric Power. Please rate the effectiveness of each method separately on a scale of 1 to 5 with 1 being not effective at all, 2 not very effective, 3 somewhat effective, 4 very effective, and 5 totally effective.

	1. Not Effective at All	2. Not Very Effective	3. Somewhat Effective	4. Very Effective	5. Totally Effective
Radio	❍	❍	❍	❍	❍
Smart Phone	❍	❍	❍	❍	❍
Telephone/Land-line	❍	❍	❍	❍	❍
Cell Phone	❍	❍	❍	❍	❍
Text Messaging	❍	❍	❍	❍	❍
NOAA Weather Radio	❍	❍	❍	❍	❍
E-mail Alerts	❍	❍	❍	❍	❍
Television/Cable News	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍
Instagram	❍	❍	❍	❍	❍

The following questions concern how you view or perceive Spent Nuclear Fuel Storage within society.

On a scale from 1 to 7, with 1 being no benefit and 7 being high benefit to society, what is the overall benefit to society of Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Benefit:High Benefit	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no risk and 7 being high risk, what is the risk to society of an accident involving Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Risk:High Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being totally unwilling to accept risk and 7 being willing to accept the risk, what is your willingness to accept the risk, if any, given the overall societal benefit derived from Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
Totally Unwilling to Accept Risk:Willing to Accept Risk	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no impact or risk of death from an incident and 7 being an immediate impact and death from an incident, what do you believe is the accident potential for Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Impact or Risk of Death:High Potential for Immediate Impact and Death	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no dread, fear or foreboding and 7 being a sense of high dread, fear or foreboding, please indicate how the threat of an accident involving Spent Nuclear Fuel Storage makes you feel.

	1	2	3	4	5	6	7
No Dread, Fear or Foreboding Feeling:Strong Dread, Fear or Foreboding Feeling	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no probability of an accident and 7 being the high probability of an accident, what do you believe is the likelihood of an accident occurring which involves Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Probability:High Probability	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident is certain to not be fatal and 7 being certain that an accident is fatal, what do you believe is the severity of consequences of an accident involving Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
Certain to NOT be fatal:Certain to be fatal	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being an accident were there are a no deaths or injuries occurring over time and 7 is a sudden catastrophic number of deaths or injuries, what do you believe an incident involving Spent Nuclear Fuel Storage would cause?

	1	2	3	4	5	6	7
No deaths or injuries:Catastrophic number of deaths and injuries	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being precisely known to science and 7 being completely unknown to science, what do you believe the level of knowledge is concerning Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
Completely known to science:Completely unknown to science	❍	❍	❍	❍	❍	❍	❍

On a scale of 1 to 7, with one being a completely new or novel potential hazard and 7 being a completely familiar potential hazard, how would you rank Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
Completely New:Completely Familiar	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no control and 7 being highly controllable, if you were exposed to the risk created by Spent Nuclear Fuel Storage to what extent do you have control over an incident where you can by preparation, personal skill or diligence avoid personal harm?

	1	2	3	4	5	6	7
No Control:Highly Controllable	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much personal preparation should be done to reduce the impact of a potential accident involving Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no personal preparation and 7 being high personal preparation, how much preparation have you personally done to prepare for a potential accident involving Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
No Personal Preparation:High Personal Preparation	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being not prepared and 7 being highly prepared, in your opinion, how prepared is the state to respond to an accident involving Spent Nuclear Fuel Storage?

	1	2	3	4	5	6	7
Not Prepared:Highly Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no prepared and 7 being highly prepared, in your opinion, how prepared is/are the company(ies) that operate the Spent Nuclear Fuel Storage site in your area/region to respond to an accident?

	1	2	3	4	5	6	7
Not Prepared:Prepared	❍	❍	❍	❍	❍	❍	❍

On a scale from 1 to 7, with 1 being no knowledge and 7 being highly knowledgeable, please rate your level of knowledge concerning the potential risks, that may or may not be created by Spent Nuclear Fuel Storage.

	1	2	3	4	5	6	7
No Knowledge on Topic:Highly Knowledgeable and Informed on Topic	❍	❍	❍	❍	❍	❍	❍

Have you ever been negatively impacted by a prior event involving Spent Nuclear Fuel Storage?

- ❍ YES
- ❍ NO

Do you believe that there is an adequate notification system in place to alert you to an incident involving Spent Nuclear Fuel Storage?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe
- ❍ Probably Yes
- ❍ Definitely Yes

Here is a list of information sources that could be used to share news/alerts or general information in the event of an incident involving Spent Nuclear Fuel Storage. Please rate the effectiveness of each method separately on a scale of 1 to 5 with 1 being not effective at all, 2 not very effective, 3 somewhat effective, 4 very effective, and 5 totally effective.

	1. Not Effective at All	2. Not Very Effective	3. Somewhat Effective	4. Very Effective	5. Totally Effective
Radio	❍	❍	❍	❍	❍
Smart Phone	❍	❍	❍	❍	❍
Telephone/Land-line	❍	❍	❍	❍	❍
Cell Phone	❍	❍	❍	❍	❍
Text Messaging	❍	❍	❍	❍	❍
NOAA Weather Radio	❍	❍	❍	❍	❍
E-mail Alerts	❍	❍	❍	❍	❍
Television/Cable News	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍
Instagram	❍	❍	❍	❍	❍

We request that you complete the following demographic information.
What is your gender?
- ❍ Female
- ❍ Male

What is your race?
- ❍ White/Caucasian
- ❍ African American
- ❍ Hispanic
- ❍ Asian
- ❍ Native American
- ❍ Pacific Islander
- ❍ Other

How old are you?
What is your Zip Code?

