University of Alberta

Engineering a Waste Incineration Facility to Improve Residents' Attitude

by

Lianne Michelle Lefsrud

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

Department of Civil and Environmental Engineering
Department of Sociology

Edmonton, Alberta
Fall 1996

ISBN 0-612-18288-6

University of Alberta

Library Release Form

Name of Author: Lianne Michelle Lefsrud

Title of Thesis: Engineering a Waste Incineration Facility to Improve Residents' Attitude

Degree: Master of Science

Year this Degree Granted: 1996

4503 109A Avenue
Edmonton, Alberta T6A 1S3

July 19, 1996

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *Engineering a Waste Incineration Facility to Improve Residents' Attitude* submitted by Lianne Michelle Lefsrud in partial fulfillment of the requirements for the degree of Master of Science

Dr. C.A. Zeiss

Dr. H. Krahn

Dr. H. Northcott

Dr. V. Adamovicz

June 27, 1996

ABSTRACT

The purpose of this research is to determine how environmental engineers can design a proposed waste facility to address residents' concerns and make the facility more acceptable to them. The study facility is the Umatilla Chemical Demilitarization Incineration Facility in northeastern Oregon. Local residents were surveyed during the ongoing siting process. Residents are more likely to find the facility acceptable if they believe that: the facility is needed, the site and design are the best possible, the risk perceptions and net effect from the facility are positive, and existing regulations are sufficient. It appears that residents have a cause-effect hierarchy in their preference of measures to address effects to residents' health. Residents' attitude toward the facility improved with the implementation of their preferred measures. From the results, principles are developed for environmental engineers to design and site waste facilities which are more acceptable to residents in host communities.

EXECUTIVE SUMMARY

The purpose of this research is to determine how engineers can design a proposed waste facility to make it more acceptable to host community residents by addressing their concerns about the facility. There are four objectives to fulfill this purpose. The first objective is to derive hypotheses from relevant engineering and social science theories to predict residents' response to a proposed waste facility (their beliefs, values, attitudes, and actions) and their preferences for the engineering intervention measures to address their concerns. This is completed in Chapter 3.

The second objective is to test the hypothesized predictions about residents' response to a proposed waste facility by surveying residents involved in an actual facility siting process. The facility chosen for study is the Umatilla Chemical Demilitarization Incineration Facility (UMCDF), proposed by the U.S. Army to destroy their stockpile of unitary chemical munitions stored at the Umatilla Army Depot in northeastern Oregon. The selection and description of the facility is given in Chapter 2. The methodology for testing the hypotheses is presented in Chapter 4. The first survey - Questionnaire A - measures the beliefs, values, attitudes, and actions of residents during the siting of the UMCDF. In Chapter 5, the survey responses are analyzed and the hypotheses are tested. The data gleaned from Questionnaire A support the Theory of Reasoned Action, risk perception variables, and Altruism Theory. Residents have beliefs and values about the physical cause-effect sequence (need, design, site, effects, risk perceptions) which correlate with their attitude. Attitude and motivational variables are related to the level of action taken by residents.

This research's results completed in September, 1995 are similar to those found by Intercept Research Corporation in August, 1994. Comparable distributions are found for attitude/concern toward the facility, belief that the facility is needed, trust in the Army, trust in the DEQ, sufficiency of incineration, and sufficiency of regulations. Therefore, it appears that this research which used a small (n = 102), nonrandom, unrepresentative sample of residents gives results comparable to Intercept's research with a larger (n=400) random sample.

The third objective is to determine the accuracy of the theoretical engineering design principles in predicting which engineering intervention measures will make the waste facility more acceptable to host community residents. The methodology of testing the hypotheses is discussed in Chapter 4. The second survey - Questionnaire B - presents sets of engineering intervention measur. : to redesign the facility, asks residents their preferences, and assesses their change in attitude with the implementation of their preferred measures.

These results are also presented and discussed in Chapter 5. The evaluation of engineering intervention measures is considered by the Prospect Theory and by the engineering risk assessment causal sequence. This research shows a lack of support for Prospect Theory which may have been obscured by methodological difficulties. However, residents do appear to have beliefs about the engineering/risk assessment cause-effect sequence and use a causal hierarchy to evaluate the engineering intervention measures. To address effects to residents' health, most respondents prefer: #1 to define the Army's need, community's need, and general social need and design the facility to address those needs; #2 to prevent impacts from occurring by altering the characteristics of the wastestream, inputs, and site; #3 to control impacts by altering the facility design and operation to regulate emissions; #4 to mitigate impacts which have occurred, and #5 compensate any remaining impacts. This causal hierarchy is not as apparent for addressing effects to property value and community image.

The fourth objective is to develop siting and design principles from the findings of this research which fulfills the purpose of this research. Principles are gleaned from the results to guide environmental engineers and planners in designing waste facilities which are more acceptable to host community residents in Chapter 6. These principles are:

1. the need for the facility must be identified and included in the facility design
2. the choice of site and facility design must be seen as the best possible
3. the net effect from the facility must be seen as positive
4. the implementation of residents' most preferred measures improves facility acceptance

The implications of these principles for siting and design processes are discussed.

ACKNOWLEDGMENTS

Several people must be acknowledged for their contributions which made this research possible. The ongoing support and feedback of the research supervisors. Dr. Chris Zeiss in the Department of Civil and Environmental Engineering and Dr. Harvey Krahn in Sociology, are gratefully appreciated. Individuals from the Oregon Department of Environmental Quality, the U.S. Army, and the Chemical Stockpile Emergency Preparedness Program provided invaluable information. The Natural Science and Engineering Research Council of Canada provided the funding for this research. Finally, my husband, Darin Richards, is to be thanked for his understanding and patience.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Introduction

1.1 Problem Statement

Environmental engineers must understand, assess, and manage the physical and the social impacts from proposed waste facilities. Residents in the host community are concerned about effects to the environment and their health. The residents are also concerned about effects that the facility may have on property value and community image. If the impacts which concern residents are not being satisfactorily addressed, the residents will oppose the facility and prevent the facility from being built. Therefore, the consideration of the physical and social impacts is required to design waste facilities which are acceptable to the residents in the host communities.

The purpose of this research is to determine how engineers can design a proposed waste facility to make it more acceptable to host community residents by addressing their concerns about the facility.

1.2 Objectives

There are four objectives to fulfill this purpose. The first objective is to derive hypotheses from relevant engineering and social science theories to predict residents' response to the waste facility's effects and to the engineering intervention measures. Residents' response to the siting and design of the facility is defined as their beliefs, values, attitudes, actions, and preferences for engineering the facility to address their concerns. Facility siting is the method by which a location is chosen for the facility. Facility design is the planning of the facility's inputs, operations, and emissions. Acceptability of the facility to a resident is defined as the resident holding a favourable attitude towards the facility. Making the facility more acceptable entails increasing the number of residents in the host community who find the facility acceptable. Hypotheses are drawn from relevant theories to describe the response of residents during a waste facility siting and design process.

The second objective is to test the hypothesized predictions about residents' response to a proposed waste facility. These hypotheses are tested by surveying residents involved in an actual facility siting and design process. The facility chosen for study is the Umatilla Chemical Demilitarization Incineration Facility (UMCDF). The UMCDF has been proposed by the U.S. Army to destroy their stockpile of unitary chemical munitions stored at the Umatilla Army Depot in northeastern Oregon. The study facility was chosen to test the hypotheses while assuring the validity and reliability of the results.

The third objective is to determine the accuracy of the theoretical engineering design principles in predicting which engineering intervention measures will make the waste facility more acceptable to host community residents. Sets of engineering intervention measures are developed to address residents' concerns identified by the initial survey. Then, the hypothesized principles are tested by presenting the engineering intervention measures to residents and asking what measures they prefer to address their concerns and make the facility more acceptable to them.

The fourth objective is to evaluate the results and glean principles for environmental engineers to design more acceptable waste facilities. The first three objectives consider what concerns residents, what makes a waste facility more acceptable, and why. Based on these findings, guidelines are developed so that environmental engineers and planners can design waste facilities which are more acceptable to host community residents, and therefore, more likely to be built.

1.3 Research Tasks

There are several research tasks to meet the objectives. In Chapter 2, a study facility is chosen. The facility's inputs, operations, emissions, site characteristics, and impacts are described. In Chapter 3, hypotheses are drawn from the relevant engineering/risk assessment and social science theories to explain the response of residents during a facility design process. In Chapter 4, the methodology for testing the hypotheses is presented. Two survey instruments are developed. The first survey measures the beliefs, values, attitudes, and actions of residents during the ongoing siting and design process.

The second survey presents sets of engineering intervention measures to redesign the facility, asks residents their preferences, and assesses their change in attitude with the implementation of their preferred measures. Residents are sampled and the surveys are administered. In Chapter 5, the survey responses are analyzed and the hypotheses are tested. The significance of the findings for the theories are discussed. Finally in Chapter 6, the results are summarized and the ability of the theories to explain residents' responses are discussed. Based on the results, principles are developed for environmental engineers and planners to design more acceptable waste facilities.

In the next chapter, Chapter 2, the study facility is selected and then described.

2. Study Facility Selection and Description

2.1 Introduction

The purpose of this research is to determine how engineers can design a proposed waste facility to make the facility more acceptable to residents in the host community. In this chapter, the study facility is selected to test the research hypotheses developed in the Chapter 3. The chosen study facility is the Umatilla Chemical Demilitarization Incineration Facility (UMCDF) in Oregon.

Then, the characteristics of the facility and site are described from a review of technical and nontechnical documents. This review gives additional information on residents' responses during the process, required information for the development of the questionnaires, aids in sampling, and adds background and richness to the analysis and interpretation of the results. The history of the Umatilla Depot and the overall regulatory approval process is given as general background information about the facility.

The introduction of a waste facility into a site is considered by engineering and risk assessment approaches as a cause-effect sequence. The cause-effect sequence starts with the need for the facility, which determines the inputs and the facility design and operation, leading to emissions which are transported through environmental media, to which receptors are exposed, resulting in effects (after Zeiss and Atwater, 1991; Zeiss, 1993; Wartenberg and Chess, 1992; Rodricks, 1992; Armour, 1991; ASME, 1988; Hohenemser et al., 1985; Cox and Slater, 1984; Williams et al., 1983; Fischhoff et al., 1978). The cause effect sequence is given in Figure 2.1.

Engineering intervention measures interrupt the cause-effect interactions along this sequence to alter the resulting facility effects (see Figure 2.1). Four categories of measures have been developed from a review of siting literature (Zeiss and Lefsrud, 1994) to be consistent with other categorizations of measures (Webler et al., 1995; Armour, 1991; Canter et al., 1991; Morgan, 1990; Gregory and Kunreuther, 1990; Zeiss and Atwater, 1989; Sorensen et al., 1987; Fischhoff et al., 1978). The categories of measures are: 1) need definition, 2) impact reduction, 3) compensation, and 4) process management.

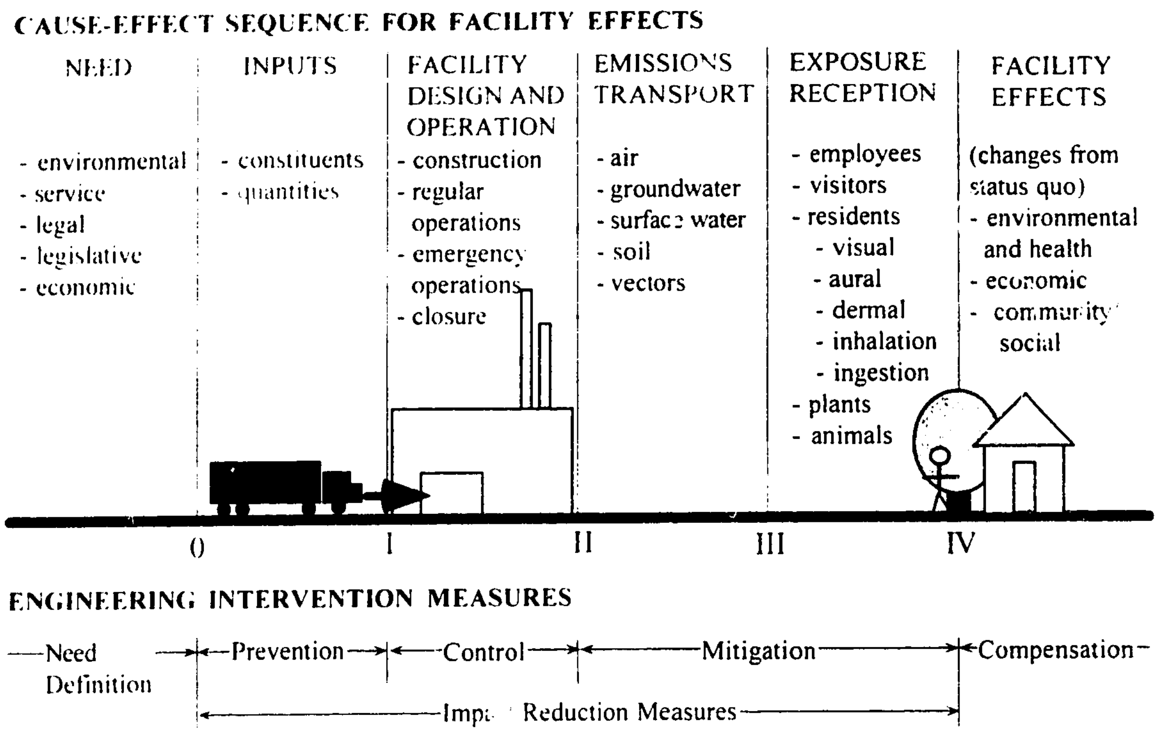

Figure 2.1 Cause-Effect Sequence for Facility Effects and Intervention Points of Engineering Measures (after Zeiss, 1991; 1993)

Need definition measures manage impacts by identifying the proponents', residents', and society's reasons for the waste facility and designing the facility to fulfill those needs (Zeiss and Lefsrud, 1994; Zeiss and Atwater, 1991; Fischhoff et al., 1978). Impact reduction measures manage impacts by diminishing the number, the spatial extent, the duration, the magnitude of consequences, and/or the frequency of impacts associated with the facility. Impact reduction measures are prevention, control, or mitigation measures (Zeiss and Lefsrud, 1994; Zeiss, 1991). Prevention measures reduce an impact by anticipating the impact and preventing its occurrence by altering characteristics of the inputs and site (Webler et al., 1995; Canter et al., 1991; Morgan, 1990; Sorensen et al., 1987; Fischhoff et al., 1978). Control measures reduce an impact by altering the facility design and operations to regulate the emission of a contaminant to the offsite environment and reduce exposure (Webler et al., 1995; Zeiss and Lefsrud, 1994; Canter et al., 1991; Morgan, 1990; Fischhoff et al., 1978). Mitigation measures reduce an impact by cleaning up environmental contamination and altering exposure (Webler et al., 1995;

Zeiss and Lefsrud, 1994; Canter et al., 1991; Morgan, 1990; Fischhoff et al., 1978). Compensation measures manage impacts by providing monetary payments or alternate good to affected individuals for residual impacts that cannot be further reduced (Zeiss and Lefsrud, 1994; Armour, 1991; Hadden, 1991; Morgan, 1990; Sorensen et al., 1987). Process management measures are public communication and participation measures that serve to increase the control and knowledge of the community and the trustworthiness of the process and the facility to residents (Zeiss and Lefsrud, 1994; Armour, 1991).

The characteristics of the study facility are described in terms of this cause-effect sequence. The need for the facility, the choice of the destruction technology, the choice of site, and the inputs are discussed. Then, the operations and emissions from the facility are given for the facility phases. The UMCDF phases are construction, incident-free operations, emergency operations, and closure. Closure is not considered by the Army's regulatory applications and will not be considered by this research. Existing engineering intervention measures are discussed. The transport of the emissions through the environmental media and the exposure to the surrounding receptors are reviewed. Lastly, the predicted impacts and benefits from the facility are given. Effects to health and the environment, economics, and the communities are discussed for the facility phases.

Step matrices and reverse-networks (Zeiss, 1993) are used to determine and summarize the resulting impacts and benefits from incident-free operations and emergency operations. Step matrices are used to evaluate the interactions along the facility's cause-effect sequence (see Figure 2.1). The interaction interfaces are: 0 - facility need and benefits, I - inputs with operations, II - operations with emission/transport, III - emission/transport with reception/exposure, IV - reception/exposure with physical impacts, and V - physical impacts with nonphysical impacts. The step matrices and reverse networks for incident-free operations and emergency operations are given in Appendix A. The interactions may be significant, insignificant, mitigated, or uncertain. Significant and uncertain interactions are continued along the cause-effect sequence while insignificant and mitigated interactions are not continued. Reverse networks summarize this information by starting with the impacts and benefits and working backwards to the operations and inputs.

2.2 Facility Selection

First, the study facility was chosen. The criteria for choosing the study facility were: 1) testing of the hypotheses to assure the validity and reliability of the results: 2) generalizability of the results to other facilities, communities, and regulatory processes: and 3) practical considerations of the research. These criteria were considered throughout the general selection process and in the final choice of the study facility.

The selection began very generally with the type of facility. A waste disposal facility was chosen for this research for several reasons. A waste disposal facility is necessary, yet its design and siting tend to be controversial. Controversy gives variability in the beliefs, values, attitudes, actions, and preferences of stakeholders. Further, negative attitudes toward the facility makes it more difficult to re-engineer the facility to improve residents' attitudes. Re-engineering the facility to improve the attitude of the most staunch opponents rigourously tests the hypotheses.

Next, several different types of waste disposal processes were considered. An incinerator's primary emissions are contaminants, noise, and view into the atmosphere (Zeiss and Atwater, 1991: ASME, 1988: Brunner, 1984; Niessen, 1978). Airborne dispersions of contaminants are easier to predict than dispersions through other environmental media (Canter, 1978). Other waste facilities (such as landfills, wastewater treatment plants, composting facilities, and recycling facilities) emit contaminants to surface water, soil, and ground water making the dispersions more variable and less easy to predict. An incinerator is chosen to simplify the contaminant dispersions and make the prediction of impacts more reliable.

Then, the status of the facility siting process was considered. The facility must be still in the planning stage and not yet received regulatory approval nor put on hold indefinitely. This aids reliability by minimizing the difficulty that stakeholders may have in accurately remembering their past beliefs, values, and attitudes (Babbie, 1992). Strongly opposing residents may leave the community. Also, if the success or failure of the siting attempt is already known, residents may have adapted to the outcome and reinterpreted their position. Therefore, it is preferred that the outcome of the facility siting be unknown.

The type of waste stream was also considered. Waste incinerators may destroy contamination from an inert material; burn municipal solid waste (MSW) for volume reduction and/or energy recovery; or destroy various types of hazardous waste (HW) such as hazardous solids, liquids, sludges, and gases (Theodore and Reynolds, 1987; Brunner, 1984; Niessen, 1978). Facilities that decontaminate materials such as drained transformers or contaminated soil were not considered for this research as they do not incinerate considerable amounts of waste but act primarily as recycling facilities. MSW incinerators are relatively common and deal with a complete MSW stream, which makes the results more generalizable. The most typical characteristics of MSW incinerators were determined. As of May 1995, there were five "typical" MSW incinerators being sited in the United States and Canada. However, all of these MSW facilities were in the northeastern United States. Due to the location of the MSW incinerators, the study of these facilities violated the third decision criterion - practicality.

Next, HW incinerators were considered. There were two HW incinerators currently being sited which are close enough to make the research practical. The facilities are a plasma hearth furnace in Idaho and a chemical demilitarization incinerator in Oregon. The characteristics of these two HW incinerators were considered in detail in Table 2.1 to decide which facility should be studied. The two facilities were ranked with regard to meeting each decision criterion: validity/reliability, generalizability, and practicality.

The threats to validity and reliability were recall bias, sampling bias, response bias, strategic bias, and researcher unreliability. Recall bias is the respondents' difficulty in remembering past beliefs, values, attitudes, and actions which is exacerbated if the respondents have adapted to a known outcome. The potential for recall bias was better minimized at the Oregon facility as the facility is still in the siting process and the outcome is still uncertain. The Idaho facility has already received approval for the first stages of the facility. The other threats to validity and reliability were similar for the two facilities (Table 2.1).

Table 2.1 Detailed Review of Two Hazardous Waste Incinerators for 1) Validity/ Reliability, 2) Generalizability of Results, and 3) Practical Considerations

Decision Criteria	Plasma Hearth Furnace U.S. Department of Energy contracted to Science Applications International Corporation (SAIC) Idaho Falls, Idaho		Umatilla Chemical Demilitarization Incineration Facility (UMCDF) U.S. Department of Defense Umatilla, Oregon	
1) Testing the Hypotheses assuring Validity/Reliability	**evaluation**	**rating ***	**evaluation**	**rating ***
• potential for recall bias - difficulty in remembering past beliefs, values, attitudes, and actions exacerbated by adaptation to a known outcome of the siting attempt	• multi-year, multi-stage permitting process for bench scale, pilot scale, field scale, then full operational scale - each permit is contingent upon results received from previous experimental scale projects; permits already granted for bench and pilot scale, some adaptation may have already occurred	1	• permit presently being written for Resource Conservation and Recovery Act (RCRA) and Oregon state regulations, estimated that draft permit will be written by April, 1996; final permit granted late 1996 - recall and adaptation bias is minimized	2
• potential for sampling bias - group of population or stakeholders systematically excluded from survey	• presence of Hispanic population a possibility - simplify vocabulary, translate Questionnaire A into Spanish?	1	• <30% population is Hispanic (migrant farm workers) who may not be literate in English and perhaps not Spanish - simplify vocabulary, translate survey into Spanish?	1
• potential for response bias - group of population or stakeholders cannot or will not participate	• SAIC expressed serious reservations about interviewing uninvolved residents, afraid of "stirring the pot", they will try to limit research	1	• Army has expressed reservations about completing structured survey and interview, although they are willing to help in any way possible	1
• potential for strategic bias - respondents systematically misrepresent their position to skew results	• potential is always present - check for extent of bias with triangulation from other sources, test-retest	2	• potential is always present - check for extent of bias with triangulation from other sources, test-retest	2
• potential for researcher unreliability - different levels of information supplied to different stakeholders involved in siting	• research proposal for funding submitted to proponent only - minimize further contact, do not discuss research further, withhold data until after defense; use structured survey instrument and method	1	• research proposal for funding submitted to regulator and community advisory commission - minimize further contact, do not discuss research further, withhold data until after defense; use structured survey instrument and method	1

*rating of facilities: 2=meets criterion and/or any problems are mitigated; 1=partially meets criterion and/or partial mitigation of problems; 0=does not meet criterion and/or cannot be mitigated

Table 2.1 Detailed Review of Two Hazardous Waste Incinerators for 1) Validity/ Reliability, 2) Generalizability of Results, and 3) Practical Considerations (continued)

Decision Criteria	Plasma Hearth Furnace U.S. Department of Energy contracted to Science Applications International Corporation (SAIC) Idaho Falls, Idaho		Umatilla Chemical Demilitarization Incineration Facility (UMCDF) U.S. Department of Defense Umatilla, Oregon	
2) Generalizability of Results	**evaluation**	**rating ***	**evaluation**	**rating ***
• typical waste stream and waste processing	• mixed (hazardous and radioactive) waste - very atypical; Plasma Hearth Process is new, innovative technology now being developed to process waste, in the research stages • No generalizability of waste stream or process	0	• 2 types of nerve gas (GB-Sarin and VX) and mustard gas (HD) in different munitions (projectiles, M55 rockets, land mines, bombs, spray tanks, and tonners) • munitions dismantled and separate components destroyed in 4 different incinerators (deactivation, liquid agent, dunnage, and metal parts) - very atypical waste and waste process, however, 7 similar facilities planned for chemical stockpiles across U.S.; limited generalizability of results to these 7 other sites	1
• typical community - smaller, rural/industrial, economically depressed, accepting waste from a larger area	• Idaho Falls pop. 50 000, other industry, facility is 30 miles out of town, accepting waste from on site only	0	• Hermiston pop. 10 000, most of community is employed by agriculture, Morrow and Umatilla Counties more depressed than other areas in Oregon, accepting waste from on site - more typical community	1
• typical stakeholder groups involved: proponent, regulator, supporting/opposing residents	• extensive, organized stakeholder involvement - band councils, residents, regulators, professional organizations, etc. (DOE may be representative of other Federal proponents, but not private proponents), limited generalizability	1	• developed opposition group - involvement of Green Peace and Sierra Club, ongoing involvement of regulator, active proponents (Army may be representative of other Federal proponents, but not private proponents), limited generalizability	1
• typical regulatory approval and design process	• multi-year, multi-stage permitting process for experimental scale then full operational scale - typical regulatory process for each incinerator, but taken together, the R&D approach is not typical	0	• typical approval process for the State of Oregon, however, cost recovery approach may not be used in other states, not used in Canada which limits generalizability	1

*rating of facilities: 2=meets criterion and/or any problems are mitigated: 1=partially meets criterion and/or partial mitigation of problems: 0=does not meet criterion and/or cannot be mitigated

Table 2.1 Detailed Review of Two Hazardous Waste Incinerators for 1) Validity/ Reliability, 2) Generalizability of Results, and 3) Practical Considerations (continued)

Decision Criteria	Plasma Hearth Furnace U.S. Department of Energy contracted to Science Applications International Corporation (SAIC) Idaho Falls, Idaho		Umatilla Chemical Demilitarization Incineration Facility (UMCDF) U.S. Department of Defense Umatilla, Oregon	
3) Practical Considerations	**evaluation**	**rating ***	**evaluation**	**rating ***
• siting and design studied extensively - required data is available on facility design, site, and community characteristics	• design work in process - data is readily available through Freedom of Information Act	2	• design work completed and being revised - data is readily available	2
• ease of completing data collection - relationship with stakeholders, availability of data and responders, complexity of process	• poor relationship with proponent and regulator, may be uncooperative; process is complex, many more residents and stakeholders	0	• good relationship with stakeholders, they appear to be readily cooperative; process is simpler, fewer residents and stakeholders	2
Overall Rating of Fulfillment of Decision Criteria		9		15

*rating of facilities: 2=meets criterion and/or any problems are mitigated; 1=partially meets criterion and/or partial mitigation of problems: 0=does not meet criterion and/or cannot be mitigated

The overall generalizability of the results is dependent upon the generalizability of the characteristics of the facility and the siting/design process which include: the waste stream and process, the community, the stakeholder groups involved, and the design and regulatory approval process. Typical characteristics are those which represent the characteristics of other facilities to increase the generalizability of the results to other facilities. The Idaho facility has an atypical wastestream, community, and regulatory approval process. Only the stakeholders are typical. Although the Oregon facility is also atypical, the results have limited generalizability to seven similar facilities that are currently being planned across the United States.

The practical considerations which may limit the research effort were the availability of all relevant technical information and the ease of completing the survey data collection. The required technical data was readily available from both facilities due to the Freedom of Information Act. However at the Oregon facility, completion of this research appeared to be easier as the stakeholders were more cooperative and were not attempting to control the research effort. The design and approval process of the Oregon facility was also less complex and included fewer stakeholders.

Overall, the Umatilla Chemical Demilitarization Incineration Facility (UMCDF) better fulfilled the decision criteria. Therefore, the proposed UMCDF at the Umatilla Depot in Oregon was the study facility used in this research project.

2.3 Background Information

History of the Umatilla Depot

The Umatilla Depot Activity (UMDA) site was chosen in 1940. The Depot is located in northeastern Oregon, in Umatilla and Morrow Counties (see Figure 2.2). The Depot is approximately 8 km by 8 km (5 miles by 5 miles) with an area over 7900 hectares (19,700 acres). Over one thousand igloos were built for storage. The Depot started storing munitions and supplies in 1942.

The conventional munitions have been shipped out, but unitary and binary chemical weapons remain in storage (Meyers, 1996a). Unitary weapons contain a single active chemical agent. Binary weapons contain two relatively harmless chemicals which combine to produce agent after the munition has been fired. Including at the Umatilla Depot, unitary chemical munitions are stockpiled at eight locations across the continental U.S. (see Figure 2.3) and off-shore on Johnston Island (U.S. Army, 1995). Johnston Island is 1300 km (825 miles) southwest of Honolulu, Hawaii (U.S. Army, 1995).

Approximately 3400 tonnes (3700 tons) of unitary chemical agent is being stored in munitions and bulk containers at the Umatilla Army Depot (UMDA) equally 11.6% of the U.S. Army's total unitary munitions stockpile (Meyers, 1996a; U.S. Army, 1995). The chemical agents are two types of nerve agent, GB (Sarin) and VX, and a blister agent, HD (mustard gas) (U.S. Army, 1995).

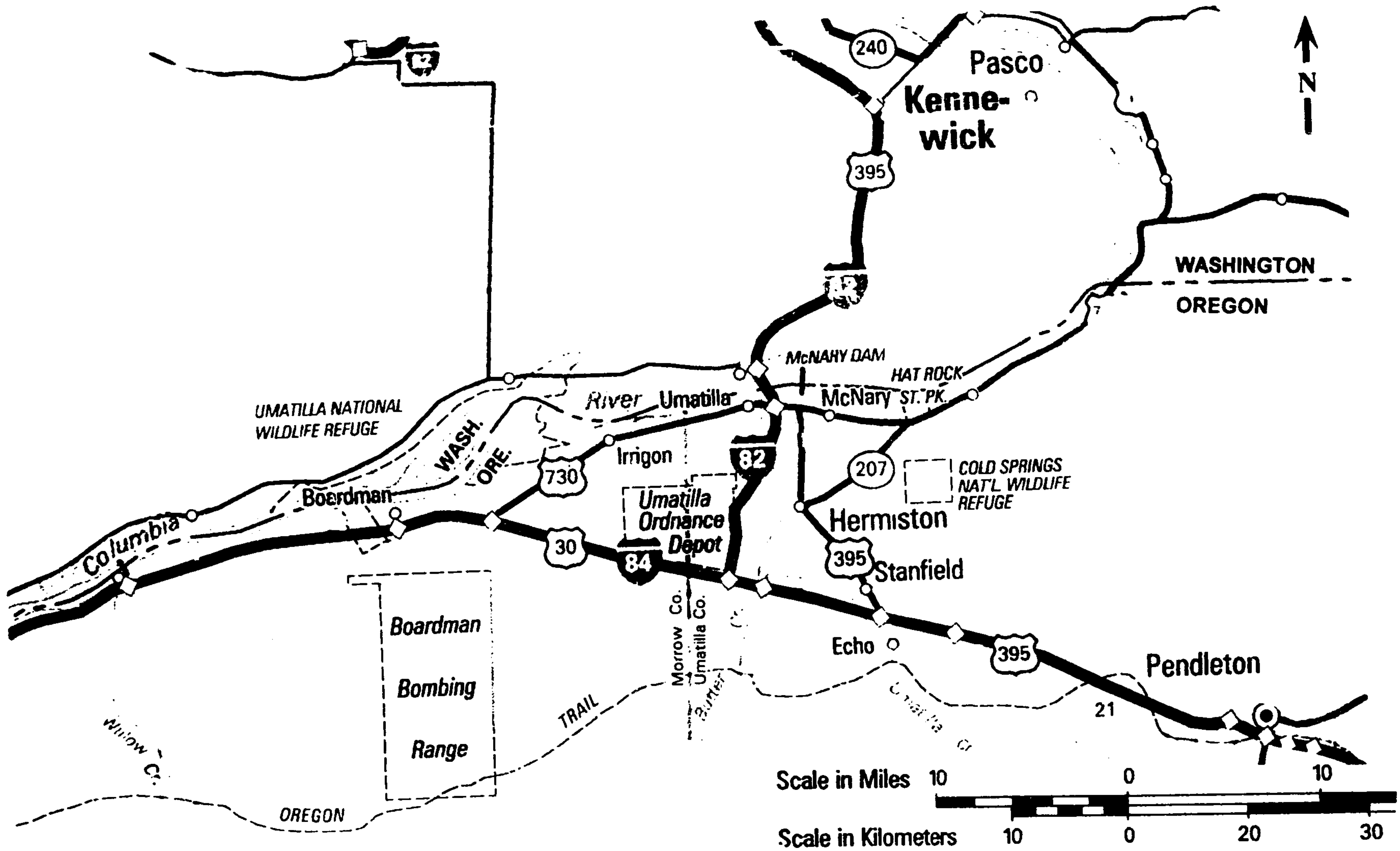

Figure 2.2 Location of the Umatilla Depot

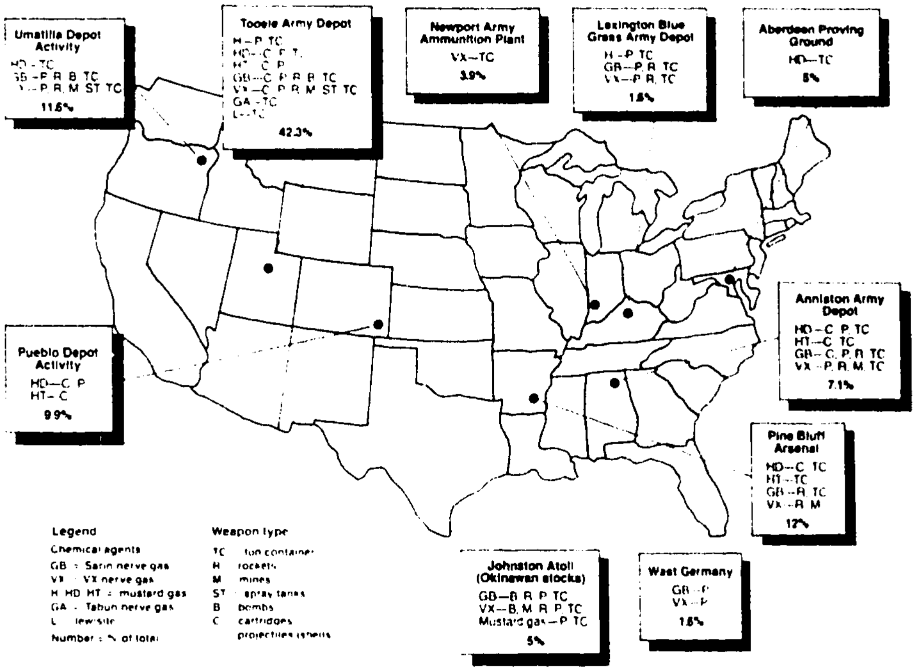

Figure 2.3 Locations of the Unitary Chemical Munitions Stockpiles (Ember, 1990)

The unitary chemical agents stored at the Umatilla Depot are in a variety of munitions (see Figure 2.3). Mustard gas (HD) is being stored in ton containers (U.S. Army, 1995). There is GB in projectiles, rockets, and bombs, ton containers. There is VX in projectiles, rockets, mines, spray tanks, and ton containers. Pictures of the chemical munitions are given in Figures 2.4 to 2.10. In total, there are 220,599 unitary chemical munitions and 241,328 binary chemical munitions being stored at the Umatilla Depot (Meyers, 1996b; Hagey, 1996).

Rockets, projectiles, and mines contain propellants or explosives (U.S. Army, 1995). Only the rockets have the fuses attached while in storage. The fuses are assembled on the projectiles when they are about to be fired and on the mines when they are in place. The bulk items - including ton containers, bombs, and spray tanks - do not contain propellants or explosives (U.S. Army, 1995).