Please indicate the highest level of education completed.
- ❍ Less than High School
- ❍ High School or equivalent
- ❍ Vocational/Technical School (2 year)
- ❍ Some College
- ❍ College Graduate (4 year)
- ❍ Master's Degree (MS)
- ❍ Doctoral Degree (PhD)
- ❍ Professional Degree (MD, JD, etc.)

What is your current marital status?
- ❍ Rather not say
- ❍ Divorced
- ❍ Living with another
- ❍ Married
- ❍ Separated
- ❍ Single
- ❍ Widowed

Which occupational category best describes your employment? (U.S. Census, 41 Categories)

- ❍ Management: professional or related occupations
- ❍ Management: business or financial operations occupations
- ❍ Management occupations, except farmers and farm managers
- ❍ Farmers and farm managers
- ❍ Business and financial operations
- ❍ Business operations specialists
- ❍ Financial specialists
- ❍ Computer or mathematical
- ❍ Architects, surveyors, cartographers, or engineers
- ❍ Drafters, engineering, or mapping technicians
- ❍ Life, physical, or social science
- ❍ Community and social services
- ❍ Energy Production
- ❍ Emergency Management/Homeland Security
- ❍ Legal
- ❍ Education, training, or library
- ❍ Arts, design, entertainment, sports, or media
- ❍ Health diagnosing or treating practitioners & technical occupations
- ❍ Health technologists or technicians
- ❍ Health care support
- ❍ Fire fighting, prevention or law enforcement workers, (including supervisors)
- ❍ Other protective service workers (including supervisors)
- ❍ Food preparation or serving-related
- ❍ Building, grounds cleaning or maintenance
- ❍ Personal care or service
- ❍ Sales or related occupations
- ❍ Office or administrative support
- ❍ Farming, fishing, or forestry
- ❍ Supervisors, construction or extraction
- ❍ Construction trades workers
- ❍ Extraction workers
- ❍ Installation, maintenance, or repair occupations
- ❍ Production
- ❍ Supervisors, transportation or material moving
- ❍ Aircraft or traffic control
- ❍ Motor vehicle operators

- ❍ Rail, water or other transportation
- ❍ Material moving
- ❍ College Student
- ❍ Unemployed
- ❍ OTHER Not Listed

Which of the following best describes the area you live in?

- ❍ Urban
- ❍ Suburban
- ❍ Rural

Number of people (by age) that reside at this address at least half-time. If there is no one living at this address within a specific age group, please enter a zero.

0-4 years old
5-9 years old
10-17 years old
18-24 years old
25-44 years old
44-64 years old
65 years and over

Please indicate your current household income in U.S. dollars

- ❍ Under $24,999
- ❍ $25,000 - $49,999
- ❍ $50,000 - $74,999
- ❍ $75,000 - $99,999
- ❍ Over $100,000
- ❍ Rather not say

In general, how would you describe your political ideals or beliefs?

	Extremely Liberal	Liberal	Moderately Liberal	Middle of the Road	Moderately Conservative	Conservative	Extremely Conservative	Have not thought much about politics
Political Ideology Spectrum	❍	❍	❍	❍	❍	❍	❍	❍

APPENDIX D. INSTITUTIONAL REVIEW BOARD APPROVAL DOCUMENT

NDSU NORTH DAKOTA STATE UNIVERSITY

January 10, 2014 FederalWide Assurance FWA00002439

Daniel Klenow
Emergency Management
Minard 428 B2

Re: IRB Certification of Exempt Human Subjects Research:
Protocol **#HS14137 , "Risk Perception and Nuclear Power"**

Co-investigator(s) and research team: **David Duff**

Certification Date: 1/10/14 Expiration Date: 1/9/2017
Study site(s): **varied/online**
Funding: **n/a**

The above referenced human subjects research project has been certified as exempt (category # 2) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, *Protection of Human Subjects*). This determination is based on protocol materials (received 1/8/2014).

Please also note the following:

- If you wish to continue the research after the expiration, submit a request for recertification several weeks prior to the expiration.
- Conduct the study as described in the approved protocol. If you wish to make changes, obtain approval from the IRB prior to initiating, unless the changes are necessary to eliminate an immediate hazard to subjects.
- Notify the IRB promptly of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
- Report any significant new findings that may affect the risks and benefits to the participants and the IRB.
- Research records may be subject to a random or directed audit at any time to verify compliance with IRB standard operating procedures.

Thank you for your cooperation with NDSU IRB procedures. Best wishes for a successful study.
Sincerely,

Kristy Shirley

Kristy Shirley, CIP, Research Compliance Administrator

INSTITUTIONAL REVIEW BOARD
NDSU Dept 4000 | PO Box 6050 | Fargo ND 58108-6050 | 701.231.8995 | Fax 701.231.8098 | ndsu.edu/irb

Shipping address: Research 1, 1735 NDSU Research Park Drive, Fargo, ND 58102