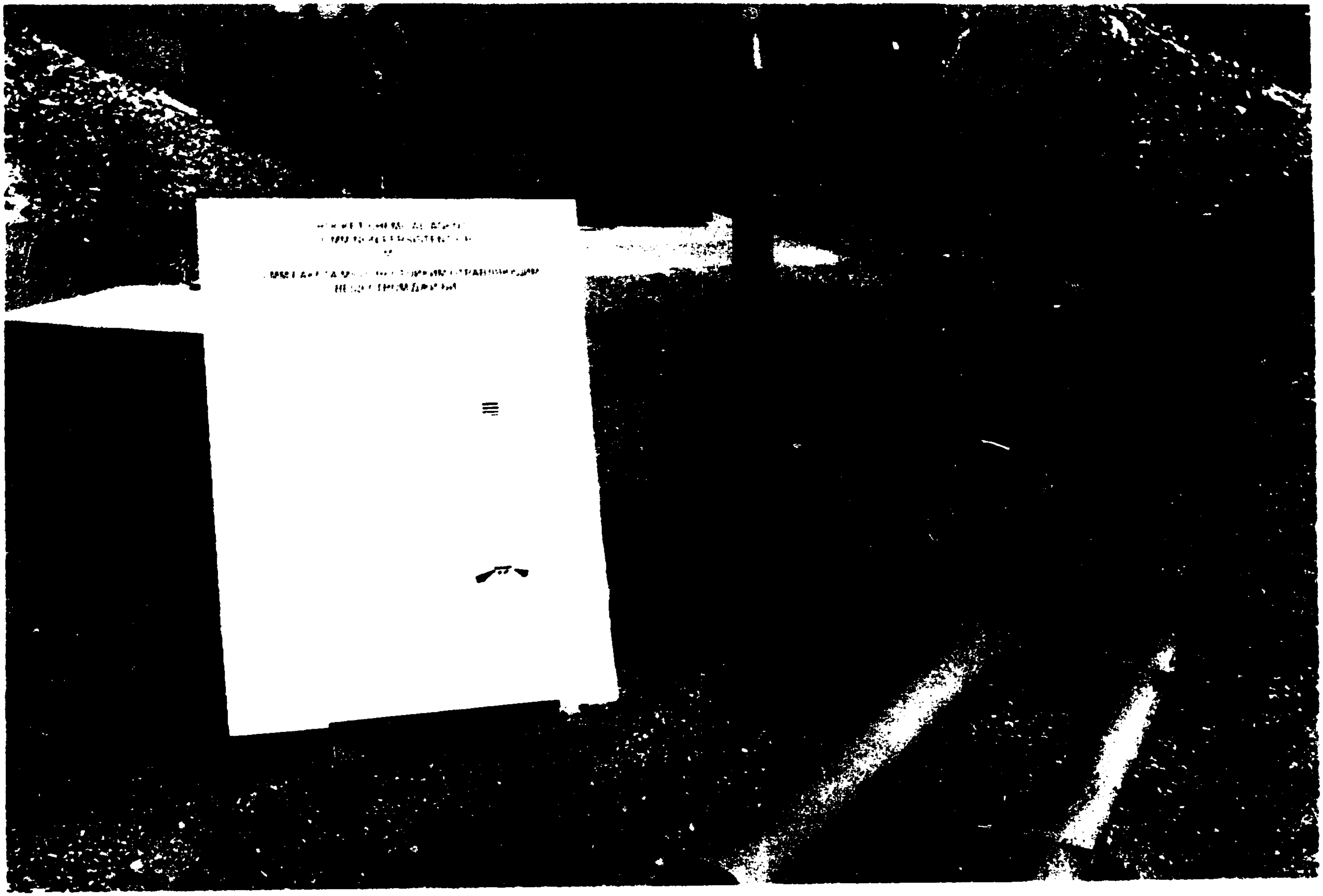

Figure 2.4 Picture of M55 Rocket

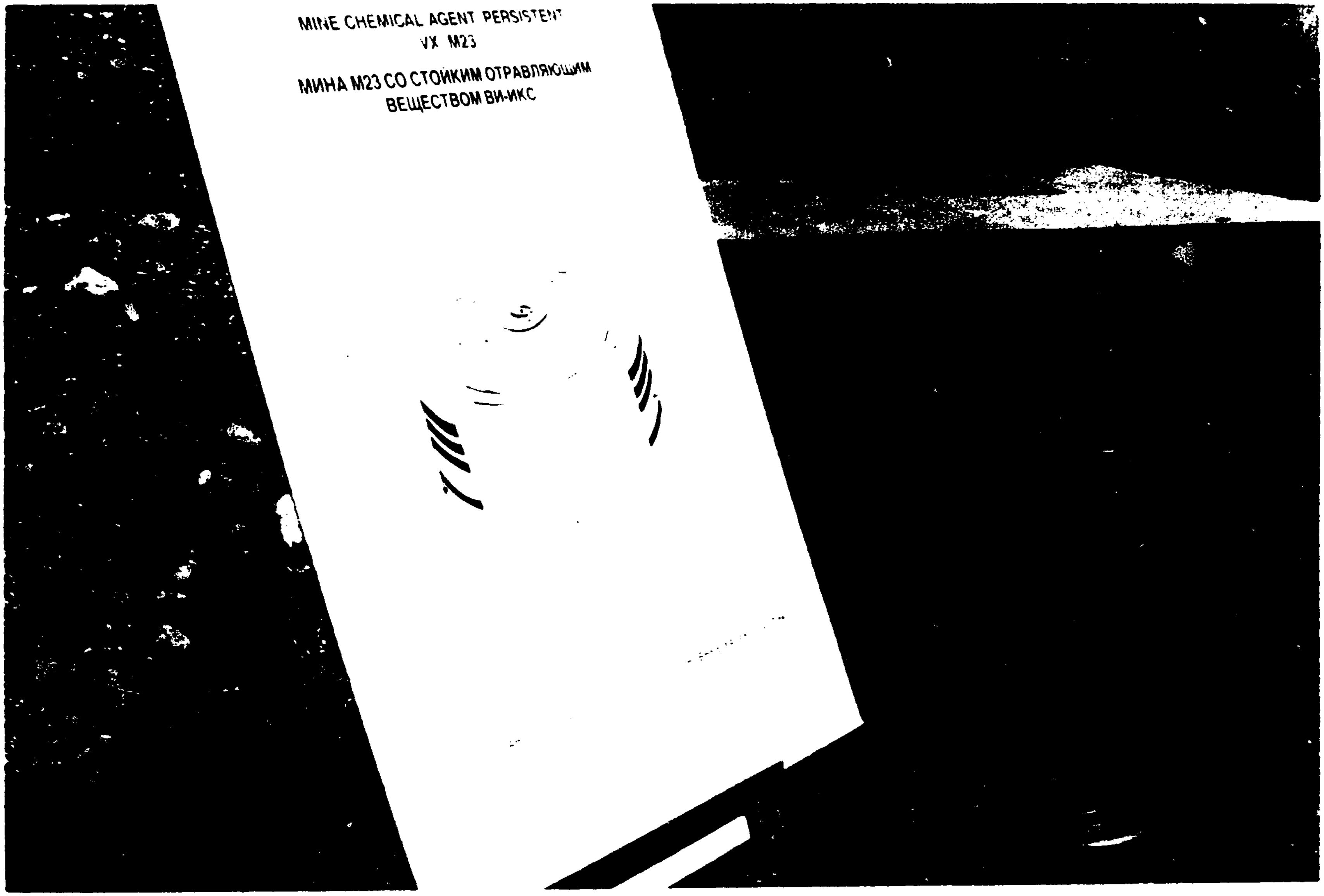

Figure 2.5 Picture of Land Mine

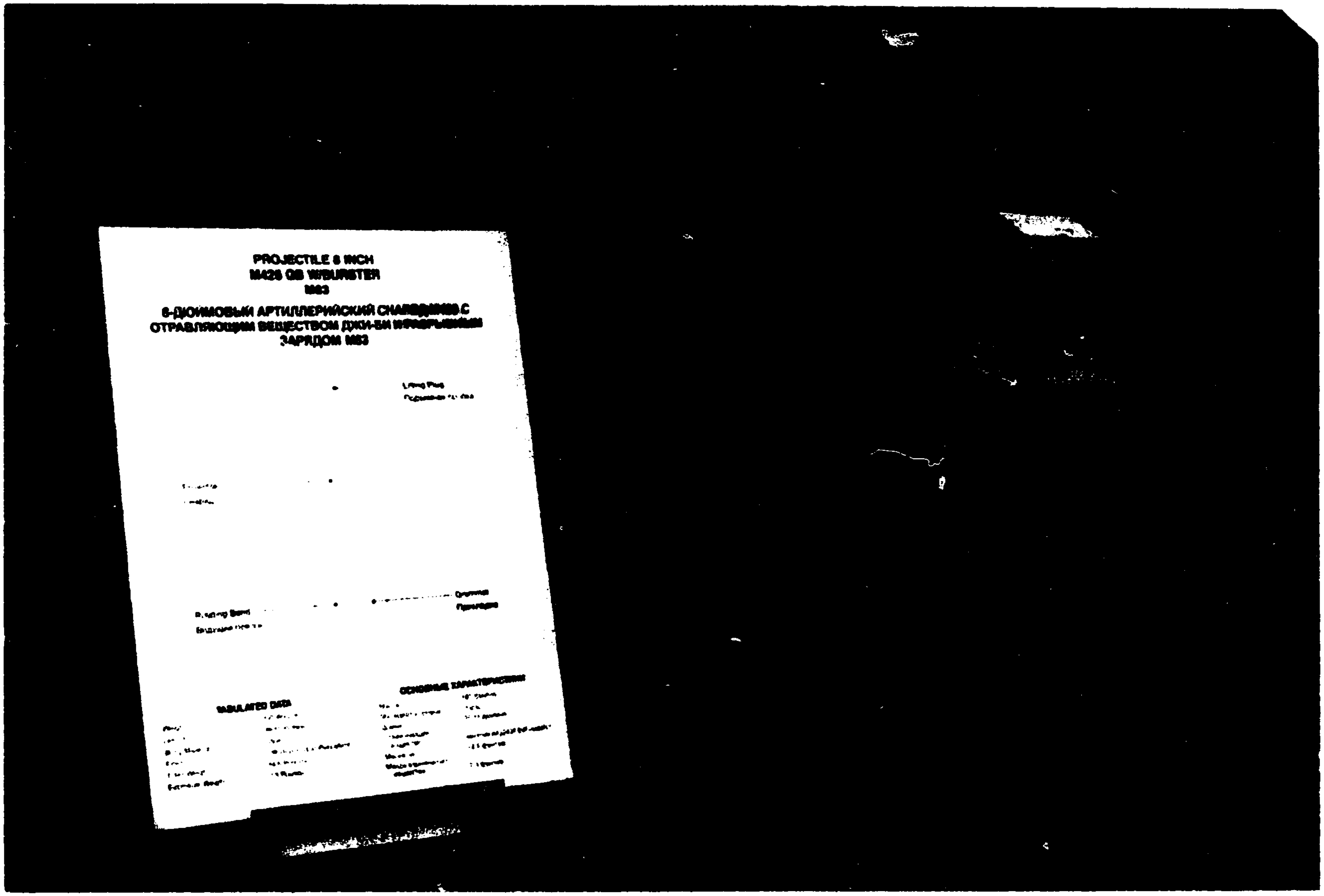

Figure 2.6 Picture of 8 Inch Projectile

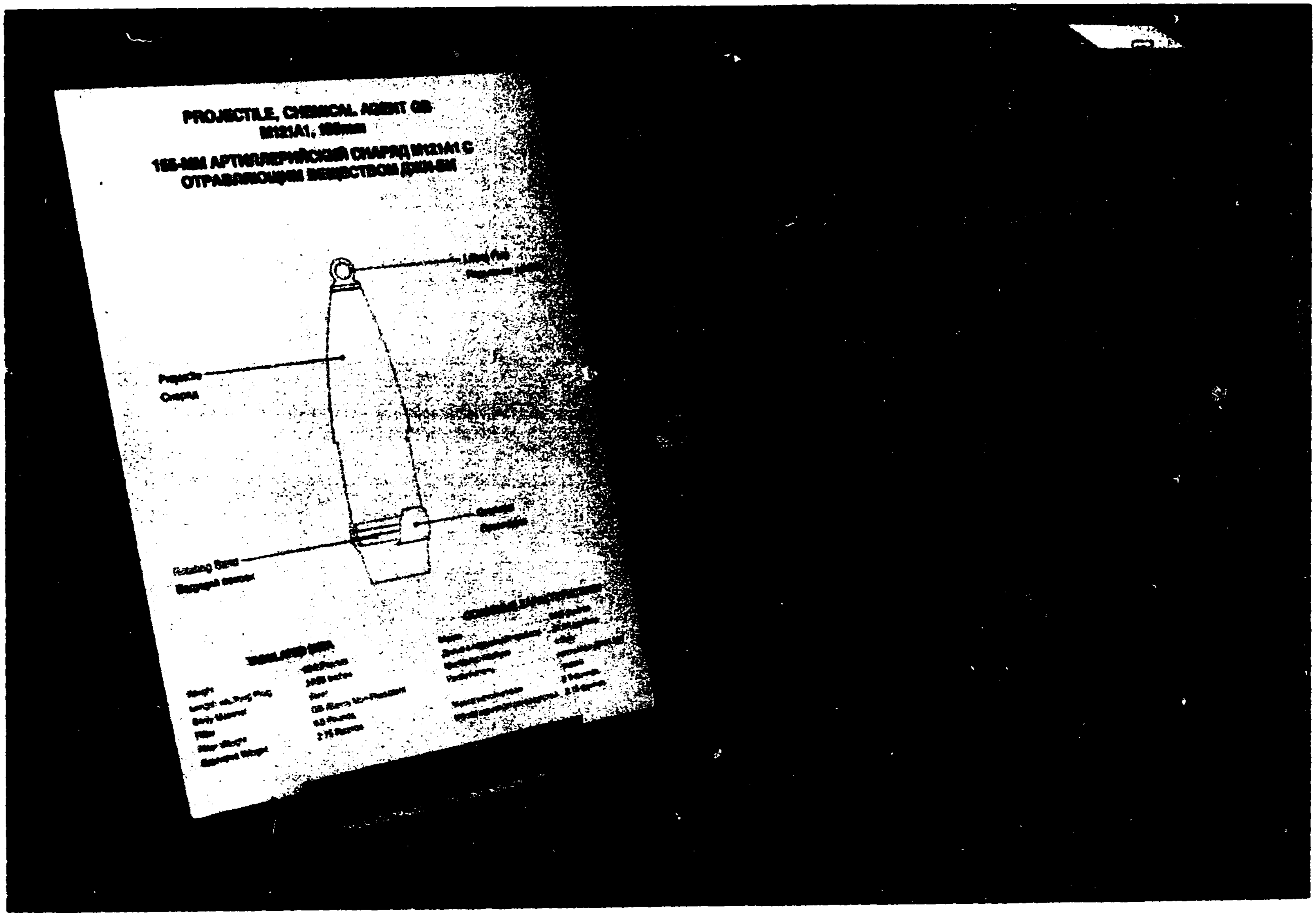

Figure 2.7 Picture of 155 mm Projectile

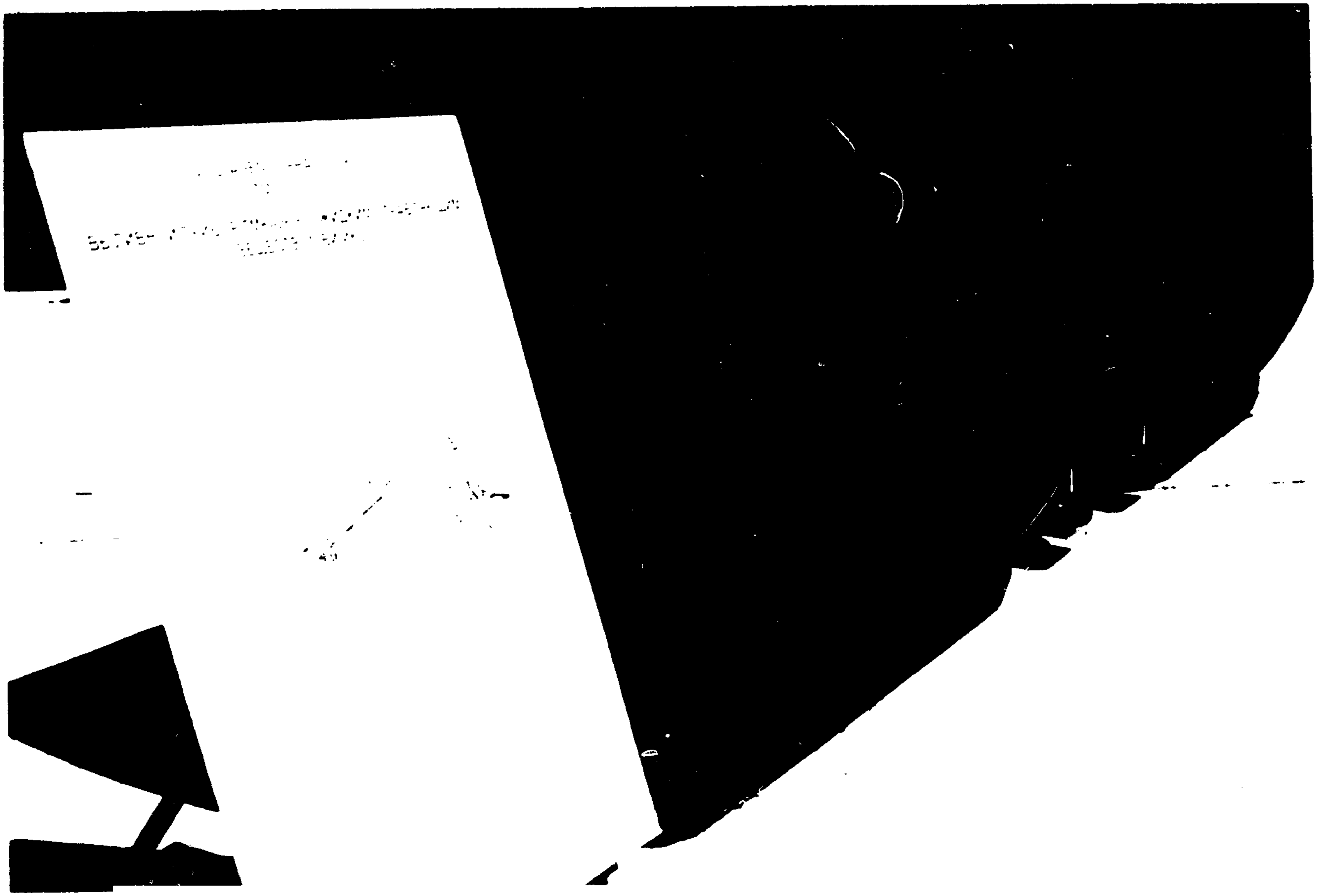

Figure 2.8 Picture of Spray Tank

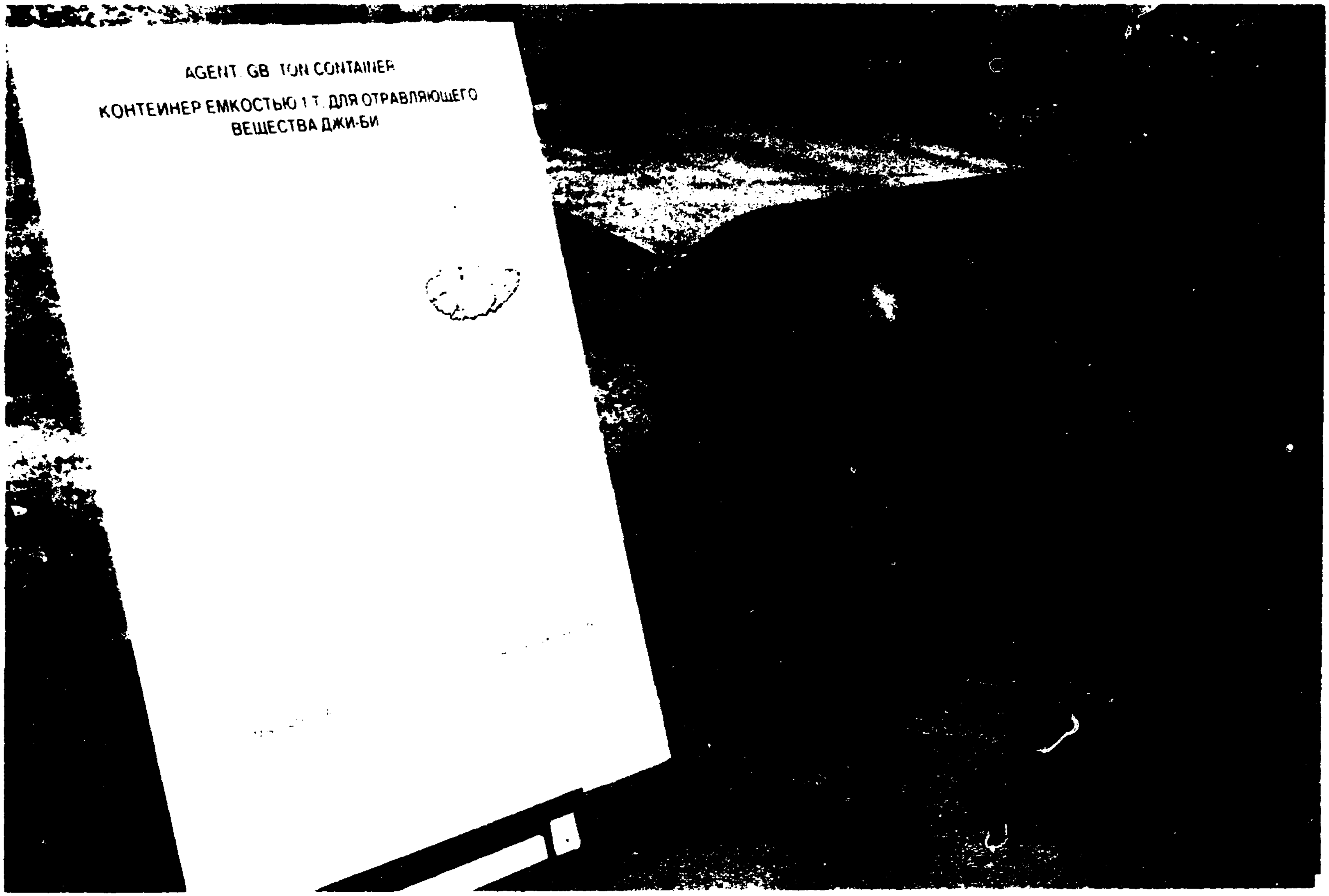

Figure 2.9 Picture of Ton Container

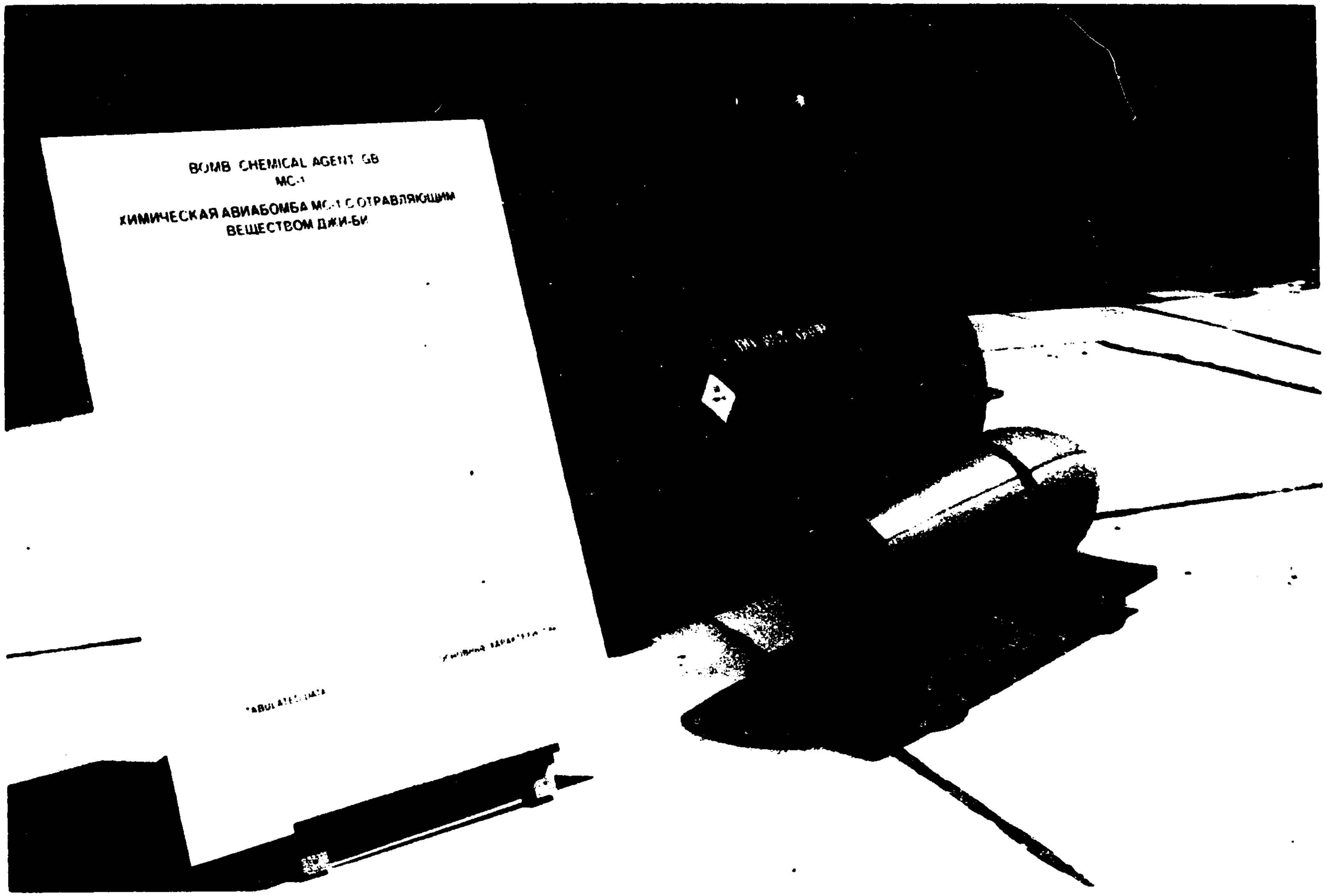

Figure 2.10 Picture of Bomb

Regulatory Approval Process

The Army is proposing to build an incineration facility on the Umatilla Depot to destroy the unitary munitions. The Army's proposal must be approved by several regulators. The Armed Forces Appropriation Acts of 1970 and 1971 require that any Army disposal plan must be reviewed and approved by the U.S. Department of Human and Health Services (DHHS) (U.S. Army, 1995). It is required that the Army comply with all state and federal environmental regulations and that permits be granted prior to construction (U.S. Army, 1995). A Resource Conservation and Recovery Act (RCRA) Part B incinerator permit, a Clean Air Act permit, and a Water Pollution Control Facility permit must be obtained by the Army (U.S. Army, 1995). Some munition containers are contaminated with PCBs. To destroy these containers, a permit is also required under the Toxic Substance Control Act (TSCA) which is regulated by the EPA.

Permitting is a multi-stage process (U.S. Army, 1995). Permit applications are submitted to Oregon's Department of Environmental Quality (DEQ) and the EPA for review. For RCRA and the Clean Air Act, the regulators give the Army Notice of Deficiencies (NODs). The Army addresses the NODs and resubmits the revised applications. The regulators provide a Letter of Completeness indicating that the received application is complete. Then the regulators prepare a Draft Permit stating permit conditions. The Draft Permit is made available for a 45-day public review period. The public review period may be extended. The regulators prepare responses to the public's comments and prepare the Final Permit. The Environmental Quality Commission, which oversees the DEQ, then reviews the Final Permit. For any hazardous waste facility (DEQ considers nerve agent to be hazardous waste), the Commission requires that the destruction technology is proven as the best available method, as defined by the Commission (Sue Oliver, pers. comm., 1996). If the permit meets the Commission's approval, the Final Permit is granted. There may be appeals to the permit approval. If these appeals are dealt with, then facility construction begins. Training of the personnel and startup of the facility follow. A series of trial burns are conducted, first with a chemical surrogate and then with agent. The Army submits the results of the trial burns to the DEQ and the EPA. The regulators impose the final operating conditions for the facility and plant operations begin.

The regulators are preparing the Draft Permit and planning to make it available for public review in early April, 1996 (Oliver, pers. comm., 1996). The DEQ has established a local office for the duration of the permitting process for public information and liaison purposes. There is also a Citizens' Advisory Commission (CAC) consisting of nine members appointed by the Governor to collect citizen and state comments about the U.S. Army's Chemical Stockpile Disposal Program (CSDP). The CAC will remain active during the operation of the facility. The Army hopes to begin construction in late 1996 (Meyers, 1996b) and begin operations in 2000 (Hagey, 1996c). It will take three years to destroy the unitary chemical munitions stockpile stored at the Umatilla Depot (Hagey, 1996c).

2.4 Need for Chemical Demilitarization

The purpose of the U.S. Army's Chemical Stockpile Disposal Program (CSDP) is to destroy (demilitarize) the Continental U.S. (CONUS) stockpiles of obsolete unitary chemical munitions (U.S. Army, 1995). The CSDP is driven by a domestic mandate and an international agreement. A Congressional mandate in the Department of Defense Authorization Act of 1985 required the Army to destroy the national unitary chemical stockpile by September, 1994. Congress agreed to fund the production of a new generation of binary chemical munitions if the Army agreed to destroy the obsolete unitary weapons (Carr, 1988; Rife et al., 1989; Silton, 1993). Subsequent amendments have extended the destruction deadline to December 30, 2004 (U.S. Army, 1995). In 1993, the U.S. and other nations created the Chemical Weapons Convention to prohibit the production, stockpiling, and use of chemical weapons (GAO, 1994a). The deadline for destroying the stockpile of all chemical munitions (unitary and binary) is ten years after the treaty is ratified by the U.S. Senate, with the possibility for a five year extension (GAO, 1994a). The destruction of the binary munitions is to be addressed separately (U.S. Army, 1995).

Chemical demilitarization is also needed to remove the risk to human health from continued storage of the unitary munitions. The Army assessed that the chemical munitions could be safely stored until 2004, based on the stability of the M55 rocket propellant (GAO, 1994b). The propellant is inherently unstable and requires a stabilizer to prevent spontaneous ignition. The propellant stabilizer can deteriorate over time. Separation of the propellant from the rockets is difficult due to the configuration of the rocket warhead. There are 91,375 M55 rockets stored at the Umatilla Depot (Hagey, 1996a). Continued storage of the M55 rockets is a concern.

However, there is uncertainty associated with the stability assessment (GAO, 1994b). The assessment was based on unrepresentative data from propellant samples taken from the time of manufacture (1959-1965) and from limited field samples taken before 1989. Also, the nerve agents become acidic with time and may cause external and internal corrosion. The corrosion may cause leaks and possibly auto-ignition. Internal corrosion cannot be detected without disassembling the munition, which is highly dangerous. The GAO (1994b) report recommendations were to expand the monitoring program to better determine the stability of the propellant and to develop a contingency plan for the emergency disposal of M55 rockets. The Chemical Weapons Working Group, a citizen's group that opposes incineration, reviewed the assessment calculations and found them to be off by a factor of seven. The time was calculated in days, when it should have been calculated in weeks. Correcting this miscalculation, the stockpile should be stable for another 120 years (Cockle, 1994; Early, 1994). Therefore, the duration that the M55 rockets may be safely stored is uncertain due to insufficient data and incorrect calculations.

There have been over 100 leaking munitions since inspections began in October, 1984 (East Oregonian, October 18, 1995). During periodic inventorying and surveillance of the munitions, the air of storage igloos is sampled for agent. If agent is detected, then the leaking munition is identified and removed from its box or pallet. Then, the leaking munition, surrounding munitions, and other contaminated areas are decontaminated with decontaminating solution. The leaking munition is overpacked (U.S. Army, 1995). If the concentration of agent in the igloo approaches the stack emission standard, then filters are placed on the vents before the munition is handled (U.S. Army, 1995).

In summary, the UMCDF is needed by the Army, the local residents, and by society generally. The Army's need for the facility is to fulfill the Congressional mandate in the Department of Defense Authorization Act of 1985. The mandate requires the Army to destroy the unitary chemical stockpile by the year 2004. The local residents need the facility to remove the risk to their health from continued storage of the munitions at the Depot. The munitions are leaking. Further, the M55 rockets may auto-ignite. The duration of continued safe storage is unknown - it may be from 10 to 120 years. The UMCDF is also required by society to meet an international agreement with other countries. The Chemical Weapons Convention requires that all chemical weapons be destroyed within 10 years of the treaty's ratification by the U.S. Senate (yet to be ratified).

2.5 Choice of Destruction Technology and Site

Choice of Destruction Technology

From 1943 to 1969, chemical munitions were buried at sea under Operation CHASE (Cut Holes And Sink 'Em) (Rife et al., 1989; Silton, 1993). International environmental concern prompted the U.S. Congress to ban ocean disposal and to explore alternate disposal methods for chemical munitions (Rife et al., 1989; Silton, 1993).

From 1973 to 1982, the Army tested neutralization and neutralization-incineration at Rocky Mountains Arsenal in Colorado and at the Chemical Agent Munitions Disposal System (CAMDS) facility at Tooele, Utah. 198 tonnes of GB was disposed of by neutralization (U.S. Army, 1995). However, neutralization was rejected because the military considered the disposal costs for the resultant salts, which contained trace amounts of GB, to be unacceptable (Silton, 1993). 3600 tonnes of GB was disposed of by neutralization-incineration (U.S. Army, 1995).

Incineration was tested at CAMDS and at Pine Bluff arsenal in Arkansas from 1972 to 1989 (U.S. Army, 1995). Almost 2900 tonnes of GB, VX, and HD have been destroyed at these sites by incineration (U.S. Army, 1995). Based on these results, in 1981 the Army chose incineration as the preferred technology for the CSDP (GAO, 1994;

Silton, 1993). This choice was endorsed by the National Research Council (NRC) in 1984 (GAO, 1994b).

Following the 1985 Congressional mandate, a prototype full-scale incineration facility - Johnston Atoll Chemical Agent Disposal System (JACADS) - was built on Johnston Island. The facility was built to destroy chemical munitions stockpiles moved from Japan and Germany (Silton, 1993). The facility started operational verification in 1990 and full-scale operations in September, 1991 (GAO, 1990). JACADS has destroyed 163 tonnes of GB, VX, and HD in M55 rockets, ton containers, and projectiles (U.S. Army, 1995).

JACADS has had difficulties. Full-scale operations of JACADS were almost three years behind schedule due to design difficulties, construction defects, conducting of operational verifications, and technical and staffing problems (GAO, 1990; 1991). JACADS has met air emissions standards, USEPA health risk assessment levels of concern ($1X10^{-6}$ lifetime cancer risk), and operational verification testing safety standards (U.S. Army, 1995). There have been two accidental releases of GB from the stack. One release was below the emission standards while the other was 18 times the allowable stack concentration. However, no adverse effects were predicted to occur (U.S. Army, 1995). Lessons learned from JACADS are to be incorporated into the CONUS facilities (U.S. Army, 1995).

Construction was completed on the first CONUS demilitarization incinerator, at the Tooele Depot in Utah, in 1993. The facility is currently undergoing equipment testing. In September 1994, the Tooele facility's safety officer was fired. The officer stated that he was fired because he refused to agree that the safety risks were acceptable. His supervisors stated that he was let go because of his management style (Schafer, 1994; Schneider, 1994; Raloff, 1994). The U.S. Inspector General investigated the safety allegations and found that most of the problems were procedural and not systemic. The Army stated that the problems would be addressed before operations begin (Lipman, 1994; Raloff, 1994). County commissioners in Tooele have requested that the Army's permit be delayed until the offsite emergency preparedness program is adequate (Hagey, 1996b).

Design and operational difficulties and program delays have caused the CSDP budget to increase dramatically. Budget estimates to dispose of the chemical munitions stockpile were $1.7 billion in 1985 (GAO, 1985). The cost estimates have risen to $6.5 billion in 1991 (GAO, 1991) and to $12.6 billion in 1995 (Tri-City Herald, November 16, 1995).

Greenpeace, the Sierra Club, a national citizen's group - the Chemical Weapons Working Group (CWWG), and a local citizen's group - Citizen's for Environmental Quality (CEQ), are concerned about using incineration for chemical demilitarization (Silton, 1993; Ember, 1990; Defense Environmental Alert, May 18, 1994; East Oregonian, June 3, 1994). Opponents question the urgency of chemical demilitarization. If the M55 rockets can be safely stored for 120 years and the treaty has yet to be ratified, then there is time to develop alternative disposal technologies which may be less risky, and less costly (Defense Environmental Alert, May 18, 1994). They are concerned by the poor operational record of JACADS and question the Army's ability to safely destroy chemical munitions with incineration (Environmental Research Foundation, 1992). The opponents are concerned by the emission of products of incomplete combustion (PICs), heavy metals, dioxins and furans, and unburned agent even when the facility may be meeting emission standards. They are concerned that these emissions may be bioaccumulated and transformed to cause uncertain hazardous effects. The landfilling of the scubber brines and residual ash is also a concern. Finally, in the event of an emergency release of agent, present emergency preparedness programs are inadequate (GAO, 1994c; Hagey, 1996b).

In 1993, Congress directed the Army to review alternatives to incineration for destruction of the chemical stockpile, using National Research Council (NRC) reports (GAO, 1994a). The NRC reports indicate that there are several alternatives to incineration, however, they require at least 13 years before being operational (GAO, 1994a). Alternative demilitarization technologies include: chemical neutralization by hydrolysis followed by molten salt oxidation, fluidized bed oxidation, supercritical water oxidation, biological oxidation, molten metal pyrolysis, plasma arc pyrolysis, or steam gasification (G.A.O., 1994a; Nathan, 1994; Meyers, 1995).

The NRC recommended using incineration as it is adequate for destruction and would meet the deadlines required by Congress and the Chemical Weapons Convention (GAO, 1994a). It is uncertain when alternate demilitarization technologies will be available. Alternate technologies may not be able to handle the entire munition. The agent would have to be separated from the munition, which may be very difficult for the M55 rockets. Therefore, the technologies may only be applicable to bulk containers (Meyers, 1995). Several destruction steps may be required to destroy the chemical munitions irreversibly (GAO, 1994a). The relative costs and risks of alternate technologies are unknown (GAO, 1994a). Finally, all destruction technologies create potentially hazardous products such as ash or salts which would require final disposal in an approved landfill.

Choice of Site

In 1986, the Army submitted a plan to Congress which considered the risks and benefits of transferring the entire CONUS stockpile to a single site, transferring the stockpile to two regional sites, or operating separate disposal facilities at each of the nine sites (GAO, 1991). In 1988, the Army announced that on-site disposal was preferred due to transportation and concerns (GAO, 1991; Ember, 1990). Transporting munitions to other sites may also be politically impossible. Therefore, the munitions are to be destroyed on the Umatilla Depot.

The Army then considered alternative sites for the facility within the Depot boundaries (see Figure 2.11). The alternative sites were chosen to minimize the transportation distance from the storage area and to minimize disruption of existing Depot activities (U.S. Army, 1995). The sites were compared and evaluated in terms of their relative advantages and disadvantages. . Site A is equal to or better than the other sites based on the evaluation criteria. Also, Site A is farther from the Depot boundaries to allow a larger buffer zone. Based upon this preliminary analysis, Site A was chosen as the location for the UMCDF on the Umatilla Depot.

In summary, the incineration has been chosen as the preferred destruction technology. Incineration appears to be the best proven technology to destroy the all the unitary chemical munitions in a timely and safe manner. The facility is to be located on the

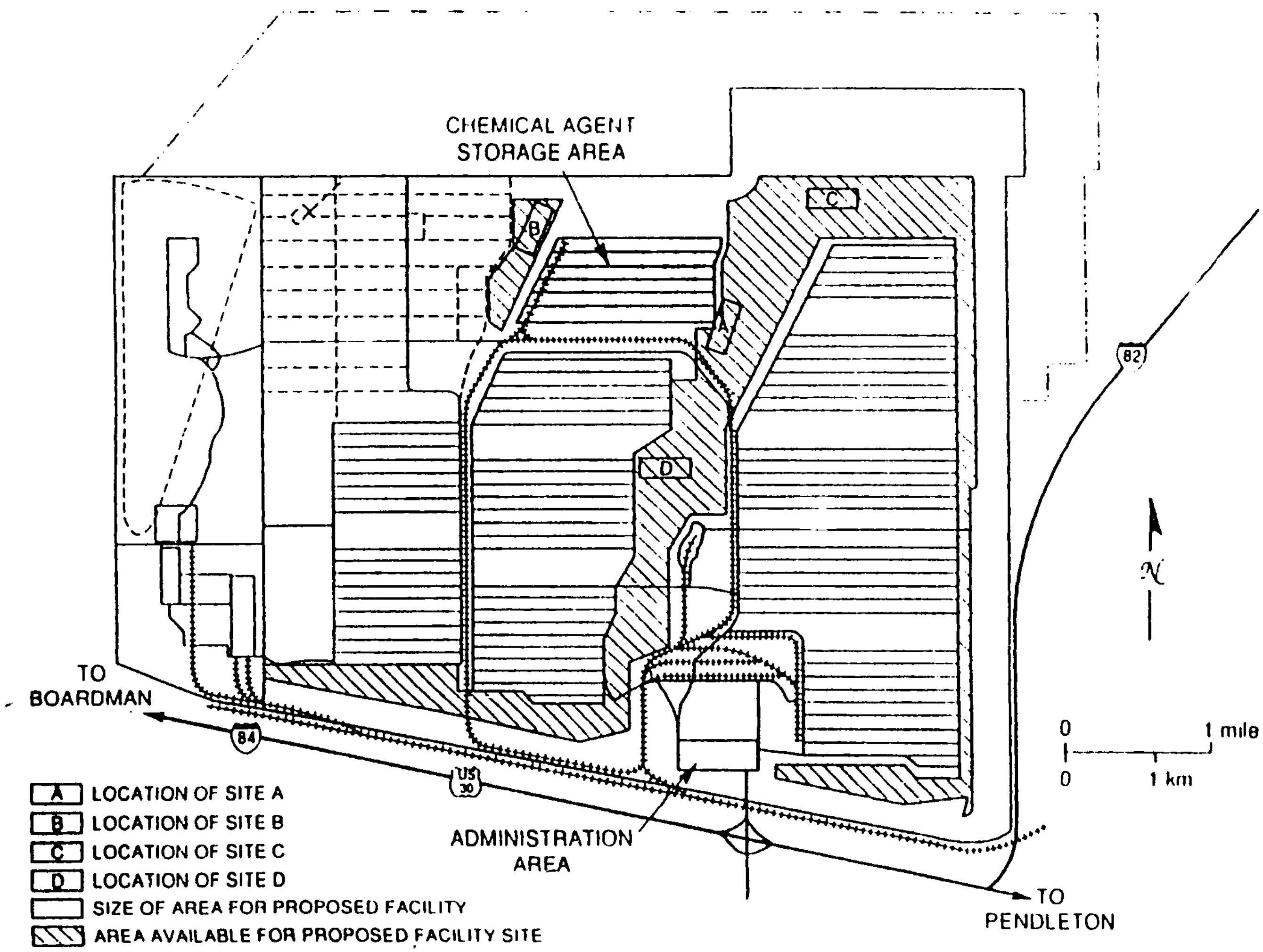

Figure 2.11 Alternative Sites on the Umatilla Depot for the Proposed Chemical Demilitarization Incineration Facility

Umatilla Depot to avoid the health risks and political difficulties of transporting the munitions to another location. A site has been chosen on the Depot to minimize the risks from the facility. Next, the inputs into the facility are described.

2.6 Description of Facility Inputs

The inputs into the facility during the operational phases (construction, incident free operations, and emergency operations) are described. Greater detail is given in the step matrices and reverse networks in Appendix A for incident free and emergency operations.

Construction

Construction of the Umatilla Chemical Demilitarization Incineration Facility is scheduled to take 38 months (U.S. Army, 1995). Inputs to the construction phase are the necessary construction materials, equipment, and personnel. The peak work force is 550.

Incident-Free Operations

There are various inputs into the facility demilitarization operations (UMCDF RCRA Application, 1995). The wastestream to be processed are the unitary munitions and bulk containers stored at the Depot. The input rate varies with the differing process rates of munitions. Operations require a total of 586 contractors and 150 government employees for munition handling, security, and other support activities (U.S. Army, 1995). Also required are transport trucks and forklifts to handle the munitions. Inputted into the processing of the munitions are fire and process water, sodium hypochlorite, sodium hydroxide, and hydrochloric acid. Sodium hypochlorite is a constitute in decontaminating solution for VX and HD. Sodium hydroxide is a constitute in decontaminating solution for GB and used in the quench tower and the demister in the Pollution Abatement Systems. Hydrochloric acid is used to wash down the demister when a pressure drop indicates plugging. The energy sources are electricity, fuel oil, and natural gas. Wastes generated to be further processed are brine, spent carbon and miscellaneous solid wastes, and solid and liquid lab wastes.

Emergency Operations

The inputs into the emergency operations are the same as for incident free operations. Additionally, an aircraft may crash into the site and facility and interact with the operations.

A summary of the inputs and input rates during the facility's operational phases is given in the step matrices documentation sheets in Appendix A.

2.7 Description of Facility Operations

Construction

Construction includes erecting the disposal facility and support facilities, building the roads, and providing the necessary utilities (water lines, natural gas lines, power lines and substation, sewage lines, and underground cables). Onsite construction disturbs about 23 hectares (58 acres). Offsite, construction of connecting power lines and a natural gas line disturbs about 7 hectares (17 acres).

Incident-Free Operations

Following construction of the facility, there is an 18 month pre-operational verification (U.S. Army, 1995). The systems are tested and the personnel trained. The trial burns begin with mock agent then agent. The data are submitted to the regulators and the final operating permit will be granted.

The layout of the UMCDF site is given in Figure 2.12. A simplified process diagram for the incident free operations is given in Figure 2.13. The main processes are storage of the munitions, transportation to the demilitarization facility, storage in the facility, handling and processing of the munitions, incineration of the separate components, the pollution abatement and carbon filter systems, brine reduction area and pollution abatement.

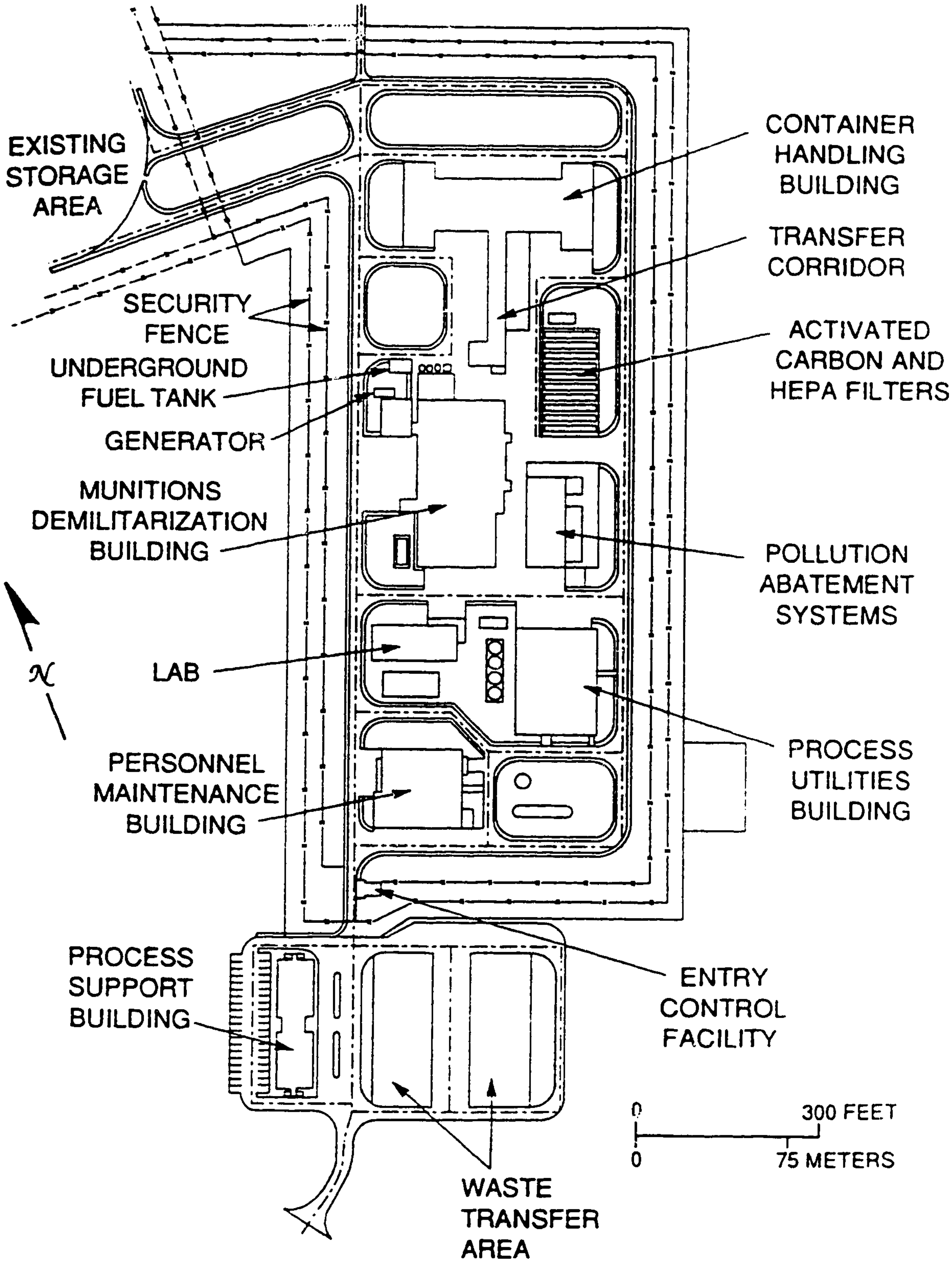

Figure 2.12 Layout of the Umatilla Chemical Demilitarization Incineration Facility (UMCDF) Site (U.S. Army, 1995)

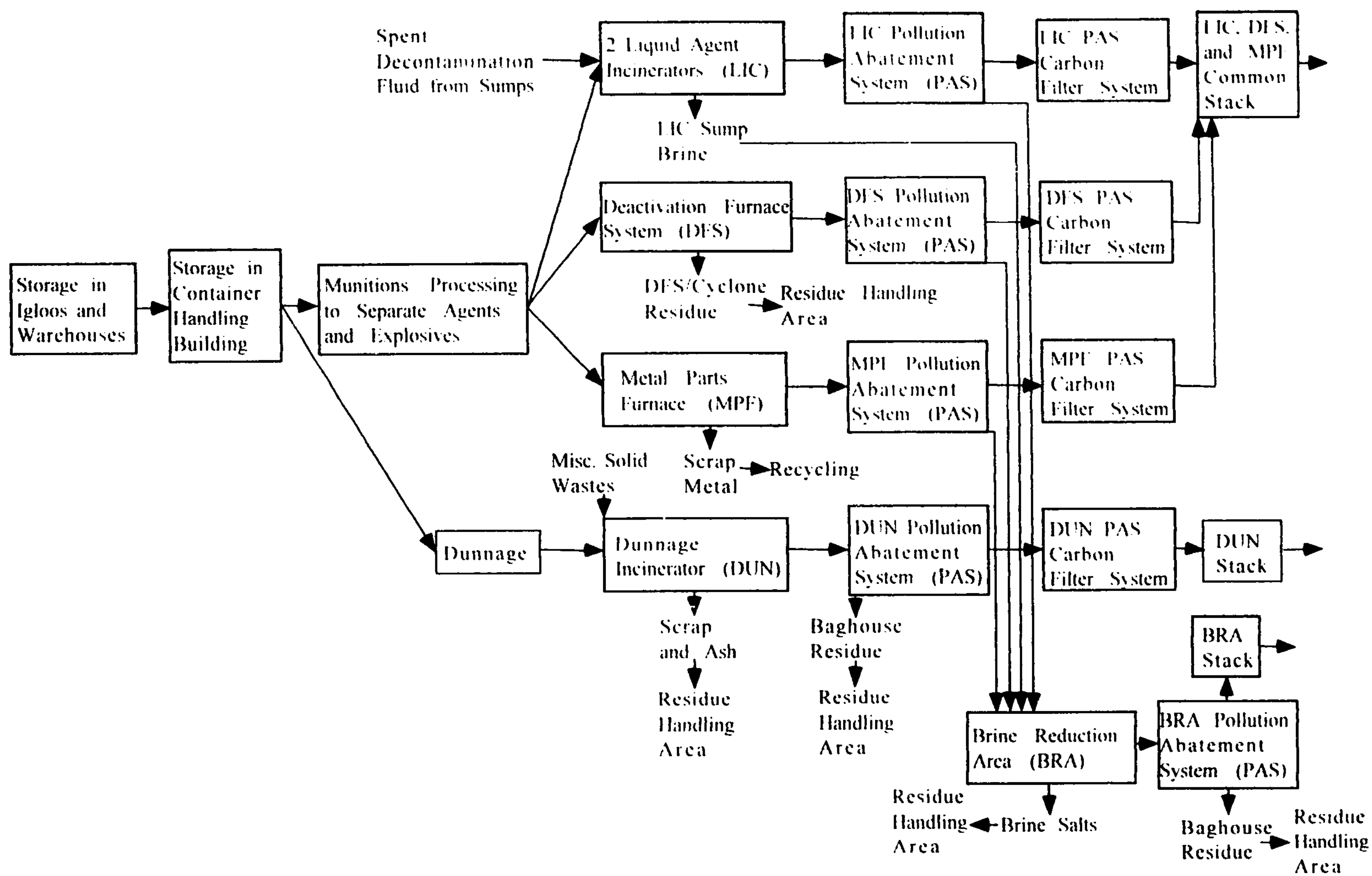

Figure 2.13 Schematic Diagram of the Munitions Processing for the Umatilla Chemical Demilitarization Incineration Facility (after U.S. Army, 1995; UMCDF RCRA Application, 1995)

The unitary chemical munitions are being stored in K-block, with extensive security precautions (see Figure 2.11 for the location of the storage area). Ton containers are being stored in a metal warehouse while the rest of the munitions are being stored in igloos (U.S. Army, 1995). The munitions are stored in overpack containers (shown in Figures 2.4 to 2.10) and on pallets (U.S. Army, 1995). There are aisles between the pallets for inspection, removal, and maintenance of the munitions (U.S. Army, 1995).

The storage igloos are constructed of reinforced concrete and covered with earth (see Figure 2.14) (U.S. Army, 1995). The igloo doors are steel or concrete and steel. There are louvered vents in the door and a stack in the roof for passive ventilation. The floor is concrete. To prevent a chain detonation of the igloos, they are they are laid out in staggered rows and designed so that an explosion is directed upwards.

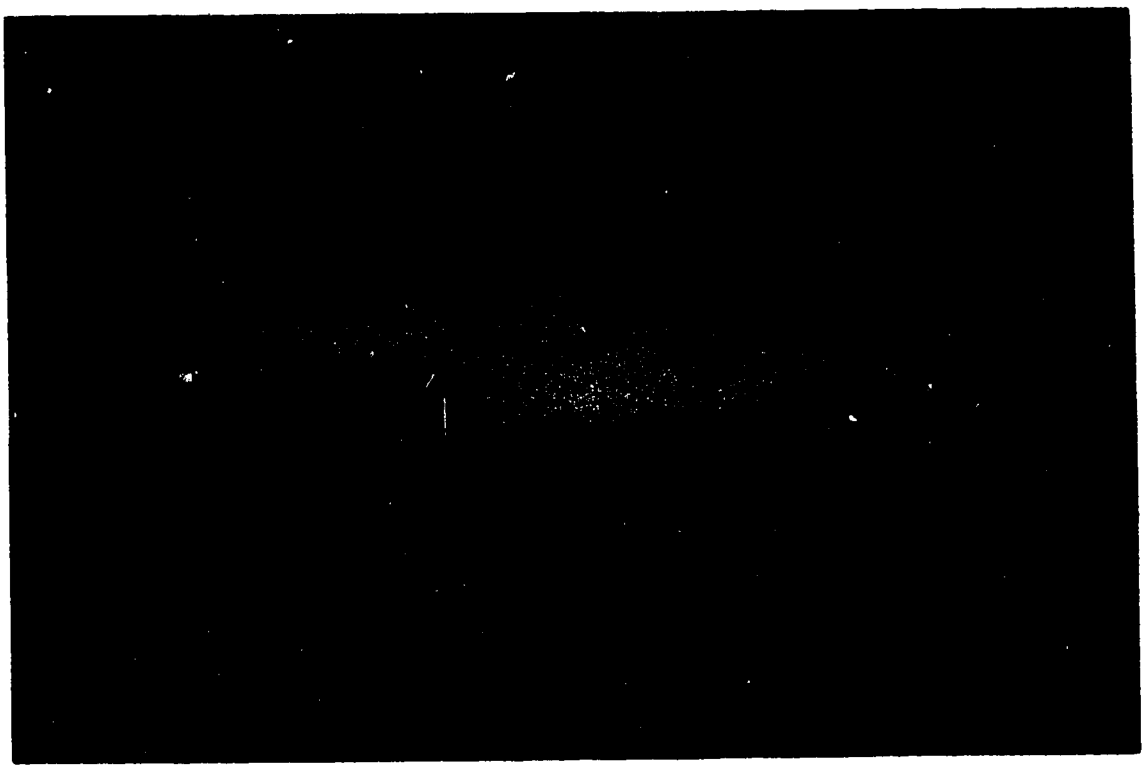

Figure 2.14 Picture of Storage Igloos

The munitions are taken from storage and transported to the Container Handling Building (CHB) (UMCDF RCRA Application, 1995). The igloo air is sampled for agent, then the door is opened. The munitions are placed on load trays and into onsite containers (ONCs) by a qualified forklift operator. There are blunt bumpers on forklift tines. The ONCs are transported on truck flatbeds. To prevent accidents, the munitions and bulk items are transported during daylight hours only (U.S. Army, 1995). The roads are upgraded and widened, with strict speed limits, and controlled access (UMCDF RCRA Application, 1995). The ONCs are designed to contain vapours and explosions. Transport operations are observed by guards and there is an emergency response vehicle available at all times.

The CHB will store enough munitions for 24 hour operations (U.S. Army, 1995). The storage quantity depends on the type and process rate of munitions being destroyed. The stored munitions are regularly inspected and the air is continuously monitored for agent (UMCDF RCRA Application, 1995). The CHB is enclosed, with filtered vents. From the CHB, the ONCs are handled and moved by a pneumatic roller track conveyor and lift system through an enclosed corridor to the Munitions Demilitarization Building (MDB) (UMCDF RCRA Application, 1995). In the unpack area of the MDB, air inside the ONC is sampled for agent. If there are no leaking munitions, the ONC is opened and the munitions are placed on trays for processing. Leaking munitions are unpacked by personnel wearing protective suits in the toxic maintenance area (TOX). Munitions containing explosives are conveyed to the Explosive Containment Room (ECR) for further processing (U.S. Army, 1995). There are metal shields on the conveyor in the ECR to contain shrapnel (U.S. Army, 1995).

The munitions have different disassembly procedures (UMCDF RCRA Application, 1995). Inside the glove box, the land mine drums are opened and the arming plugs are removed. The drums are conveyed to the Metal Parts Furnace (MPF). The packing material and arming plugs are conveyed to the Dunnage incinerator (DUN). The mines are punched and drained in the ECR. The drained agent is pumped to a holding tank in the TOX then pumped to the two Liquid Incinerators (LICs) for destruction. The bursters and mine bodies are sent to the Deactivation Furnace System (DFS) to destroy the explosives and residual agent. The rockets are punched inside the ECR, the agent is drained, and the rockets are sheared into sections. The drained agent is pumped to the TOX holding tank then the LICs. The rocket sections are sent to the DFS. In the ECR, projectiles are disassembled to remove the fuse, supplementary charge, and bursters which are sent to the DFS. Then, the projectiles are punched and drained and sent to the DFS. The agent is pumped to the TOX holding tank then to the LICs. Bulk munitions - ton containers, bombs, and spray tanks - are punched and a tube is inserted to pump the agent to the TOX holding tank. The drained munitions are then sent to the MPF.

Agent stored in the TOX holding tank is pumped through a duplex strainer to remove large particles. The agent is then dispersed into the LIC burner block with an atomizing nozzle. The nozzle rapidly mixes the agent with combustion air and fuel gas at 1370-1930°C (2500-3500°F). Flue gas passes into a secondary chamber. Spent decontamination solution is atomized at the top of the chamber at 1100°C (2000°F) for 2 seconds. The temperature is maintained by a separate burner block. The flue gas then goes to the Pollution Abatement System (PAS).

Mine boosters, fuses, activators, and bodies; sheared rocket pieces; and projectile nose plugs enter the DFS through a feed chute into the rotary retort. The rotary retort is rotated at 0.5 to 2 rpm depending on the munition processed. The furnace thermally deactivates and incinerates the explosives and propellants. The furnace also destroys residual agent on the hardware. A heated discharge conveyor removes the ash and scraps, holding them for 15 minutes at 540 °C (1000°F) for 5X destruction of residual agent. A 5X decontamination level indicates that the agent has been destroyed and the material is clean. The flue gas is maintained at 540-980°C (1000-1800°F). The flue gas passes through a blast attenuation duct, then a cyclone to remove particles, and through the afterburner. The cyclone discharge is enclosed to control fugitive emissions. The afterburner holds the flue gas at 1100-1200°C (2000-2200°F) for 2-3 seconds. Finally, the flue gas goes to the PAS.

Empty mine drums, projectile bodies, and drained bulk containers are conveyed on trays to the MPF through an airlock. The MPF is a direct fired, roller hearth incinerator. The tray is fed into the burnout chamber and held at >540°C (>1000°F) for 20-85 minutes for 5X decontamination. The flue gas is vented to the afterburner. The trays of decontaminated parts are conveyed though the discharge airlock, then to the cooling area, and finally to the scrap metal bins. The flue gas then goes to the PAS.

Packing materials and pallets from the land mines, M55 rockets, and projectiles are conveyed to the DUN for incineration. Operating procedures reduce the possibility of accidentally feeding a burstered munition into the DUN. Miscellaneous solid waste and spent carbon from the carbon filters are also incinerated in the DUN. Waste is charged into the primary chamber through an airlock lift system and feed ram. The feed ram pushes the charged waste along the chamber at 820-980°C (1500-1800°F) until all the waste ash falls into the collection bin below. The flue gas flows into the afterburner at 1100°C (2000°F) for 2 seconds. Then, the flue gas goes to the PAS.

There are separate, parallel Pollution Abatement Systems (PAS) for the two LICs, DFS, MPF and DUN. The PAS for the LICs, DFS, and the MPF consist of a quench tower, Venturi scrubber, packed bed scrubber tower, and a demister vessel. The flue gases from the LICs, DFS, and MPF then flow through a carbon filter system and blower and out a common stack. The carbon filter system consists of a gas/gas heat exchanger, a gas chiller exchanger, carbon filter units, through an exhaust blower.. The DUN flue gas flows through a PAS consisting of a quench tower and baghouse, through the carbon filter system, an exhaust blower, and out a separate stack. The Destruction Removal Efficiency (DRE) for chemical agent must be greater than 99.9999% (U.S. Army, 1995)

Brine is added to the Venturi scrubber and taken from the scrubber tower of the PAS for the LICs, DFS, and MPF. The brine is stored in brine surge tanks and recycled back to the Venturi. After one or two of the brine surge tanks are filled, then the composition of the brine batch is sampled. The brine then goes through the Brine Reduction Area (BRA) enclosed in the Process and Utility Building (PUB). The brine is preheated through a heat exchanger then recirculated through a flash evaporator until the specific gravity is greater than or equal to 1.08. The brine is fed through the evaporator one more time, then fed to drum dryers. The dryers are heated with steam on the inside of the rotating drum. Knife blades continuously scrap the salts from the sides of drums. The salts drop through collection guides, onto conveyor belts, and into a lined collection container. When the collection container is full, it is sent to the Residue Handling Area (RHA) for sampling and storage until final disposal. The water vapour and air from the BRA is sent through a PAS. The BRA PAS consists on a dryer knockout box to remove particles and heat to prevent condensation, then through baghouses for more particulate removal, through a blower, and out the stack.

Process wastes without free liquids are stored in the Residue Handling Area (RHA) in the Process and Utility Building. The wastes to be stored are brine salts, incinerator ash, slag, DFS cyclone residue, and baghouse residue. The wastes are cooled (if necessary) and transferred from the collection containers into lined and covered bulk transportation containers. The wastes are stored for less than 90 days while awaiting transport to an approved hazardous waste treatment, storage, or disposal facility.

There are several prevention and control measures on the processes (U.S. Army, 1995; UMCDF RCRA Application, 1995). These measures include security; personnel hiring and training; inspection schedules; preventative procedures, structures and equipment; emergency preparedness and prevention; and precautions to prevent the reactions of ignitable and reactive wastes. Extensive security measures are taken to prevent the access of unauthorized personnel. There is double fencing around the UMCDF perimeter with warning signs and security lighting. There are 24 hour roving armed patrols on the site. There is two-way radio communication for personnel, security, and the control room. Access is limited to one gate staffed by armed security. Only authorized personnel displaying appropriate ID badges are granted access.

There are strict hiring practices. Personnel who may have access to agent are carefully screened for competence, reliability, emotional stability, attitude, and drug usage (U.S. Army, 1995). Security checks are completed by the Federal Bureau of Investigations (FBI). Personnel must pass random drug testing. Initial and refresher training of personnel is conducted at the Central Demilitarization Training Facility at the Aberdeen Proving Ground. There is additional training at the Umatilla Chemical Demilitarization Facility. Operators must prove their competence prior to full-scale operations.

There is a regular inspection schedule to detect equipment deterioration and malfunction and prevent and control the occurrence of impacts. Inspections are completed on containers, tanks, controls, leak detection, cathodic protection, surface impoundment, pressure relief devices, connection systems, valves, carbon filters on tanks and buildings. and the emergency preparedness system. The emergency preparedness assures a speedy response to onsite emergencies. All emergency equipment, supply, and design requirements are met to prevent impacts. There are internal and external communication systems and onsite emergency response to control impacts.

The structures. equipment. and procedures are designed to prevent the occurrence of impacts. The liquid storage tanks (for agent, spent decontaminating solution, and the brine surge tanks) have a working capacity less than the total capacity; the design, materials, and construction meet ASME codes; they have continuous level sensors with rupture disks and sight gauges for manual observation; level and pressure alarms: the sump and foundation providing secondary containment; and there are vacuum relief valves and carbon filters on the agent storage tanks. The incinerators also have several controls such as trial burns of surrogate and agent to detect and correct problems and to demonstrate compliance, working at a negative pressure, redundant draft fans on all furnace systems. damper systems on agent containing furnaces to fail in "fail-safe" position, continuous remote monitoring of process parameters, centralized automatic control system, automatic shutoff systems, conservative temperature and residence times, and continuous emission monitoring on the stacks. Safe unloading and handling procedures are developed. There is an emergency power system to extend operational time to 45 minutes. Personnel protection equipment is available and there are onsite medical personnel. Agent is monitored throughout the facility: in storage in the CHB, in the MDB, on the exhaust stacks, at perimeter stations around the site.

Several precautions are taken to prevent the reactions of ignitable and reactive wastes. Waste and storage containers are compatible. There are no ignitable wastes onsite and the buildings are designed to prevent accidental ignition or reaction. All equipment is grounded. All buildings are nonsmoking. There is a seismically actuated cutoff valve on the main gas supply and on special circuit breakers in the facility. Cutting and welding in process areas is not allowed while agent is present. The fire protection system includes: automatic smoke, thermal, and photoelectric detectors; manual alarm pulls; automatic sprinklers system in the unpack area; automatic fire extinguishers in the control room and power room; dry chemical fire protection in the toxic cubical (TOX), water deluge system in the Explosive Containment Room (ECR), and portable fire extinguishers located throughout.

Emergency Operations

The engineering measures of the incident-free operations are developed to prevent and control the occurrence of emergencies. However unlikely, emergencies are possible. Emergency releases may be due to igloo or warehouse storage accidents, loading and transport accidents, or plant accidents. The U.S. Army completed a hazard analysis identifying different accident scenarios, munitions and agents involved, with different meteorological conditions (U.S. Army, 1995). The most probable storage accident scenarios are an earthquake or airplane crashing into the igloos or warehouses, with or without fire, which leads to an emergency release of chemical agent. The most probable transport accidents are vehicle accidents or earthquakes, with fire or detonation, which leads to an emergency release of agent. The most probable plant accidents are an earthquake or airplane crashing into the facility, with or without fire, which leads to an emergency release of chemical agent.

The prevention measures for incident free operations also prevent the occurrence of emergency operations. There are additional prevention and control measures to further reduce the emergency releases of agent. Designating the area over the Depot as restricted airspace would help prevent emergencies caused by airplane crashes. This is currently under review (U.S. Army, 1995). The deep foundations of some of the facility buildings may magnify earthquake induced ground movements. Designing to reduce earthquake magnification is a consideration (U.S. Army, 1995). The roads are upgraded and there are traffic control measures to prevent an accident. If a vehicle accident should occur, the truck fuel is limited to 386 L (102 gal) which would fuel a fire for only 10 minutes (U.S. Army, 1995).

The facility operations for incident-free operations and emergency operations are given in the step matrices in Appendix A.

2.8 Facility Emissions and Transport

Description of Surrounding Environment and Transport Mechanisms

The Umatilla Depot area is east of the Coast and Cascade Mountain Ranges (U.S. Army, 1995). The area is semi-arid, receiving only 25 cm (10 inches) of annual precipitation. The climate tends to be quite moderate with average temperatures between 0°C (30°F) and 21°C (70°F). The prevailing wind direction is from the west northwest.

The background air quality and noise levels around the Depot tend to be quite good (U.S. Army, 1995). The background concentrations of SO_2, NO_2, and lead are 25% to 30% of the state and national standards. However, suspended particulate matter is a concern. There have been 24 violations of primary national standards for particulate matter from 1983 to 1993 in the area. About 80% of the airborne particulate is naturally occurring dust. Current noise sources are agricultural equipment in the surrounding fields and detonation of conventional ammunitions at the Depot. Irrigon might be receiving 62 to 70 dBC during the detonations.

The Depot is in the Columbia River basin (U.S. Army, 1995). The Columbia River has an average discharge 5,165 m^3/s (182,400 ft^3/s). The Umatilla River (average discharge 23.8 m^3/s (841 ft^3/s) is a tributary of the Columbia. Also flowing into the Columbia are Butter Creek, Sand Hollow Creek, and Willow Creek which have only seasonal flow. The river flows are highest during spring runoff and lowest in autumn and winter. There are several power generating dams on the Columbia River, the nearest is the McNary Dam at Umatilla. There are also irrigation canals around the Depot for the crop land.

The groundwater aquifers beneath the Depot area are an unconfined alluvial aquifer in the surficial sediments above a confined basalt aquifer (U.S. Army, 1995). The aquifers flow northwest from the Blue Mountains to the Columbia River. The Depot has seven wells that draw from the basalt aquifer. There are also 636 irrigation wells and 3467 wells for domestic consumption and livestock drawing from the basalt aquifer. The high consumption rates and the aridity of the area has caused the basalt aquifer level to decrease 91 m (300 ft) since 1950.

Seismicity is a potential concern (U.S. Army, 1995). The Uniform Building Codes locate the Depot in seismic zone 2 (1985) and zone 2B (1988). The zones correspond to moderate earthquake damage. Deep foundations may magnify earthquake induced ground motions. The local soils are not expected to be sensitive to liquifaction.

Construction

Emissions to air from construction are vehicle exhaust, fugitive dust from the disturbed areas, and noise. It is unlikely that the facility site is contaminated. Therefore, it is unlikely that there will be hazardous emissions from the disturbed areas. Vehicle exhaust emissions are likely to be insignificant. However, the vehicles are equipped with emission controls. Fugitive dust from the disturbed area is predicted to exceed the 24 hour national and Oregon standards for Total Suspended Particulate (TSP) and particulate matter less than 10 μm in diameter (PM_{10}). Several conservative assumptions are used in this estimation, so the predicted dust emission rates are an upper limit. Dust suppression measures are to be used to minimize the fugitive dust emissions.

Emissions to surface water and groundwater are likely to be insignificant. Little runoff leaves the Depot due to the low precipitation rates. Surface disturbances of wetland areas will be minimized. There are no emissions to groundwater and no existing contamination at the UMCDF site.

Incident-Free Operations

The emissions from the stacks include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulates, heavy metals, volatile organic compounds (VOCs) (U.S. Army, 1995). The emission rates from the stacks are far below the Oregon and national standards for all air emissions except particulate matter less than 10 μm in diameter (PM_{10}). The PM_{10} standard is exceeded by the maximum background concentration - causing the small contribution of particulate matter by the facility to further exceed the standard. The emission rates are given in the step matrices data sheets in Appendix A.

There are also liquid and solid waste emissions from the facility (U.S. Army, 1995). The only liquid waste is domestic sewage emitted at an average rate of 81,000 L/day (21,500 gal/day). The solid wastes generated are 4,580 kg/hr (10,100 lb./hr) of nonhazardous metal scrap, 710 kg/hr (1,580 lb./hr) of scrap/ash, and 2,860 kg/hr (6,300) of brine salts.

Emergency Operations

The most credible emergencies (probability$\geq 10^{-8}$ occurrences/year) are considered under worst case and conservative most-likely meteorological conditions which disperse the released agent. The worse case meteorology conditions have a wind speed of 1 m/s (2 mph) and stable conditions which gives minimum dispersion, maximizing the received concentration of agent. The conservative most-likely meteorology conditions have a wind speed of 3 m/s (7 mph) and unstable conditions. It is unlikely that worst case meteorological conditions will occur during on-site transport. Transport will only be conducted during the day and worst case conditions almost always occur at night at the Depot.

The released chemical agent may be the nerve agents VX or GB or the blister agent HD. The nerve agents are organophosphates. The chemical formula for GB is $C_4H_{10}FO_2P$ and for VX is $C_{11}H_{26}NO_2PS$ (U.S. Army, 1995). GB volatilizes more quickly while VX is more persistent and toxic. The blister agent, mustard gas HD, has the chemical formula $C_4H_8Cl_2S$ (U.S. Army, 1995). HD is persistent, moderately volatile, and burns well (Watson, 1995).

If an emergency release should occur, there are emergency response measures to mitigate impacts onsite and offsite (UMCDF RCRA Application, 1995). The Army initiated the Chemical Stockpile Emergency Preparedness Program (CSEPP) with the assistance of the Federal Emergency Management Association (FEMA), the Department of Health and Human Services (DHHS), the Environmental Protection Agency (EPA), and state and local officials. The purpose of (CSEPP) is to mitigate impacts to human health from accidental releases of chemical agent during storage and the CSDP (U.S. Army, 1995).

CSEPP involves onsite Army personnel and offsite civilian personnel. When a spill occurs onsite, the spill observer radios the UMCDF control room who contacts the Emergency Coordinator. The Emergency Coordinator directs the emergency response operations to evaluate, contain, and remediate accidents. Based on the emergency scenario and location, the UMCDF emergency operations center takes the current meteorological data and predicts the plume distances (1% deaths distances, no deaths distances, and no effects distances) to determine if the plume will travel offsite.

The UMCDF notifies the County Emergency Operations Centers of the purpose of the message (initial notification, change in classification, status update, or termination of emergency), the type and classification of the emergency, the plume distances and directions, and the protective action recommendation for the Immediate Response Zones (IRZ) and Protective Action Zones (PAZ). The area around the Depot is divided into an Immediate Response Zones (IRZs) and Protective Action Zones (PAZ). The zones depend on the credible emergency scenarios, the population distribution, the available response time, and the response options.

If offsite protective actions are required, the County Emergency Operations Center will call in another dispatcher. The Emergency Broadcast System (EBS) is started, playing the appropriate prerecorded messages in English and Spanish in the different IRZ and PAZ zones. The EBS consists of messages on television, local radio stations, highway reader boards, and loudspeakers with chimes. The message may be to shelter in place or to evacuate to a reception and shelter site. More detailed emergency information in English and Spanish is distributed to the public on a calendar. The Sheriff's Department notifies all emergency response personnel via radio. Vehicle and boat traffic is blocked from going into the plume. The Emergency Management staff informs key personnel of the situation, protective action plans are decided on, activities are coordinated, and appropriate messages are played on the EBS. Decontamination and triage sites are activated along the evacuation routes. Emergency events are monitored until the response phase is over and the recovery phase can begin.

The recovery phase consists of controlling access to the area. After the release of the agent has ended, then the monitoring team may reenter. The team monitors and samples to determine the decontamination and quarantine needs. Decontamination and quarantine procedures are completed for contaminated materials. Police and other public service personnel may then reenter the area. Once residual contamination is reduced below action level concentrations, the "all clear" notice is given to the public. Claims centers, help lines, etc. are set up to assist the public and to establish normal activities.

There are concerns that the CSEPP presently provides insufficient protection (Tri-City Herald, January 31, 1996). For emergency workers, the emergency communication system is inadequate and protective suits still have to be provided. The EBS system is not functional and is incomplete. Sirens and loudspeakers have been installed, but they are not operating. Still to be supplied are the television "scroll" to transmit messages across the bottom of the screen and tone alert radios to be put inside houses. County officials have requested that the State not grant regulatory approval until the emergency program is prepared.

2.9 Receptor Exposure

Location of Receptors: Surrounding Communities, Land uses and Ecological Resources

The Umatilla Depot is close to several population centres (see Figure 2.2). The Depot is about 10 km (6 miles) west-southwest of Hermiston (population 10,040), 18 km (11 miles) southwest of Stanfield (population 1,568), 20 km (12 miles) southwest of Echo (population 499), 10 km (6 miles) southwest of Umatilla and McNary (population 3,046), 8 km (5 miles) southeast of Irrigon (population 737), and 23 km (14 miles) east of Boardman (population 1,387). Farther population centres are Pendleton which is 54 km (34 miles) southeast and the Tri-Cities, Pasco, Kennewick, and Richland which is about 56 km (35 miles) northeast.

The land use around the Depot is primarily agricultural. In Umatilla and Morrow Counties there are 376,000 hectares (930,000 acres) of cropland, 239,000 hectares (590,000 acres) of pasture land, 23,000 hectares (58,000 acres) of woodland, and 64,000 hectares (157,000 acres) of conservation wetlands (USDA, 1995). In Umatilla County, one sixth of the crop land is irrigated from the Columbia River, its tributaries, or from groundwater (USDA, 1995). A significant area of Umatilla and Morrow Counties is also Indian reservation (U.S. Army, 1995). There are also cultural and anthropological resources in Umatilla and Morrow Counties (U.S. Army, 1995). There are three national historic sites within 25 km (16 miles) of the facility. There are also 500 historic sites in the counties and seven archaeological sites used by Indians in the vicinity of the facility.

Agriculture is the major source of income in the area (USDA, 1995). The main sources of agricultural revenue are cattle and calves, hay, greenhouse/nursery products milk, wheat, forest products, fruit/nuts, vegetables, and seed crops (U.S. Army, 1995). There has been a 100% and 240% increase in the Hispanic population in Umatilla and Morrow Counties, respectively, from 1980 to 1990 (U.S. Army, 1995) to meet the employment demands of agriculture. There are many more seasonal workers that are not enumerated in the census. The average personal income in Morrow and Umatilla Counties is $16.579 and $16.368, respectively. This is below the Oregon average of $19.347 (U.S. Department of Commerce, 1994).

The current public service infrastructure is sufficient or overextended (U.S. Army, 1995). There are nine hospitals within 50 km (31 miles) of the facility. The hospitals (excluding the psychiatric hospitals) are currently at 48% of their capacity. Water and wastewater treatment, utilities, police and fire protection, and transportation are also sufficient. The schools in Umatilla and Morrow Counties are presently filled to capacity. There is little financial support to expand the schools. Increasing demands are met through temporary buildings and increasing the staff. Therefore, most of the public service infrastructure is sufficient while schools are being overextended.

Residents in the area have had mixed experiences with the Army and the Federal government. During the peak operations of the Depot, it employed over 2000 people. Many people have been employed by the Depot or know someone who has. Many residents have been employed by the U.S. Armed Forces. Local residents have had bad experiences with the Department of Energy (DOE) Hanford nuclear weapons facility across the border in Washington. Conservative assessments estimated that three percent of pre-1987 cancer deaths in Hanford workers were caused by low levels of ionizing radiation (Kneale and Stewart, 1993; Upton et al., 1992). Further, the Hanford plant released 400,000 curies of radioactive iodine from 1944 to 1947 into the atmosphere to determine dispersions (Kimball and Glass, 1991). 5.3 million m^3 (200 billion gallons) of contaminated wastewater were also released into the ground water and the Columbia River since 1944 (Kimball and Glass, 1991). There are concerns of a higher rate of thyroid cancer among local residents due to these releases (Kimball and Glass, 1991). Residents also believe that the DOE downplayed the risks and avoided taking responsibility (Kimball and Glass, 1991). Past experiences with the Depot, the Armed Forces, and the Federal government may affect peoples' trust of the Army.

There are also many ecological resources within 100 km (62 miles) of the facility. There are six national forests, two national wilderness areas, six national wildlife refuges, two state wildlife areas, three state fish hatcheries, two state forest waysides, six state parks, five state habitat management units, and five natural areas and nature conservancy (U.S. Army, 1995). Terrestrial plants and animals are similar to those found elsewhere in the region. In the nearby Columbia River, there are salmon, steelhead, sturgeon, smelt, shad, walleye, bass, perch, crappie, and catfish providing commercial and recreational fishing on the river. Wetland areas along the Umatilla and Columbia Rivers provide waterfowl habitat. Finally, there are several threatened or endangered species in the area around the Depot. These species include the peregrine falcon, the bald eagle, the spotted owl, the Snake River sockeye salmon, the Snake River Chinook salmon, the sand roller, and 43 plant species. These ecological resources may be more sensitive to facility emissions to the environment.

2.10 Predicted Impacts and Benefits

Construction

Noise emissions from construction activities may be as high as 45 dBA at the nearest residence, which is less than or equal to the background noise from agricultural activity. The surface disturbances may disrupt wildlife habitats. However, the affected area would be small.

During construction, the effects to residents' health and the environment are predicted to be negligible (U.S. Army, 1995). The air quality may exceed the national standard for particulate matter less than 10 μm in diameter (PM_{10}) as the background levels are already high. The noise levels received by the nearest residences should be equal to or less than the USEPA standards. It is unlikely that the extra dust and noise from construction would impact residents' health. The UMCDF also requires additional water drawn from the groundwater. There may be some nuisance and annoyance to residents from the view and noise from construction and from the additional water usage. Surface disturbances onsite and offsite may cause some disruption to wildlife habitats. However, the impacted area is small and the effected wildlife populations are representative of those in the surrounding areas.

Construction of the UMCDF would affect the local employment rates, development, and property values. Five hundred fifty skilled workers are required for construction, most of whom will emigrate into the area. The influx of workers and their families will likely increase the housing demand, rental rates, and property values in the surrounding area. The temporary population influx may also increase the demand in service industry such as restaurants and accommodations. The service industry would grow to meet these demands. Therefore, construction is likely to improve the local economy.

The construction phase of the facility will affect the public services, community image, and cultural resources of the local communities. Construction requires 550 workers, many of whom will temporarily move to the area with their families. This increase in population will further stress the social services, especially schools and perhaps law enforcement. Schools are already filled to capacity, and there may be insufficient funding for temporary expansions. The local community image may also be affected. The image may become more positive due to the increased development and the belief that actions are being taken to reduce the risk due to storage. However, the effect to community image may be negative resulting from the increased demand on public infrastructure and an increased awareness of the chemical demilitarization facility. Cultural resources may be slightly impacted during construction as the Oregon Trail Immigrant Wagon Road would be crossed by the gas pipeline. Construction may have a negative effect on public infrastructure, a positive or negative impact on community image, and a slight negative effect on cultural resources.

Incident-Free Operations

The incident-free operations of the facility may affect residents' health and wildlife populations (U.S. Army, 1995). The facility emits contaminants to air, domestic sewage to a septic field and to groundwater, and solid wastes (scrap metal, ash, brine salts) to recycling facilities or approved hazardous waste storage, treatment, or disposal facilities. The emissions to air are below the state and national air quality standards, except for particulate matter less than 10 μm in diameter (PM_{10}) due to high background levels (see Appendix A for details). The noise levels received by the nearest residences should be equal to or less than the USEPA standards (U.S. Army, 1995). The view of the facility and its operation are limited. The facility requires additional process and fire additional water from the groundwater. It is predicted that the emission of contaminants, noise, and view to the atmosphere will have an insignificant impact to residents health (U.S. Army, 1995). There is some concern for unknown effects from low concentrations of contaminants (U.S. Army, 1995). However, there is insufficient information to determine the effect (U.S. Army, 1995). There may be some annoyance and psychological stress to residents from the view and noise of the facility. Air emissions are predicted to also have an insignificant effect to wildlife populations. However, again the cumulative effects of low-levels of contaminants are unknown (U.S. Army, 1995). Overall, incident-free operations will likely have an insignificant effect on the health of residents and wildlife populations but there may be some nuisance and psychological stress (U.S. Army, 1995). Destruction of the chemical stockpile would eliminate the possibility for future impacts to residents' and wildlife health.

Incident free operations of the UMCDF will require a total of 586 contractors and 150 government employees (U.S. Army, 1995). The population growth would further increase the local demand for housing and services. It is predicted that property values and local service industry development would increase

Incident free operations would affect the local communities. Operations need 736 employees - 186 more employees than the peak number of employees for construction (U.S. Army, 1995). The operations work force will be more stable than the construction work force and will further increase the demand on social services. As for construction, community image may become more positive or negative. It is unlikely that cultural resources will be impacted (U.S. Army, 1995). Therefore, incident-free operations may have a negative effect on public infrastructure, a positive or negative effect on community image, and no effect on cultural resources (U.S. Army, 1995).

Emergency Operations

The most credible emergencies (probability$\geq 10^{-8}$) are given in Table 2.2 with the accident scenario, the agent and munition involved, under worst case and conservative most-likely meteorological conditions, leading to potential fatalities. There are several conservative assumptions made in the determination of potential maximum fatalities so that the values given in Table 2.2 can be considered to be the upper bound (U.S. Army, 1995). Consideration of sensitive populations (infants, children, elderly) is less than the uncertainty associated with the modeling assumptions (U.S. Army, 1995).

The nerve agents are almost colourless, odourless, and tasteless (U.S. Army, 1995). They are highly toxic in liquid and vapour form. The 8 hour workplace limits are 1×10^{-4} mg/m^3 for GB and 1×10^{-5} mg/m^3 for VX (Watson, 1995). The 72 hour Time-Weighted Average (TWA) limits for the general population are 3×10^{-6} mg/m^3 for GB and 3×10^{-6} mg/m^3 for VX (Watson, 1995). The agent is readily absorbed dermally through the skin and eyes, through inhalation, or through ingestion. The mode of action is a poisoning of the nervous system (U.S. Army, 1995). The early symptoms of dermal exposure may be localized sweating and muscular twitching. The early symptoms of exposure through inhalation may be pinpointing of eye pupils, dimness of vision, running nose, tightness of chest, and difficulty in breathing. Later symptoms for severe exposures may be nausea and vomiting, cramps and involuntary defecation or urination, headache or drowsiness, convulsions, cessation of breathing, and coma.

Table 2.2 Most Credible Emergency Accident Scenarios and Impacts (U.S. Army, 1995)

Accident scenario	Agent, munition	Worst-Case conditions: Computed no-deaths distance[a], km (MI)	Worst-Case conditions: Plume arrival time[b], hr	Worst-Case conditions: Potential maximum fatalities[c]	Conservative Most-Likely conditions: Computed no-deaths distance[a], km (MI)	Conservative Most-Likely conditions: Plume arrival time[b], min	Conservative Most-Likely conditions: Potential maximum fatalities[c]
Storage							
earthquake followed by fire in warehouses	HD, ton containers	314(195)	27.8	10,300	31(19)	275(4.6h)	6,610
crash of aircraft followed by fire	HD, ton containers	202(125)	27.8	10,300	23(14)	275(4.6h)	6,610
earthquake followed by fire in warehouses	HD, ton containers	202(125)	27.8	10,300	23(14)	275(4.6h)	6,610
crash of large aircraft followed by fire	GB, M55 rockets	125(77)	27.8	10,300	23(14)	275(4.6h)	6,610
crash of large aircraft without fire	GB, M55 rockets	48(30)	13.9	3,740	20(12)	115(1.9h)	1,920
crash of large aircraft followed by fire	VX, spray tanks	19(12)	5.6	940	5(3)	28	1
Onsite Transport Accidents							
vehicle accident with fire detonation	VX, M55 rockets	14(9)	5.6	940	4(2)	28	1
earthquake/accident with fire/detonation	GB, M55 rockets	14(9)	5.6	940	4(2)	28	1
vehicle accident with fire/detonation	GB, M55 rockets	12(8)	5.6	940	3(2)	28	1
vehicle accident with fire/detonation	GB, 8" projectiles	10(6)	2.8	41	3(2)	28	1
vehicle accident with fire/detonation	VX, 8" projectiles	10(6)	2.8	41	3(2)	28	1
Plant Accidents							
crash of large aircraft without fire	GB, M55 rockets	28(17)	13.9	3,740	7(4)	56	77
earthquake followed by fire	VX, mines	28(17)	13.9	3,740	7(4)	56	77
earthquake followed by fire	GB, M55 rockets	18(11)	5.6	940	5(3)	28	1
crash of large aircraft without fire	GB, M55 rockets	18(11)	5.6	940	5(3)	28	1
earthquake followed by fire	VX, M55 rockets	17(10)	5.6	940	5(3)	28	1
earthquake followed by fire	VX, 8" projectiles	12(8)	5.6	940	4(2)	28	1
earthquake followed by fire	VX, spray tanks	12(7)	5.6	940	2(1)	11	0
earthquake followed by fire	GB, 155mm projectiles	9(6)	2.8	41	3(2)	28	1

a = No-deaths distance is the estimated downwind distance beyond which no fatalities would be expected for healthy, young males. All distances are rounded to the nearest whole number.

b = Arrival time is based on the rounded up distance of the no-deaths distance to 2, 5, 10, 20, 50, or 100 km (1, 3, 6, 12, 31, or 62 miles) and the wind speed of 1 m/s (2 mph) for worst case conditions and 3 m/s (7 mph) for conservative most likely conditions. No deaths distances greater than 100 km (62 miles) are rounded down to 100 km, due to the limitations of the atmospheric dispersion models' accuracy beyond 100 km (62 miles).

c = The rounded up no-deaths distance, 1% deaths distances, and 50% deaths distances are overlaid on the population distribution map around the Depot. 50% deaths distance is the downwind distance where the concentration of agent is 50% of the lethal concentration. The number of people in each distance category are counted: 0 distance to 50% deaths distance, 50% death distance to 1% deaths distance, 1% deaths distance to no deaths distance. The death rate is assumed to be the average of the limits. The potential maximum fatalities is the sum of the average death rate for each distance category is multiplied by the number of people in that category. The plume is expected to travel in the direction causing the largest potential for death.

The blister agent, mustard gas HD, as a liquid is pale yellow brown and the gas is colourless (U.S. Army, 1995). HD has a mustard-garlic smell. The 8 hour workplace limit is 3×10^{-3} mg/m^3 and the 72 hour Time Weighted Average limits for the general population is 1×10^{-4} mg/m^3 (Watson, 1995). The mode of action is poisoning the cells in the exposed surface (U.S. Army, 1995). The early symptoms of exposure are inflammation of the surface contacted. Later symptoms for severe exposures are blistering and ulceration. Toxicological data indicates that HD exposure may result in carcinogenesis.

Emergency operations have the possibility to significantly impact residents' health and wildlife populations. The most credible emergency scenarios from storage, transportation or plant accidents may disperse agent over a large area and result in a maximum of 1 [illegible] acute fatalities. Since mustard gas is a carcinogen, there may also be chronic impacts from a release (U.S. Army, 1995). The impact to common, threatened, and endangered wildlife populations would also be significant (U.S. Army, 1995). Since, wildlife populations may be more sensitive to contamination than humans, the impact area may extend beyond the human impact area (U.S. Army, 1995). Disruption to the lives of residents during an emergency would cause significant psychological stress (U.S. Army, 1995). Overall, an emergency release would cause significant impacts to the acute and chronic physical and psychological health of residents and wildlife (U.S. Army, 1995).

Emergency operations would significantly disrupt the local economy. Contamination of property and the perception of contamination would reduce property values and product values. All local industries would be shut down and everyone evacuated stopping all local employment until the area is safe to re-enter. Local employment rates may also be affected in the long-term if agricultural industries (e.g. food processing) move from the area to become disassociated from the facility. Therefore, emergency operations would significantly affect property values, product values, employment rates, and local development during the accident response and recovery phase.

Emergency operations would significantly affect the public services, community image, and cultural resources of local communities. An accidental release of agent requiring the evacuation of residents would require the complete cooperation of all emergency response personnel during the response and recovery phase of the emergency. Public infrastructures (schools, hospitals, water treatment) would have to be declared safe prior to re-entry. The image of the local communities would be negatively impacted. An emergency would likely receive national, if not international, media coverage which would stigmatize the area. Finally, an emergency release would contaminate cultural resources and prevent access during the emergency. Local communities would be significantly affected by an emergency release of agent.

For impacts that do occur, there is additional mitigation and compensation available through legislation. The legislation includes the Stafford Act, the Federal Tort Claims Act, the Military Claims Act, and the Comprehensive Environmental Response, Compensation, and Liability Reauthorization Act (CERCLA). The Stafford Act provides assistance for an emergency or major disaster as requested by the Governor or granted by the President, when State resources are overwhelmed. An emergency declaration provides federal assistance for short-term measures to protect health, lives, and property such as providing temporary housing or removing debris. Expenditures are limited to $5 million. A major disaster declaration must be requested by the Governor and provides assistance from long-term measures such as housing, unemployment assistance, grant programs, community disaster loans, etc. with no expenditure limit. An emergency release of agent can only be declared a major disaster if it is associated with a natural disaster such as an earthquake or flood or with a fire or explosion. The Stafford Act provides additional mitigation of an emergency or disaster.

The Federal Tort Claims Act compensates claims for death, personal injury, and damage or loss of property. The impacts must be caused by actions of military personnel or civilian employees within the line of duty. Claims not payable are those which are based on act or omission while exercising due care, based on the performance of a discretionary function, damage caused by a quarantine, or damage caused during relief efforts.

The Military Claims Act compensates claims for death, personal injury, and loss or destruction of property. The impacts must be caused by a negligent or wrongful act of military personnel or civilian employees of the U.S. Army acting within the scope of their employment in noncombative duties. Claims are not granted if they are based only on compassionate grounds or if they are not in the best interests of the United States.

Compensation may be granted under CERCLA. For the Army to be held liable for damages incurred, there must be: a release or threat of a release caused solely by the Army, the claimant must show the Army as the responsible party, and the Army must have an absence of defense (i.e. release is not an act of God, act of war, or due to error or omission of a third party). Therefore, all of the most credible accident scenarios (earthquakes, terrorism, airplane crash) may not compensated under CERCLA.

2.11 Summary

In this chapter the study facility - the UMCDF - was selected and described. The facility was chosen to rigourously test the research hypotheses. The facility selection process began by choosing the type of facility - a waste disposal facility. Then, several different types of waste disposal processes were considered and an incinerator was chosen to simplify the contaminant dispersions and make the prediction of impacts more reliable. Next, the status of the facility siting process was considered. Only facilities still in the planning stage were considered. The type of waste stream was also considered. Proposed hazardous waste facilities which were nearby were reviewed. Two facilities - a plasma hearth furnace in Idaho and a nerve gas incinerator in Oregon were compared for their adequacy in fulfilling the research requirements. From this comparison, the Umatilla Chemical Demilitarization Incineration Facility (UMCDF) on the Umatilla Army Depot in Oregon was chosen as the study facility.

Then, the UMCDF was described consistent with the engineering/risk assessment physical cause-effect sequence (see Figure 2.1). The facility need, inputs, operations, emissions, and existing engineering interventions were reviewed for construction, incident-free operations, and emergency operations. The surrounding communities and environment are described and the possible effects of the facility are given. Detailed descriptions are given in the step matrices and reverse networks in Appendix A.

During construction of the UMCDF, effects to residents' health and the environment are predicted to be negligible. It is unlikely that the extra dust and noise from construction would impact residents' health, although there may be some nuisance and annoyance. The temporary population influx would increase the demand in service industries to improve the local economy. Increased demand would also improve the property values. Construction may have a positive or negative impact on community image, depending on the media coverage.

It is predicted that incident-free operations of the UMCDF will have insignificant effects to residents' health and the environment. There may be some nuisance and psychological stress to residents. Destruction of the chemical stockpile would eliminate the possibility for future impacts to residents' and wildlife health. The population growth, during operations would further increase the local demand for housing and services increasing local property values. Currently, public infrastructure is strained. So an influx of workers may cause the community image to be decreased. Negative media coverage would also impact community image.

An emergency release of chemical agent would cause significant impacts to the acute and chronic physical and psychological health of residents and wildlife. It is predicted that as many as 10,300 people would die during the worst case scenario. Emergency operations would significantly disrupt the local economy. Contamination of property and the perception of contamination would reduce property values and product values. Emergency operations would significantly affect community image as the community would likely be stigmatized.

The description of the UMCDF provides the context for the siting and design of the facility. The review of the relevant siting and design theories and the development of the research hypotheses is completed in the next chapter, Chapter 3. This description also gives the necessary information to develop the research methodology and provides the baseline design to which additional engineering intervention measures may be added to further improve residents' attitude towards the facility (given in Chapter 4).

3. Review of Waste Facility Siting and Design Theory to Develop Research Hypotheses

3.1 Introduction

As stated in the introduction, the purpose of this research is to determine how engineers can design a proposed waste facility to address residents' concerns to make it more acceptable to them. The selection and description of the study facility, the Umatilla Chemical Demilitarization Incinerator Facility (UMCDF) was completed in Chapter 2. Reviewing the relevant theories and developing the research hypotheses is completed in this chapter. Then, these hypotheses are tested by determining the actual beliefs, values, attitudes, and preferences of residents during the ongoing siting and design of the UMCDF (see Chapter 4 - Methodology and Chapter 5 - Results and Discussion). The testing of the hypotheses fulfills the two research objectives: 1) to generally test the theories from which the hypotheses are derived and 2) to specifically describe the response of residents during the siting and design of the study facility.

3.2 Development of a Conceptual Framework to Structure Residents' Response towards the Facility - Residents' Beliefs, Values, Attitudes, Actions, and Preferences for Engineering Intervention Measures

This research attempts to manage the physical and social impacts from a waste facility with engineering intervention measures. To accomplish this, theories are drawn from engineering, risk assessment, social psychology, economics, and anthropology. No single theoretical approach fully captures residents' beliefs, values, attitudes, actions, and management preferences during a waste facility siting (Krimsky, 1992; Slovic, 1992; Kartez, 1989; Douglas, 1985; Johnson and Tversky, 1984; Covello, 1983). The multi-disciplinary approach of this research attempts to take a holistic view - not just considering each facet of a residents' response but emphasizing the interaction between the different facets. This chapter develops the general conceptual framework and applies it to the Umatilla Chemical Demilitarization Incineration Facility (UMCDF).

The engineering/risk assessment approaches and social science approaches are explored for their relevance to waste facility siting and design. What does each theory contribute to the understanding of residents' responses? First, the engineering/risk assessment approaches are reviewed to determine the physical cause-effect sequence and the intervention points of the engineering measures. Next, the social science approaches are reviewed. The Theory of Reasoned Action and Altruism Theory look at the contribution of beliefs about the facility to attitude which is affected by motivation variables and leads to actions toward the facility. Risk perception literature is reviewed to further quantify residents' beliefs about the facility effects which contribute to their attitude towards the facility. Prospect Theory is also used to explain residents' evaluation of the effects which contribute to their attitude. Finally, the correlation of residents' general beliefs and values about: technology, the environment, and risk management with residents' attitude and actions is considered. At the end of this chapter, hypotheses are drawn from the conceptual framework regarding the beliefs, values, attitudes, actions, and preferences of respondents during a waste facility siting.

3.2.1 Engineering/Risk Assessment Approaches to Waste Facility Siting and Design Processes

The engineering and risk assessment approaches consider the facility' physical causal-effect sequence. Figure 3.1 represents the cause-effect sequence starting with the need for the facility. The facility need determines the inputs and wastestreams and the facility design and operation. The facility operation causes emissions which are transported through environmental media. Receptors are exposed to the contaminant concentrations in the environmental media. If the quantity of the contaminant received by the receptor exceeds a significant dose, then the exposure will result in an effect to the receptor (after Zeiss and Atwater, 1991; Zeiss, 1993; Wartenberg and Chess, 1992; Rodricks, 1992; Armour, 1991; ASME, 1988; Hohenemser et al., 1985; Cox and Slater, 1984; Williams et al., 1983; Fischhoff et al., 1978). The effects may be positive (benefits) or negative (impacts). An impact is defined as any change, direct or indirect, caused by the facility that impairs or damages the environment, human physical and psychological health, safety, economics, or property.

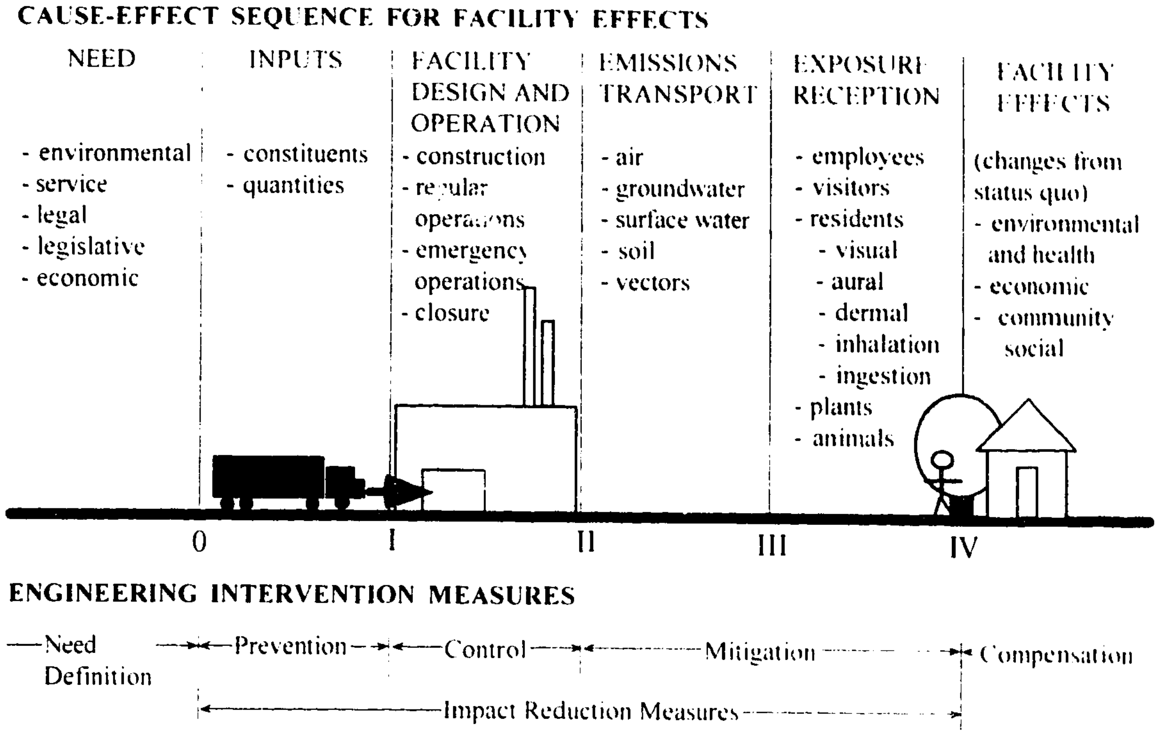

Figure 3.1 Cause-Effect Sequence for Facility Effects and Intervention Points of Engineering Measures (after Zeiss, 1991; 1993)

When designing a waste facility, first the need for the facility must be defined. The facility need may include legislative, environmental, regulatory, economic, and service needs (Williams et al., 1983). Quantitative Risk Assessment (QRA) has not traditionally considered the facility need (Hohenemser et al., 1985). However, the need for the facility determines the development and evaluation of options for inputs and facility design (Armour, 1991; Williams et al., 1983). The selection of the most appropriate technology is based upon the ability to meet the need (Hohenemser et al., 1985) while minimizing impacts and maximizing benefits.

There are four steps in Quantitative Risk Assessment (QRA) (Rodricks, 1992; Wartenberg and Chess, 1992). These steps sequentially evaluate the interactions between inputs, facility design and operation, contaminant emissions and transport, reception and exposure which result in human health effects. The first step is hazard identification - the consideration of all the possible scenarios of inputs, operations, and emissions which may cause adverse health effects (Rodricks, 1992; Wartenberg and Chess, 1992). The inputs are the constituents and quantities of materials that enter the facility to be processed (Rubel, 1974). Facility inputs include money, construction material, the wastestream, transport trucks, process water, fuel gas, and process chemicals. The size of the facility is dependent upon the annual waste capacity, the dimensions, and the area of the site (Williams et al., 1983). The facility operations process the inputs and byproducts which lead to emissions. The facility emissions are mass and energy (heat, light, noise) that are released by the facility and its operations into the surrounding environment (Zeiss and Atwater, 1991; Washburn et al., 1989).

The second step of QRA is exposure assessment - the determination of emission rates, dispersion of the contaminants through the environmental media, and the resulting exposure (Rodricks, 1992; Wartenberg and Chess, 1992). Emissions from the operations are carried by the surrounding environment through air, groundwater, surface water, soil, and vector media (Zeiss, 1993; Rodricks, 1992). The emissions go through decomposition, transformation, and other chemical reactions and are be passed from one medium to another (Rodricks, 1992). Employees or visitors in the facility and residents, plants, animals in the surrounding environment are exposed to the facility emissions through visual, aural, dermal, inhalation, and/or ingestion routes from the various environmental media (Zeiss, 1993; Rodricks, 1992). The effective dose received from the exposure is dependent upon the duration of exposure, concentration in the medium, exposure route, receptor's body weight, absorption rates, and metabolic rates and processes (Rodricks, 1992). Receptors also interact directly with the facility and its operations.

The third step in QRA is toxicity assessment - the determination of the dose of a given contaminant that produces harmful health effects to humans (Rodricks, 1992; Wartenberg and Chess, 1992). The dose-response modeling relies on data from toxicology and epidemiology to determine human dose-response curves (Rodricks, 1992). Toxicology uses laboratory animals as models for human responses. Epidemiology uses data on past environmental and occupational exposure to the contaminant by humans.

The final step in QRA is risk characterization - determining the overall level of health risk by combining the information from the first three stages (Rodricks, 1992; Wartenberg and Chess, 1992). The probability of contaminant emissions is determined in the first step - hazard identification. The resulting lifetime cumulative dose of each contaminant from all environmental media and exposure routes is determined in the second step - exposure assessment. Finally, the total dose of each contaminant is multiplied by the potency estimated in step three - toxicity assessment - to determine the cancer risk and non-cancer risk from that contaminant. The cumulative risk from the facility is determined by adding the risks of all the contaminants.

Thus, QRA determines the cumulative human health risk from the facility as a product of probability of occurrence of exposure and the consequences of that exposure (usually given in probability of human deaths per year). QRA may be then used to compare alternate technologies and designs, including the no-action alternative, to determine which alternative poses the least risk to human health. It must be noted that QRA relies on value judgments and simplifying assumptions made throughout the process to deal with the high level of uncertainty associated with predicting facility operations, the environment, and people (Rodricks, 1992; Wartenberg and Chess, 1992). However, QRA is the best available means to quantify the health risk from a proposed waste facility (Rodricks, 1992).

In addition to human health effects, environmental impact assessment considers environmental, economic, and community/social effects. For a hazardous waste incinerator, the possible positive and negative effects are (Farago et al., 1989; Zeiss and Atwater, 1991):

- health/environmental - change in human health (acute or chronic), environmental quality, and animal populations;
- economic - change in property values, product values, employment rates, local industry and development; and
- community/social - change in the demand on local infrastructure (sewers, roads, utilities) and water availability; change in community image resulting from traffic, odour, view, and visibility; and change in political identity, control, and confidence.

Engineering Intervention Measures

Engineering intervention measures interrupt the cause-effect interactions along this sequence to alter the resulting facility effects (see Figure 3.1). Four categories of measures have been developed from a review of siting literature (Zeiss and Lefsrud. 1994) to be consistent with other categorizations of measures (Webler et al., 1995; Armour. 1991: Canter et al.. 1991: Morgan, 1990: Gregory and Kunreuther. 1990: Zeiss and Atwater. 1989: Sorensen et al.. 1987: Fischhoff et al.. 1978). The categories of measures are: 1) need definition. 2) impact reduction. 3) compensation, and 4) process management.

Need definition measures manage impacts by identifying the proponents', residents', and society's reasons for the waste facility and designing the facility to fulfill those needs. (Zeiss and Lefsrud. 1994: Zeiss and Atwater. 1991; Fischhoff et al.. 1978). The proponent proposes and designs the facility. Therefore the proponents' need is reflected in the overall facility need - which governs the facility design. Residents' need for the facility includes the fulfillment of basic. health and safety. pleasure. or economic requirements (Gregory and Mendelsohn. 1993). The waste facility may be needed by residents to protect the health or economic stability of themselves and their family. The more general societal need considers ...mmunities' requirements of the facility such as maintaining political stability and community image. Residents' need for a waste facility likely differs from the general societal need and the proponent's need.

Impact reduction measures manage impacts by diminishing the number. the spatial extent. the duration. the magnitude of consequences. and/or the frequency of impacts associated with the facility. Impact reduction measures are prevention. control. or mitigation measures (Zeiss and Lefsrud. 1994: Zeiss. 1991). Prevention measures reduce an impact by anticipating the impact and preventing its occurrence by altering characteristics of the inputs and site (Webler et al., 1995; Canter et al., 1991; Morgan, 1990; Sorensen et al., 1987; Fischhoff et al., 1978). Input alterations include sorting of the wastestream into its various components for more appropriate destruction. Altering the site characteristics include choosing a location to minimize transport route distances and to minimize the number of potential receptors. Control measures reduce an impact by altering the facility design and operations to regulate the emission of a contaminant to the offsite environment and reduce exposure (Webler et al., 1995; Zeiss and Lefsrud, 1994; Canter et al., 1991; Morgan, 1990; Fischhoff et al., 1978). Control measures include pollution abatement systems with baghouse filters, afterburners, and scrubbers, and carbon filters. Noise control measures are enclosing blowers and providing treed buffer zones. Visual control measures are a restriction of view of the site. Water emission control measures are regulating the release of wastewater. Mitigation measures reduce an impact by cleaning up environmental contamination and altering exposure (Webler et al., 1995; Zeiss and Lefsrud, 1994; Canter, 1991; Morgan, 1990; Fischhoff et al., 1978). Mitigation includes evacuating residents to reduce their exposure and cleaning up the site following a release of contamination.

Compensation measures manage impacts by providing monetary payments or alternate good to affected individuals for residual impacts that cannot be further reduced (Zeiss and Lefsrud, 1994; Armour, 1991; Hadden, 1991; Morgan, 1990; Sorensen et al., 1987). An example of compensation includes paying residential property taxes within the impact zone or paying a tipping fee based on the quantity of waste handled. The provision of an alternate, unrelated good includes donations to improve local services, activities, and facilities.

Process management measures are public communication and participation measures that serve to increase: the trustworthiness of the process and the facility, residents' knowledge, and residents' control over the facility siting and design process (Zeiss and Lefsrud, 1994; Armour, 1991). Process management measures also affect the implementation and perception of need definition, impact reduction, and compensation measures. Process management measures include the formation of a citizens' advisory group. The purpose of this research is to determine engineering principles. Therefore, the explicit consideration of process management measures is outside the scope of this research. It is attempted to hold the effect of process management measures constant with the implementation of need, impact reduction, and compensation measures.

There is qualitative support for a causal hierarchy in residents' preference of engineering intervention measures. It is suggested (Zeiss and Paddon, 1992; Camerer and

Kunreuther, 1989) that need definition must be completed first to show that present conditions are unacceptable and that the facility will address present losses. Then, impact reduction measures must reduce the facility impacts to within an acceptable level of safety. Finally, compensation measures can be introduced to increase the benefits.

There is also some quantitative evidence that "upstream" engineering intervention measures (i.e. intervene earlier in the cause-effect sequence) are preferred by residents. Zeiss (1991) found that prevention is preferred, then control, mitigation, and lastly, compensation to address the impacts from a municipal solid waste landfill and incinerator. Webler et al. (1995) also found that prevention measures are of primary importance, then control, and lastly, mitigation to address impacts from the land application of sewage sludge.

In summary, the facility's physical cause-effect sequence was developed from engineering and risk assessment approaches (see Figure 3.1). Categories of engineering intervention measures were developed: need definition, prevention, control, mitigation, and compensation. These measures interrupt the interactions along the causal sequence to alter the resulting effects. This cause-effect sequence was applied to the UMCDF - the study facility - in Chapter 2. From the literature, it appears that "upstream" engineering intervention measures are preferred by residents to manage facility effects. The social science approaches are reviewed next for their relevance to waste facility siting and design processes.

3.2.2 Social Science Approaches to Waste Facility Siting and Design Processes

Several social science theories were reviewed for their relevance to waste facility siting and design processes. The theories presented here are those which appear to contribute to the understanding of how engineers can design more acceptable waste facilities.

Theory of Reasoned Action and Altruism Theory

The Theory of Reasoned Action (Motameni and Falcone, 1990; Fishbein and Ajzen, 1975) describes the response of an individual: beliefs and values which contribute to attitude, intention to act, and behavior. This theory works at a conceptual and operational level, incorporating variables and principles from other theories of attitude formation (Fishbein and Ajzen, 1975).

A belief is defined as the representative information that a person has about an object, linking the object to some attribute (Fishbein and Ajzen, 1975). Beliefs may be 1) descriptive - based on direct perception and experience with the object, 2) inferential - based on past experiences to make judgments, or 3) informational - formed by accepting outside information. A small number of salient beliefs contribute to the formation of an attitude, as an individual is only capable of processing five to nine items of information at a time. The set of salient beliefs may be subject to change - strengthened, weakened, or replaced with other beliefs.

There is evidence that individuals have beliefs which parallel the physical cause-effect sequence as defined by the engineering and risk assessment approaches (Webler et al., 1995; Bostrom et al., 1992; Hohenemser et al., 1985). However, residents may not have salient beliefs about each element and their beliefs may not be a linear cause-effect sequence (Bostrom et al., 1992). Instead, their beliefs about the impacts and benefits may be determined solely by their past experiences or their trust in the Army.

Attitude is a "learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object" (page 6, Fishbein and Ajzen, 1975). An attitude, A_o, is formed about an object as a summation of the salient beliefs, b, of the association of the attribute, i, with the object multiplied by the evaluation, e, of the attribute, i, from 1 to n, where n equals the number of salient beliefs (Fishbein and Ajzen, 1975; Motameni and Falcone, 1990): $A_o = \Sigma_i b_i e_i$.

Behavioral intention is the subjective probability that the person will take some action toward the object. Behavioral intention is determined by three factors. Attitude towards an object is the first determinant of the person's behavioral intention (Goldenhar and Connell, 1993; Motameni and Falcone, 1990; Fishbein and Ajzen, 1975; Weigel and Weigel, 1978). If a person holds a favourable attitude towards the incinerator, he or she is more likely to intend to support the facility. Conversely, if a person holds an unfavourable attitude, he or she is more likely to intend to oppose the facility. The second determinant of behavioral intention is an expectation that the given response will lead to a specific event, which is a summation of the beliefs, b, that the behavior will lead to salient consequences multiplied by the evaluation, e, of the salient consequences: $A_B = \Sigma_i b_i e_i$ (Motameni and Falcone, 1990; Fishbein and Ajzen, 1975). Beliefs include perceived likelihood of success and available resources such as time, money, and expertise (Lober, 1995; Fishbein and Ajzen, 1975). The third determinant of behavioral intention is the normative influences of the social environment (Goldenhar and Connell, 1993; Motameni and Falcone, 1990; Fishbein and Ajzen, 1975). The person holds beliefs about subjective social norms - what significant others consider to be acceptable behavior. The sum of normative beliefs, b, is multiplied by the motivation to comply, m, with the beliefs: $A_n = \Sigma_i b_i m_i$ (Motameni and Falcone; Fishbein and Ajzen, 1975).

In addition to social norms, Altruism Theory (Hopper and Nielsen, 1991; Piliavin and Libby, 1986; Schwartz, 1973) also considers the personal norms held by the individual. Personal norms are internal moral obligations to acceptable behavior. A social norm may determine a personal norm and conversely a personal norm may affect the perception of a social norm (Piliavin and Libby, 1986). Internalization of a social norm to a personal norm increases the motivation to comply with that norm (Weenig et al., 1990; Piliavin and Libby, 1986; Fl ming et al., 1985). Compliance with a personal norm is consistent with the person's v.. ues and causes pride while a violation of a personal norm counters values and causes guilt (DeYoung, 1986; Piliavin and Libby, 1986). The final determinants of resp ndents' intention to act are an awareness of the consequences for themselves and for ot rs and an ascription of responsibility to take personal action (Lober, 1995; Gamba and Oskamp, 1994; Eden, 1993; Baldassare and Katz, 1992; Hopper and Nielsen, 1991; Gunter and Finlay, 1988; Katzev and Pardini, 1987; Piliavin and Libby, 1986; Van Liere and Dunlap, 1978; Webster, 1975; Schwartz, 1973). The intention to act determines the actions taken by the person (Fishbein and Ajzen, 1975; Goldenhar and Connell, 1993; Motameni and Falcone, 1990).

Attitude and actions towards environmental issues have also been shown to correlate with sociodemographic variables. Correlated with environmental attitudes and actions are age (the younger the more concerned) (Howe, 1990; Hamilton, 1985; Van Liere and

Dunlap. 1980). having children under 18 years of age living at home (Howe. 1990; Hamilton. 1985). gender (women more concerned) (Scott and Willits. 1994; Howe. 1990; Pilisuk et al.. 1987; Gould et al.. 1988; Hamilton. 1985; Pilisuk et al.. 1987; Van Liere and Dunlap. 1980). income (Scott and Willits. 1994; Vining and Ebreo. 1990; Gould et al.. 1988; Van Liere and Dunlap. 1980). education (Scott and Willits. 1994; Gould et al.. 1988; Pilisuk et al.. 1987; Van Liere and Dunlap. 1980). distance to waste site (Howe. 1990). and political ideology (democrats and liberals more concerned) (Scott and Willits. 1994; Gould et al.. 1988; Gardner et al.. 1982; Van Liere and Dunlap. 1980). However. any correlations between sociodemographic variables and environmental attitudes and actions have been weak and many researchers have found no relationship (Krause. 1993; Van Liere and Dunlap. 1980).

The Theory of Reasoned Action and Altruism Theory contribute to the conceptual framework by considering respondents' beliefs about the facility and its effects. their attitude. motivations for actions. and resulting actions intended and taken. The beliefs about the facility effects are evaluated and summed to determine their attitude towards the facility. Motivational variables translate attitude to actions intended and taken. Motivational variables include social and personal norms. awareness of consequences. ascription of responsibility. belief in success. and available resources and expertise.

Risk Perception Variables

Risk perception variables further describe respondents' beliefs about the facility's effects. QRA defines risk as being the product of probability and consequences of a facility's impacts. Conversely. risk perceptions are subjective cognitions based upon the psychological. ethical. and societal dimensions of the risk (Slovic. 1992; 1987). The risk perception variables are highly intercorrelated across a number of individuals (laypersons and experts) for a large number of hazards (from bicycles. hazardous waste. saccharin. to handguns) (Slovic. 1992). So. factor analysis is used to condense the risk perception variables down to two dimensions: dread risk and unknown risk. Dread risk includes uncontrollability. dread. globally catastrophic. fatal consequences, inequitable. high risk to future generations. not easily reduced. risk increasing. and involuntary. Unknown risk includes not observable, unknown to those exposed, unknown to science, delayed effects, and newness.

Perceived risk is combined with the perceived benefits to give a net risk valuation of the facility (Gregory and Mendelsohn, 1993; Gould et al., 1988). Alhakami and Slovic (1994) have also found that perceived risks and benefits are not judged independently but appear to have an inverse relationship. Technologies judged as being risky are not judged as beneficial, and beneficial technologies are not judged as risky. The net risk perception (risks minus benefits) correlates with respondents' attitude. The greater the net perceived risk, the more unacceptable the technology or the regulation of the technology, and the greater the opposition (Lober, 1995; Hallman and Wandersman, 1995; Vaughan, 1993; Fort et al., 1993; Flynn et al., 1992; Kunreuther et al., 1990; Gould et al., 1988; Gardner et al., 1982; Fischhoff et al., 1978). Therefore, to decrease the opposition towards a proposed facility, the net risk perception must be reduced.

Risk perception variables subjectively describe characteristics of the facility and its effects which may contribute to attitude. Risk perception variables are not predictive of attitude. The variables do not necessarily describe the facility's effect per se, but the individual's perception of the effects (Slovic, 1992; Krimsky and Golding, 1992). The subjective evaluation of risk varies with the facility characteristics and the individual's beliefs and values. There is also no established level of significance against which to compare risk perception variables. The greater the net perceived risk, the greater the opposition (Lober, 1995; Hallman and Wandersman, 1995; Vaughan, 1993; Fort et al., 1993; Flynn et al., 1992; Kunreuther et al., 1990; Gould et al., 1988; Gardner et al., 1982; Fischhoff et al., 1978). But at what level does the perceived risk become unacceptable? How is "acceptable" risk defined?

In summary, the risk perception variables further describe the characteristics of the facility and effects associated with residents' attitude toward the facility. Residents could believe that the incinerator increases the risk to human health. It is hypothesized that the associated risk perception variables may include the beliefs that the health risk is catastrophic, acute, involuntary, uncontrollable, and dreaded. Therefore, the risk perception variables add qualitative depth to the beliefs about the facility's impacts and benefits. The risk perception variables also correlate with attitude and actions. As residents' perception of the net risk increases, the more unfavourable their attitude, and the greater their opposition. However, the risk perception variables cannot predict the attitude and actions of residents towards a certain type of facility.

Prospect Theory

Prospect Theory looks further at the individual's evaluation of facility effects and the formation of attitude towards the facility. There are three phases in this evaluation: 1) valuation, 2) editing of options, and 3) final evaluation of options with the decision weighting function (Thaler, 1985; Kahneman and Tversky, 1984; 1979). First, Prospect Theory states that resultant effects (the change caused by the facility plus the baseline condition) are valued by individuals as gains and losses on an asymmetrical value function relative to a neutral reference point rather than in terms of absolute value (Kahneman and Tversky, 1979). This hypothetical value function is given in Figure 2.4. The shape of the value function is concave above the reference point and convex below the reference point to represent that marginal losses have greater value than marginal gains and that the marginal value of both gains and losses decrease with their magnitude (Kahneman and Tversky, [illegible]. The shape of the value curve also indicates that individuals are risk seeking for [illegible]s and risk averse for gains. The value function is much steeper for losses [illegible] gains. Research suggests that a loss is evaluated at two to over five times the absolute value of an equivalent gain (Knetsch, 1995). The shape of the hypothesized value function has been shown to hold for numerous individual and group decision making processes in basic and applied contexts (Knetsch, 1995; Schneider, 1992).

The reference point is defined as "...a neutral reference outcome, which is assigned a value of zero..." from which "outcomes are expressed as positive or negative deviations (gains or losses)" (p. 454, Tversky and Kahneman, 1981). The reference point is further described as "a state to which one has adapted; it is sometimes set by social norms and expectations; it sometimes corresponds to a level of aspiration, which may or may not be realistic" (p. 456). The individual's reference point may also be a minimum level required for survival (March and Shapira, 1992). The reference point may not be static but shifting from one point to another (March and Shapira, 1992). To further complicate matters, respondents may not be aware of the reference point that they are using in their evaluations nor be able to consciously choose between alternate reference points (Fischhoff, 1983; Tversky and Kahneman, 1981). Defining respondents' reference point is stated as a difficulty of applying Prospect Theory (Gregory et al., 1993).

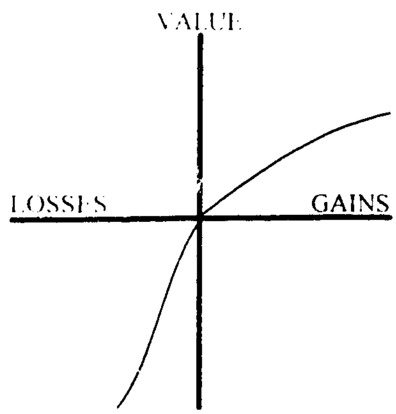

Figure 3.2 Prospect Theory Value Function (Kahneman and Tversky, 1979)

Prospect Theory states that individuals are biased towards the maintenance of status quo (Kahneman et al. 1991; Hartman et al., 1991; Samuelson and Zeckhauser, 1988). Individuals prefer to remain at their current status quo condition than to accept a change. Samuelson and Zeckhauser (p.33, 1988) explain that this status quo bias may be due to: 1) avoiding transaction costs and/or uncertainty; 2) cognitive misperceptions; and 3) psychological commitment due to the misperception of sunk costs, avoidance of regret, and need for consistency. A necessary but not sufficient condition for residents to accept a proposed facility, is the evaluation of the status quo as being in the loss domain with respect to their reference point (Kunreuther and Portney, 1991). The facility is then seen as a means which reduce the current losses (Zeiss and Paddon, 1992; Carlson, 1991; Zeiss, 1990; Gregory and Kunreuther, 1990; Camerer and Kunreuther, 1989; Ajzen and Fishbein, 1980).

Next, Prospect Theory states that individuals go through an editing phase to "...organize and reformulate the options so as to simplify subsequent evaluation and choice" (p. 274, Kahneman and Tversky, 1979). Kahneman and Tverksy (1979) state six main editing operations. The first operation is coding whereby the individual sets their reference point on their value curve against which to evaluate gains and losses (Kahneman and Tversky, 1979). The second operation is simplification where the individual rounds off the probabilities and ignores highly unlikely probabilities altogether (Kahneman and Tversky, 1979). The third operation is grouping equivalent outcomes together (Kahneman and Tversky, 1979). The next operation, segregation, considers the treatment of prospects with all positive (or negative) outcomes (Kahneman and Tversky, 1979). The fifth operation is cancellation, whereby outcomes common to all outcomes are canceled (Kahneman and Tversky, 1979). The sixth operation is dominance detection whereby dominated outcomes are eliminated (Kahneman and Tversky, 1979).

The final stage of Prospect Theory is the evaluation of the overall value of the option for all of its outcomes (Kahneman and Tversky, 1979; 1984). The value of each probable outcome $v(x_i)$ is then multiplied by a decision weight, $\Pi(p_i)$. The decision weight measures the desirability of prospects and the perceived likelihood of these events. Decision weights, $\Pi(p)$, are lower that the actual probabilities, p, over most of the range ($0<p<1$), except for low probability events which are higher. Very low probabilities are greatly overestimated or they are ignored. This overweighing of low probabilities, makes low probability losses and gains appear to be more likely or desirable than they actually are. The overall value of an option, V, is the sum of the weighting function multiplied by the value for each its possible outcomes: $V = \Sigma_i \Pi(p_i) \bullet v(x_i)$.

Prospect Theory also hypothesizes that multiattribute decisions are separated into different mental accounts with different attributes being valued on separate curves (Thaler, 1985; Kahneman and Tversky, 1984; Thaler, 1980). The advantages and disadvantages of each attribute are evaluated relative to the attribute's reference state. An example of mental accounting is a family's monthly budget. Monthly pay is allocated to separate accounts: food, rent, entertainment, savings, etc. which are used to evaluate purchases. Zeiss (1991) applied mental accounting to waste facility impacts whereby residents may have separate value curves to evaluate the different effects. Mental accounting may explain why monetary compensation is more acceptable when it is linked to economic impacts than to health impacts (Knetsch, 1995; Hadden, 1991; Kunreuther et al., 1991; Gregory and Kunreuther, 1990; Gould et al., 1988; O'Hare et al., 1983; Carnes et al., 1983). Money and health are valued on separate curves and are not tradable (Zeiss and Paddon, 1992) If perceived health risks are not reduced to within an acceptable limit, then compensation may be viewed as a bribe for reduced health which is an unacceptable trade (Mank, 1991; Kunreuther et al., 1990; Davis, 1984; Bacow and Milkey, 1982)

Prospect Theory explains uncertain choices well for the majority of individuals. Most individuals are risk averse for gains and risk seeking for losses, for example. However, Prospect Theory does not explain single individual choices very well (Schneider 1992; Abelson and Levi, 1985). Individuals may tend to be risk averse - choosing the less risky option for both losses and gains. Individuals may also try to be consistent in their choices always choosing the risky choice. The salience of the outcomes may also affect the choice. The use of a negative frame (e.g. giving alternate outcomes in terms of number of deaths) emphasizes negative outcomes and makes the individual more risk averse. Conversely, using a positive frame (e.g. giving alternate outcomes in terms of lives saved) may make the outcomes seem more desirable and make the individual more risk seeking. Therefore, Prospect Theory applies to the majority of individuals in a group, but does not predict individual choices very well.

This research applies Prospect Theory to explain respondents' attitude as dependent upon the sum of the individuals' valuations of the facility effects. Prospect Theory appears to be consistent with the Theory of Reasoned Action. It is hypothesized that each resulting facility effect is judged on a separate value curve as a gain or loss relative to the reference point for that effect. Then, the values of the effects are summed to determine the respondent's overall attitude toward the facility. Prospect Theory also appears to be consistent with risk perception variables. Risk perception variables describe qualitative characteristics of the facility effects. Residents may have salient value curves for variables like controllability, fairness, and trust which also contribute to their attitude.

Prospect Theory is somewhat inconsistent with engineering/risk assessment approaches. Engineering/risk assessment literature indicates that "upstream" engineering intervention measures (i.e. intervene earlier in the cause-effect sequence) are preferred by residents (Zeiss, 1991; Webler et al., 1995). However, the Prospect Theory principles indicate that residents' preference of engineering intervention measures depends upon whether the residents are in the loss domain or neutral or gain domain with respect to their reference point. First, residents set their reference point, then they judge facility effects (changes to the baseline condition caused by the facility) relative to their reference point (Thaler, 1985; Kahneman and Tversky, 1984; 1979). Need definition identifies the proponents', residents', and society's reasons for the waste facility. The definition of residents' needs sets their reference point for basic, health and safety, pleasure, or economic requirements to be attained by the facility. Therefore, it is hypothesized that need definition measures are preferred to set respondents' reference point. Loss reduction has more value than an equivalent increase in benefits. Therefore, if respondents are in the loss domain with respect to their reference point, then they will prefer impact reduction measures to minimize losses. Then, they will choose compensation measures to further increase the benefits. If res[illegible] near or above their reference point, they will not see any negative effect [illegible] be reduced. Those, respondents will prefer compensation to further increase the benefits from the facility.

General Beliefs and Values about Risk Management

Previous research indicates that respondents' general beliefs and values about risk management are associated with specific attitudes and actions towards a risky technology. Gould et al. (1988) sampled 1320 people from the general population and from lists of intervenors who had given testimony for state hearings on then-current technical issues. The intervenors were categorized as giving testimony favourable to industry (pro-benefit) or against industry (pro-safety). They found that the acceptability of a risky technology was correlated with the acceptability of present regulations and moderately correlated with general attitudes towards the environment and technology (Gould et al., 1988). Buss, Craik, and Dake (1991) developed and used scales to measure general beliefs and values about the environment, technology, and risk management. They found that attitudes towards technologies, perceived risk and perceived benefit were significantly correlated with groups of beliefs and values. Dake (1992, 1991) and Dake and Wildavsky (1990) also developed scales of beliefs and values about technology, the environment, and risk management. They too found that groups of general beliefs and values are correlated with societal risk taking and concern about technological and environmental dangers. Therefore, it appears that residents may have general beliefs and values about technology, the environment, and risk management which may be related to their attitudes and actions toward the study facility.

Development of a Conceptual Framework to Structure Residents' Response towards the Facility

A conceptual framework structures the elements of the different theoretical perspectives to describe the response of residents (see Figure 3.3). This conceptual framework considers residents' beliefs and values contributing to their attitude and actions towards the proposed facility. The conceptual framework is oriented toward action - the actions of residents to support or oppose the facility which may affect the regulators' approval of the facility. The consideration of residents' beliefs, values, and attitudes about the facility explains their actions. Knowing why residents oppose a planned facility allows engineers to develop engineering intervention measures to more effectively address residents' concerns.

The arrows in this conceptual framework (refer to Figure 3.3) represent causation between elements, however, only correlation can be determined. Support for causation requires, as a minimum, that the cause temporally precedes the effect, that the cause and effect are correlated, and that the correlation between cause and effect is not spurious (Babbie, 1992). This research cannot determine if the cause temporally precedes the effect and if the correlation between the cause and effect is not spurious. This research relies on surveys which provide a "snapshot" in time. Therefore, it is impossible to determine whether or not the cause precedes the effect. A resident may hold a negative attitude towards the facility which biases their beliefs about the facility effects and the

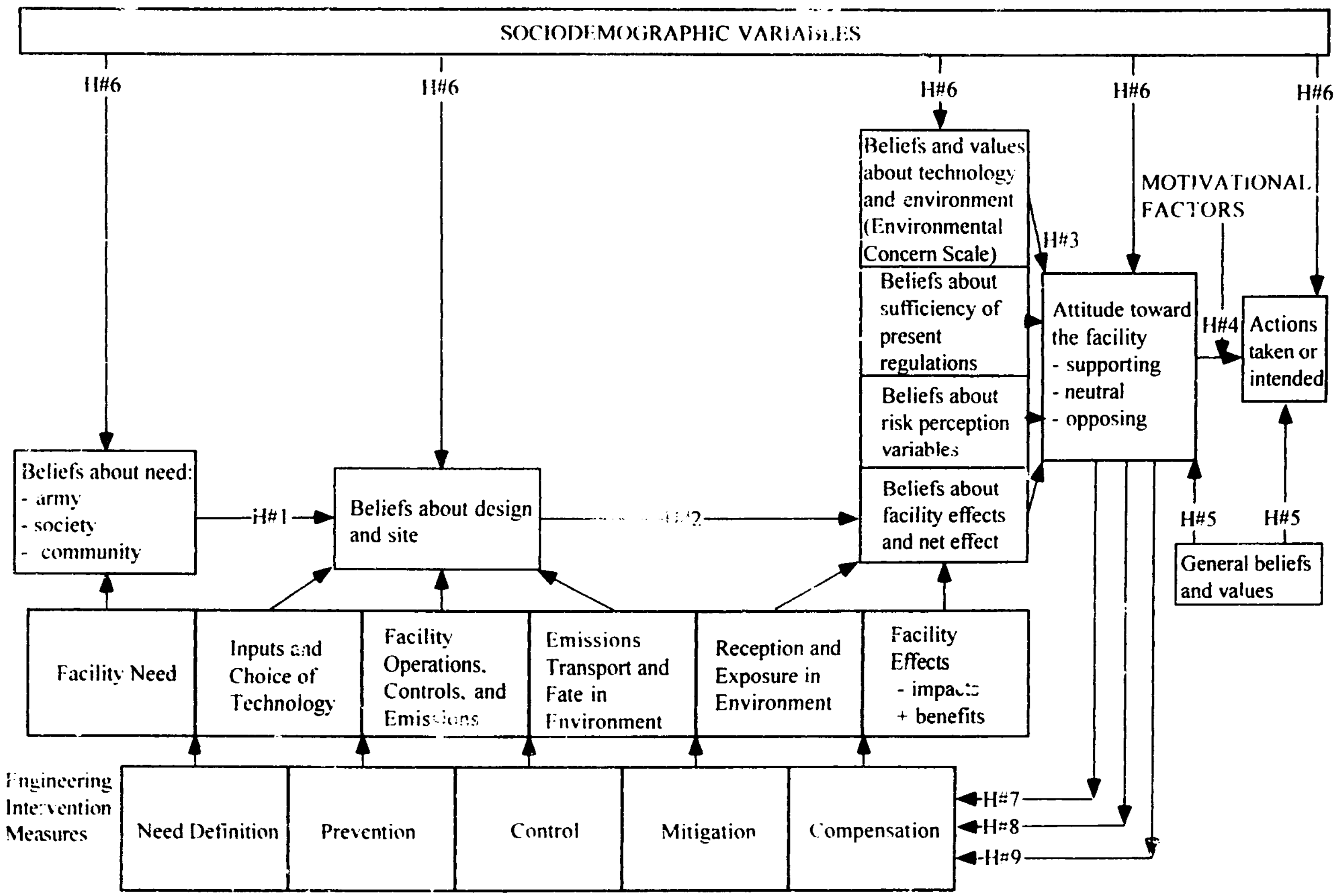

Figure 3.3 Conceptual Framework Developed from Engineering/Risk Assessment and Social Science Theoretical Approaches and the Associated Research Hypotheses

emissions. Further, the non-normal distributions limit the statistical analysis to nonparametric tests results that do not allow the determination of spurious correlations. Although, the framework arrows represent causation, there is only support for correlation.

3.3 Hypothesis Development

The conceptual framework is constructed from the different theoretical approaches to describe the response of residents during a waste facility siting and design. Next, research hypotheses are developed for relationships between variables in this framework to test the applicability of these theories (see Figure 3.3).

These first four hypotheses address respondents' beliefs about the facility and its effects, respondents' attitude, and respondents' actions. Hypothesis #1 considers the beginning of this sequence: the contribution of sociodemographic variables and beliefs about facility need to facility planning/design. Hypothesis #2 considers the contribution of sociodemographic variables, beliefs about the sufficiency of the facility design and site, and beliefs about the impacts and benefits on the net facility effect. Hypothesis #3 considers the contribution of beliefs about the facility and its effects (beliefs about risk perceptions and effects), beliefs about current regulations, general environmental concern, and sociodemographic variables on the respondent's attitude towards the facility. Hypothesis #4 addresses the effect of attitude, motivational variables, and sociodemographic variables on the actions that the respondent intends to take or has taken towards the facility.

HYPOTHESIS #1: Respondents are more likely to believe that the planning and design of the facility is the best possible if they:

a) believe that the facility is needed by the community

b) believe that the facility is needed by the Army

NULL: There is no significant correlation between perceived need with the perceived sufficiency of design.

HYPOTHESIS #2: The net effect of the facility is more likely to be determined as positive by respondents if they:

a) believe that the site is the best place to put the facility

b) believe that the facility has been designed the best way possible

NULL: There is no significant correlation between perceived net facility effect with the perceived sufficiency of site or design.

HYPOTHESIS #3: Respondents are more likely to have a favourable attitude towards the facility if they:

a) believe that the net effect of the facility is positive
b) believe that risk perception variables are positive
c) believe that present regulations are sufficient
d) are low on the environmental concern scale

NULL: Attitude is not significantly correlated with perceived net effect of facility, risk perception, nor beliefs about present regulations.

HYPOTHESIS #4: Respondents are more likely to take actions towards the facility if they:

a) hold strongly positive or negative attitudes towards the facility
b) consider the facility effects to be important to their community
c) consider the facility effects to be important to them
d) feel personal responsibility
e) have personal resources available
f) have personal knowledge expertise
g) believe that the facility is isn't needed
h) expect that their actions will have some effect

NULL: There is no significant correlation of motivations for action with the level of action taken.

Hypothesis #5 considers respondents' attitudes and actions as a function of respondents' general beliefs and values about decision making, method of apportioning of risk, and who they trust to manage risks.

HYPOTHESIS #5: Respondents' attitude and actions toward the facility are correlated with general beliefs and values about decision making, methods of apportioning risk, and who they trust to manage risk.

NULL: There is no correlation between attitude and general beliefs and values.

Hypothesis #6 considers the effect of sociodemographic variables on respondents' beliefs, values, attitudes, and actions toward the facility.

HYPOTHESIS #6: Respondents are more likely to believe that the facility is needed, the site and design are sufficient, the net effect is positive, the risk perception variables are positive, the present regulations are sufficient, be low on the environmental concern scale, have a positive attitude towards the facility, and take less action against the facility if the respondents:

a) are older
b) have fewer children under 18 living at home
c) are male
d) have a lower income

e) have less education
f) hold a less liberal political ideology
g) live farther from the waste facility
h) have worked for the U.S. Armed Forces or live with someone who has.

NULL. There is no correlation between beliefs, attitude, and action and sociodemographic variables.

Hypothesis #7 is drawn from Prospect Theory - individuals have different mental accounts and value curves for the separate facility effects. Therefore, to reduce a negative effect (i.e. evaluated as being in the loss domain with respect to the reference point), the engineering measure must be seen as addressing the loss on the same value curve (Knetsch, 1990). Therefore, the measure which most effectively reduces a negative effect will be preferred.

HYPOTHESIS #7: Implementing engineered intervention measures which address the respondents' most negatively rated concerns improve respondents' attitude toward the facility the most.

NULL: There is no correlation between the rating of effects and the change in attitude with the implementation of the preferred intervention measures to address those effects.

Hypothesis #8 also relies on Prospect Theory (Knetsch, 1990; Zeiss and Paddon, 1992; Zeiss, 1991; Zeiss and Atwater, 1987). First, the definition of residents' needs sets their reference point for the requirements to be attained by the facility. Loss reduction has more value than an equivalent increase in benefits. Therefore, if respondents are in the loss domain, they will prefer impact reduction measures to minimize losses. Then, they will choose compensation measures last to further increase the benefits. If respondents are near or above their reference point, they will not see any negative effects to be reduced. Respondents will prefer compensation to further increase the benefits from the facility.

HYPOTHESIS #8: There are significant differences in the ranking of measures depending if the respondent is in the a) loss domain, or b) neutral or in the gain domain with respect to their reference point for each facility effect.

#8a: If the respondent is in the loss domain with respect to their reference point they will prefer: need definition first to define their reference point, then impact reduction measures to reduce their present loss, and lastly compensation measures to increase the effect beyond their reference point.

#8b: If the respondent is at or near their reference point or in the gain domain with respect to their reference point, they will prefer: need definition first to define their reference point, then compensation measures to further increase the benefits from the facility.
NULL: There are no differences in the ranking of measures depending if the respondent is in the loss or gain domain with respect to their reference point.

Hypothesis #9 tests whether respondents have a parallel, linear set of beliefs about the physical cause-effect sequence. From this sequence, it is hypothesized that respondents have a causal hierarchy, preferring upstream measures; regardless if respondents consider the facility effects to be in the loss or gain domain. Ranking the measures in this causal hierarchy - need definition, prevention, control, mitigation, and then compensation - would give support to the assumption of a linear set of beliefs about the facility.

HYPOTHESIS #9: Respondents are more likely to prefer engineered intervention measures which intervene at upstream points along the physical cause-effect sequence: preferring need definition, then prevention, control, mitigation, and lastly, compensation.
NULL: There is no consistent ranking of intervention measures depending upon the intervention point of the measures along the cause-effect sequence.

3.4 Summary

The relevant theories are reviewed to develop a general conceptual framework to describe the response and preferences of residents during a facility siting and design process (see Figure 3.3). The engineering/risk assessment approaches are reviewed to determine the physical cause-effect sequence and the intervention points of the engineering measures. The Theory of Reasoned Action and Altruism Theory look at the contribution of beliefs about the facility to attitude which is affected by motivational variables and leads to actions toward the facility. Risk perception literature further quantifies residents' beliefs about the facility effects which contribute to their attitude towards the facility. Prospect Theory also explains residents' evaluation of the effects which contribute to their attitude. Finally, the influence of residents' background beliefs and values to their specific attitude and actions are considered.

Research hypotheses are drawn from the conceptual framework (see Figure 3.3). The first four hypotheses consider the relationships of the respondent's beliefs about: facility need, sufficiency of facility planning and design, sufficiency of the site, net facility effect: risk perceptions, facility effects, sufficiency of present regulations with attitude towards the facility, motivational variables, sociodemographic variables, and actions towards the facility. Hypothesis #5 consider the relationship of respondents' general background beliefs and values with attitude and actions toward the facility. Hypothesis #6 addresses the relationships between sociodemographic variables and beliefs, attitudes, and actions towards the facility. Hypothesis #7 to #9 consider respondents' preferences for engineering intervention measures. Respectively, the hypotheses look at the ranking of measures as being a function of: addressing negative effects; the effect being in the loss or neutral/gain domain; and the intervention points along the cause-effect sequence.

Testing these hypotheses serves two purposes. The first purpose is to test the various theoretical approaches from which the hypotheses are derived. The validity, reliability, and generalizability of the theory testing allows the results to be applied to other facilities and communities. The second purpose is to explain the response of residents during the siting and design of the UMCDF. The developed hypotheses form the basis for this research to test the theories and to explain the response of residents.

In Chapter 4, the method of testing the hypotheses and the generalizability of the findings is discussed. Chapter 5 presents and discusses the results of the hypotheses testing and the significance of the findings.

4. Methodology to Test the Research Hypotheses

4.1 Introduction

The purpose of this research is to understand how a waste facility can be designed to address residents' concerns and make the facility more acceptable to them. There are two complementary objectives to meet this purpose: 1) to test waste facility siting and design theories to advance the general understanding and 2) to apply the theories to understand the specific responses of residents around the proposed Umatilla Chemical Demilitarization Incineration Facility (UMCDF) (as described in Chapter 2). This chapter discusses the method of testing the hypotheses which were developed in Chapter 3. Throughout this method, potential threats to validity and reliability are considered and minimized. The general research design and the development, sampling, and administration of the surveys is reviewed. The response rates and generalizability of the results are discussed. Lastly, the editing, coding, and analysis methods of the results are given. The results from testing the hypotheses are presented and discussed in Chapter 5.

4.2 Developing the Research Design

Once, the study facility was chosen, the stakeholders involved in the facility siting process were surveyed to test the hypotheses. Surveys are good for collecting descriptive and explanatory data to describe a population which is too large to observe directly, using individual people as the unit of analysis (Babbie, 1992). However, surveys cannot capture the effect of social interaction on individuals' response to the waste facility (Webler et al., 1995). Residents may not have formed their views without discussing the issues with other people. Also, respondents' views are given equal weight in a survey. A resident with a well thought-out rationale is given the same consideration as a resident with an ad-hoc rationale. Regardless, surveying was the most appropriate method for collecting the data to test the research hypotheses.

Stakeholders were surveyed in two phases - Questionnaire A and Questionnaire B - for several reasons. The first reason was that there appears to be two groupings of hypotheses. The first questionnaire - Questionnaire A - is a self administered survey. Questionnaire A collected the data to test the Hypothesis #1 to #6 regarding stakeholders' responses during the current facility design process: their beliefs, values, attitudes, and actions. This describes stakeholders' baseline response. The second questionnaire - Questionnaire B - is an interview. Questionnaire B presented sets of engineering intervention measures to stakeholders. The engineering measures were developed to address residents' concerns and make the facility more acceptable to them. Questionnaire B then collected the data to test Hypothesis #7 to #9 regarding stakeholders' preferences for redesigning the facility to address their concerns.

The second reason for surveying stakeholders in two phases was that information from the first questionnaire (i.e. attitude and facility effects to be addressed by engineering intervention measures) contributed to the second questionnaire. The data obtained from the first questionnaire was analyzed to determine which effects of concern should be designed for and how. It was also determined who should be sampled to represent the relevant variables (attitude, sociodemographics). Results from the first questionnaire were used in the development and sampling for the second questionnaire.

The third reason for completing the surveying in two phases is that it appears that Hypothesis #1 to #6 and Hypothesis #7 to #9 should be measured and tested differently. There should be two different survey instruments and methodologies for the two questionnaires. To test Hypothesis #1 to #6, detailed, standardized information about stakeholders' beliefs, values, attitudes, and actions was required. Since these variables were relatively straightforward, they can be measured by a self-administered questionnaire. Testing Hypothesis #1 to #6 relied on correlation where the statistics become more sensitive as the sample size increases. Therefore, the first questionnaire was a self-administered questionnaire with a large sample size. Hypothesis #7 to #9 had more complex questions - the ranking of measures by respondents to address their concerns and the rating of measures to change their attitude. The survey format was better handled by an interview questionnaire. Testing Hypothesis #7 to #9 relied mostly on tests for differences in ranking and on correlations which do not require such a large sample size. Therefore, the second survey was an interview with a smaller sample size.

For the questionnaires, the unit of analysis is the individual as a member of the larger stakeholder group. The stakeholder groups are the proponent (private or public) who proposes and presents the facility, the residents of the host community who may be directly or indirectly affected by the facility, the regulator who reviews the facility and grants the building and/or operating permit, and other involved groups. All stakeholder groups (residents, regulators, proponents, and others) were sampled. Understanding the residents' perspective in the siting process is necessary as residents' responses may be the most unknown and critical link in the siting, yet this may not be sufficient to explain the outcome of a facility siting. The groups may interact during a siting attempt and their relative influence on the siting outcome is unknown. Therefore, an understanding must also be gained of the other perspectives.

Stakeholders were surveyed in two phases using Questionnaire A and Questionnaire B. This was to follow the two groups of hypotheses, to allow more appropriate measurement and analysis methods to test the hypotheses, and to use information from Questionnaire A for the development and sampling of Questionnaire B. The development and administration of the questionnaires and the editing, coding, and analysis of the data are discussed in the next sections.

4.3 Devel[illegible]tionnaire A to Test Hypothesis #1 to #6

The [illegible]nnaire A was to determine stakeholders' response during the faci[illegible]cess, addressed by Hypothesis #1 to #6 (as developed in C[illegible]s Hypothesis #1 to #6 and the method of measuring the hy[illegible]questionnaire. The development of valid and reliable me[illegible]variables is discussed next.

Table 4.1 Statement of Hypotheses and Null Hypotheses and Method of Measuring the Hypotheses Variables for Questionnaire A

Hypotheses and Null Hypotheses	Method of Measuring Hypotheses Variables
HYPOTHESIS #1: Respondents are more likely to believe that the planning and design of the facility is the best possible if they: a) believe that the facility is needed by the community and b) believe that the facility is needed by the Army. **NULL:** There is no significant correlation between perceived need with the perceived sufficiency of design.	**Sufficiency of Design** • "Facility has been designed and planned the best way possible"; forced-choice with 5 point Likert response (disagree neither agree); open-ended "why?" **Army Need** • "Facility is needed by Army?"; forced-choice with 5 point Likert response (disagree neither agree); open-ended "why?" **Community Need** • "Facility is needed by community?"; forced-choice with 5 point Likert response (disagree neither agree); open-ended "why?"
HYPOTHESIS #2: The net effect of the facility is more likely to be determined as positive by respondents if they: a) believe that the site is the best place to put the facility and b) believe that the facility has been designed the best way possible **NULL:** There is no significant correlation between perceived net facility effect the perceived sufficiency of site or design.	**Net Effect** • "Overall are negative effects greater than positive effects, negatives equal to positives, positives greater than negatives?"; forced-choice **Sufficiency of Site** • "UMDA is best location?"; forced-choice with 5 point Likert response (disagree/neither/agree); open-ended "why?" **Sufficiency of Design** • as above
HYPOTHESIS #3: Respondents are more likely to have a favourable attitude towards the facility if they: a) believe that the net effect of the facility is positive, b) believe that risk perception variables are positive, c) believe that present regulations are sufficient, and d) are low on the environmental concern scale. **NULL:** Attitude is not significantly correlated with perceived net effect of facility, risk perception, nor beliefs about present regulations.	**Attitude** • "How much do you support or oppose facility?"; forced-choice 5 point Likert response (oppose neither support) **Net Effect** • as above **Risk Perception** • 13 risk perceptions as statements "The facility will protect future generations"; forced-choice 5 point Likert response (disagree/neither agree) **Beliefs about present regulations** • preferred strictness of regulations minus present strictness of regulations; forced-choice 5 point Likert response (not very strict/extremely strict) **Environmental Concern Scale** • developed scale; forced-choice 5 point Likert response (disagree/neither/agree)

Table 4.1 Statement of Hypotheses and Null Hypotheses and Method of Measuring the Hypotheses Variables for Questionnaire A (continued)

Hypotheses and Null Hypotheses	Method of Measuring Hypotheses Variables
HYPOTHESIS #4: Respondents are more likely to take actions towards the facility if they: a) hold strongly positive or negative attitudes towards the facility, b) consider the facility effects to be important to their community, c) consider the facility effects to be important to them, d) feel personal responsibility, e) have personal resources available, f) have personal knowledge expertise, g) believe that the facility is isn't needed, h) expect that their actions will have some effect. **NULL:** There is no significant correlation of motivations for action with the level of action taken.	**Action** • list of 9 actions taken already (yes no) or might take in the future (yes/no/DK) **Motivations for Action** • rated influence of motivators on actions taken or actions intending to take; forced-choice 3 point Likert response (no effect/slight effect/strong effect)
HYPOTHESIS #5: Respondents attitude and actions toward the facility is correlated with general beliefs and values about decision making, methods of apportioning risk, who they trust to manage risk. **NULL:** There is no correlation between attitude and actions with general beliefs and values.	**Attitude** • as above **Action** • as above **General Beliefs and Values** • 30 items (6 items/Bias); forced-choice with 5 point Likert response (agree/neither/disagree)
HYPOTHESIS #6: Respondents are more likely to believe that the facility is needed, the site and design are sufficient, the net effect is positive, the risk perception variables are positive, the present regulations are sufficient, be low on the environmental concern scale, have a positive attitude towards the facility, and take more action against the facility if the respondents: a) are older, b) have fewer children under 18 living at home, c) are male, d) have a lower income, e) have less education, f) hold a more liberal political ideology, g) live farther from the waste facility, and h) have worked for the U.S. Armed Forces or live with someone who has. **NULL:** There is no correlation between beliefs, attitude, and action with sociodemographic variables.	**Army Need** • as above **Community Need** • as above **Sufficiency of Design** • as above **Sufficiency of Site** • as above **Net Effect** • as above **Risk Perception** • as above **Beliefs about present regulations** • as above **Environmental Concern Scale** • as above **Attitude** • as above **Action** • as above **Sociodemographic variables** • gender, age, location/length of residence, home ownership, children at home, political ideology, income, education, employment by Army

To test Hypothesis #1 and #2, respondents were asked their beliefs about whether: the facility design was completed the best way possible to minimize impacts and maximize benefits, the site was sufficient to minimize impacts and maximize benefits, the facility was needed by the Army, and facility was needed by the community. Each belief was posed as a statement: "How much do you agree or di ree that the Chemical Demilitarization Incinerator has been planned and designed in the best way to minimize the negative effects and maximize the positive effects?". The questions had a forced-choice 5 point Likert response (agree/neither/disagree). Respondents were also open-endedly asked for their rationale: "If possible, please state the reasons why".

To test Hypothesis #3, the variables to be measured were the net facility effect, risk perception variables, beliefs about regulations, and the environmental concern scale. The net facility effect was a forced-choice question "Are the negative effects greater than the positive effects, the negative effects equal to the positive effects, or the positive effects greater than the negative effects?". The risk perception variables were taken from Slovic (1987). For the risk perception variables to be compared and correlated, they must be measured on the same scales. Therefore, the risk perception variables were revised as a statement: "How much do you agree or disagree? - If there was an accident or problem, people would have a greater risk of long-term health effects (e.g. cancer)" with a forced-choice 5 point Likert response (strongly disagree/neither/strongly agree).

Beliefs about the sufficiency of present regulations were measured following Gould et al. (1988). Respondents were asked: a) how strict are the restrictions and standards now for the incineration of chemical munitions and b) how strict should the restrictions and standards be. The questions had a forced-choice 5 point Likert response (1 = not very strict, 5 = extremely strict). The beliefs about the sufficiency of present regulations equaled the preferred strictness minus the present strictness.

There are several measures of environmental concern and environmental consciousness in the literature. Weigel and Weigel's (1978) environmental concern scale was used as it included attitudes towards a range of environmental issues and the actions that should be taken. The environmental concern scale items are pro-environment: "The federal government will have to introduce harsh measures to halt pollution since few people will regulate themselves" and pro-development: "We should not worry about killing too many game animals because in the long run things will balance out". The environmental concern scale is reliable (α = 0.88) (Weigel and Weigel, 1978).

Cronbach's α is a test of inter-item correlation - a measure that the scale items are measuring the same concept. The environmental concern scale has also been proven to be a reliable measure with test-retest methods (Weigel and Weigel, 1978). Respondents were given a poll which included the environmental concern scale. Six weeks later the respondents were paid $1 to complete the questionnaire again. The responses from the first questionnaire were significantly ($p<0.001$) correlated with the responses from the second questionnaire ($r = 0.83$).

To test Hypothesis #4, the variables which may motivate action were developed from the theory (see Chapter 3). These motivators are listed and their influence on the actions taken or intended was rated with a forced-choice 3 point Likert response (0 = not important/no effect, 1 = slightly important, 2 = very important/strong effect).

To test Hypothesis #5, questions were developed to test beliefs and values regarding nature, technology, method of achieving consent, liability for apportioning risk, and who is trusted to manage risk (Dake, 1992; Rayner and Cantor, 1987; Fiske, 1992; Wildavsky and Dake, 1990; Rayner, 1984; Thompson and Wildavsky, 1982; Krimsky, 1992). Questions to test general beliefs and values have been developed and used by Dake (1990, 1991). These questions revised and reworded to avoid double-barreled questions (asking two things in one question) and make the questions more understandable. The questions addressed pro-benefit and pro-Army issues: "Economic growth is the best way to improve the quality of life" and "I think that every able-bodied citizen should have to serve two years in the Armed Forces". The questions also addressed pro-conservation issues: " It is possible to have zero pollution". Each scale item was a statement with forced-choice 5 point Likert response (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree).

A list of 17 effects that the facility may have on the environment and community were developed from the step-matrix reverse-network (Zeiss, 1993) and from a review of the possible effects from the incinerator. They were arranged in a logical order starting from contamination of environmental media (air, vegetation/soil, water), to health effects, degradation of resources, to economic and community effects. Each possible effect was rated with a forced-choice 5 point Likert response (-2 = very negative effect, -1 =

somewhat negative effect, 0 = neither positive nor negative effect, 1 = somewhat positive effect, and 2 = very positive effect). To make the response categories more intuitively understandable for the respondents, negative effects were assigned a negative number, positive effects were assigned a positive number, and no effects were equal to zero.

The questions were ordered to make the questionnaire easy and enjoyable for the respondents and to minimize any ordering bias. Questionnaire A started with questions about the respondent's attitude, actions, and motivations for actions. The questionnaire then addressed attitude towards regulations, effects of concern and net effect, and sufficiency of design and site. Next, the questionnaire addressed the more qualitative aspects of the facility: the risk perception variables, general beliefs and values, Army and community need, the environmental concern index, and personal/social needs and goals. The questionnaire finished with the sociodemographic variables, any comments or questions, and asked if they would be willing to participate in the second phase. Questionnaire A is given in Appendix B. The sampling of respondents and the administration of Questionnaire A is discussed next.

4.4 Administering Questionnaire A

The sample for Questionnaire A is drawn from stakeholders involved in and affected by the design process of the Chemical Demilitarization Incineration Facility. The stakeholders are the residents (general population and community leaders), proponent, regulator, and other groups. The sampling of the general residential population is discussed first followed by the sampling of the other stakeholder groups.

A random stratified sample was drawn from households to survey the general population of residents around the proposed facility. Random sampling selects a sample that will be quite representative of the residents adjacent to the facility and it also allows an estimate of the sampling error. The sample was stratified with distance to over-sample residents who are adjacent to the facility, may be more familiar with the siting attempt, and hold strong attitudes and beliefs towards the facility. Due to the low response rate, weighting the results during analysis would not make the results more representative of the population. The sample was drawn from taxlots. Sampling from taxlots allows the determination of the households' location with respect to the facility. There was also a concern that since the area is low income, many of the residents may not have telephones. Sampling by telephone directories would systematically exclude the lower income households.

There are several steps in drawing the stratified random sample of households from the taxlots. First, taxlot data was obtained from Morrow and Umatilla County tax assessors' offices in the 9 - 36 Section areas surrounding the facility. The tax assessment data is reviewed in 3 year cycles, so the tax assessment data may be as much as 3 years out of date. From this list, all non-residential taxlots and all vacant residential taxlots were removed leaving occupied residential taxlots. Then, the number of households per taxlot was determined for the multi-unit land uses (i.e. duplexes, apartment buildings). Next, the distance of each household to the proposed facility was determined from a map. Households were sorted into five concentric strata by distance (d < 6 km, 6 km < d < 8 km, 8 km < d < 10 km, 10 km < d < 12 km, d >12 km). To reduce random sampling error, it was preferred that the effective sample size be greater than 200 to 250 people. If a 50% response rate was assumed, then 400 residents should be sampled. Therefore, 80 respondents in each stratum were sampled (5 X 80 = 400). The number of households in each stratum is divided by 80 to get the sampling ratio, n. A random number from a random number table is chosen as the starting point to draw the sample and every n^{th} household thereafter is chosen.

The 1990 Census indicates that the home ownership rate is about 60% (U.S. Department of Commerce, Bureau of the Census, 1990). Therefore, the questionnaires could not be mailed to the owner's address given in the taxlot data. Instead, the questionnaires were dropped off at the household. If anyone was home when the questionnaire is delivered, a brief introduction of the research and the questionnaire was given. If no one was home, the questionnaire was put in the mailbox. A cover letter preceded the questionnaire to explain the purpose of the research and the content of the questionnaire, to assure confidentiality, and to give the affiliation of the researchers and the source of funding. To save time and money, the respondents mailed back the questionnaires after completion. To increase the response rate, an introductory phone call was completed for those respondents where the name and address of the owner corresponded with the address of the taxlot. Reminder letters were also sent after one month to known taxlot addresses to further increase the response rate.

There is a high Hispanic population in the area. 1990 Census data determined the local Hispanic population to be about 15% of the total population in Umatilla and Morrow Counties. The Hispanic population has increased since then and may be as high as 30% of the population (Oliver, pers. comm., 1995). Offering the questionnaire only in English would systematically exclude those who are not comfortable with English. However, translating this questionnaire into Spanish introduces additional issues of validity and reliability. The meaning of the questions may be lost or altered in the translation. Also, the Hispanic population may not be literate in Spanish either. The Hispanic population is mostly migrant farm workers (not permanent residents). Therefore, it was decided that the questionnaire would not be translated into Spanish. Instead, it was attempted to capture the reasons for nonresponse by offering nonresponse options on the front of the questionnaire: "If you cannot answer this questionnaire, please check (√) the reasons why...and put it in the enclosed postage-paid envelope and mail it".

Community opinion leaders, proponents, regulators, and other involved individuals were also surveyed to determine their perspectives relative to the general population and the interaction between stakeholder groups. A listing of stakeholder groups involved in process was developed from a review of newspaper articles, listings of public officials, technical reports and documents, requests for the Environmental Impact Statement, and from recommendations. From this review, it is determined that there were about 40 involved groups:

- regulator - Oregon Department of Environmental Quality (DEQ), Environmental Protection Agency (USEPA)
- proponent - Department of Defense (DOD) , contractors under DOD, U.S. government
- residents - public officials in Morrow and Umatilla Counties
- other
  - opponents - Sierra Club, Greenpeace, Chemical Weapons Working Group (CWWG)
  - research agencies - National Research Council (NRC), Henry L. Stimson Center, Center for Disease Control (CDC)

To quantify the attitudes, actions, beliefs, and values of each stakeholder group, one to two individuals were sampled from each group. Since the identity and address of the individuals were known, the questionnaires we... mailed there and back.

4.5 Response Rate and Generalizability of Results for Questionnaire A

The response rate for Questionnaire A is given in Table 4.2. The sample size was 415 randomly chosen residents and 71 involved residents, proponents, regulators, and others (total n 486). Initial nonresponse was due to respondents refusing to complete the questionnaire during the initial telephone or drop-off contact; no one in the sampled household felt comfortable answering a questionnaire in English; the sampled household was vacant or not a residence; the sampled household could not be accessed due to a restricted access building, "no trespassing" signs, or guard dogs; or the sampled household could not be located. Overall, the initial sources of nonresponse equaled 17%, leaving 393 questionnaires delivered or mailed. Eighteen Questionnaires (4% of those sampled) were returned uncompleted. The reasons given by the sampled respondents were: moving from the area and their mail not being forwarded, not being permanent residents, not comfortable answering a questionnaire in English, and not comfortable answering the questionnaire at all. To boost the response rate, 247 reminder letters were mailed out October 7, 1995. One hundred seven completed questionnaires were received, giving an overall response rate of 22%.

Table 4.2 Summary of the Response Rate for Questionnaire A

Randomly Sampled Residents Stratum	Sampled (#)	initial non response % (#)	Questionnaires mailed or delivered #	returned uncompleted %sampled (#)	returned completed %sampled (#)
d km < 6 km	75	13% (10)	65	3% (2)	27% (20)
6 km < d < 8 km	89	21% (19)	70	2% (2)	15% (13)
8 km < d ≤ 10 km	83	19% (16)	67	0	24% (20)
10 km < d ≤ 12 km	84	21% (18)	66	1% (1)	17% (14)
d > 12 km	84	25% (21)	63	4% (3)	20% (17)
Total random sample	**415**	**20% (84)**	**331**	**2% (8)**	**20% (84)**
Involved Individuals					
proponents	2	0	2	0	100% (2)
regulators and others	19	0	19	11% (1)	33% (3)
residents	50	0	50	14% (7)	32% (19)
Total involved individuals:	**71**	**0**	**71**	**14% (10)**	**32% (23)**
Total sample	**486**	**17% (84)**	**393**	**4% (18)**	**22% (107)**

The response rate from randomly selected residents was poor (20%). Effectively, the sample of residents was not a random sample but a voluntary sample. The response rate from selected involved individuals was also low (32%). There were only two respondents for the proponent and three respondents for the regulator and others. Therefore, comparison between the stakeholder groups would be limited and was not attempted. To increase the sample size of residents to make subsequent statistical analysis more sensitive, the randomly selected residents were combined with the selected involved residents. This increases the sample size of residents to 102.

Given the small response rate, random sampling error could not be determined and nonresponse bias was a concern. To determine the extent of the unrepresentativeness of the sample, the respondents' sociodemographic characteristics were compared with the 1990 Census data for Umatilla and Morrow Counties (see Table 4.3). From this comparison, several trends may be observed. Randomly selected residents who responded to the questionnaire were more likely to be male, older, own their home, make more money, and be better educated than the general population. These trends are even more pronounced for residents who are involved in the facility siting. Involved residents also appear to be more liberal than the randomly selected residents. Based on these sociodemographic variables, the respondents to Questionnaire A do not appear to be representative of the general population. Therefore, the results represent the viewpoints of those who responded to the questionnaire and not of the community as a whole.

Table 4.3 Comparison of Sociodemographic Characteristics among Stakeholders

Sociodemographic variables		1990 Census Umatilla Co.	1990 Census Morrow Co.	Randomly Selected Residents (n = 83)	Involved Residents (n = 19)	Proponents Regulators and others (n = 5)
Gender	% Male	50.71	50.82	54.3	84.2	40.0
Age	% 18-24 yr.	9.28	7.55	0	0	0
	% >65 yr.	13.82	11.74	16.0	26.3	0
Housing	% Own	60.93	60.14	86.6	89.5	80.0
Household Income	median	$22,791	$23,969	$42,394	$50,688	$84,667
Education	% ≥highschool	75.1	73.9	90.0	100.0	100.0
	% ≥bachelors	13.3	11.8	23.8	78.9	100.0
children <18 yr.	median			0.72	0.53	0.8
politics (1=cons., 5=liberal)	median			2.65	2.84	2.40

It was then determined if the beliefs and attitudes toward the proposed Umatilla Chemical Demilitarization Incineration Facility (UMCDF) were a function of the sociodemographic variables. This was to determine if the nonrepresentativeness of the sample's sociodemographic variables affected the representativeness of the sample's beliefs and attitudes. The sociodemographic variables were correlated with attitude toward the facility and belief in Army's need for the facility, community's need for the facility, sufficiency of site, sufficiency of design, and sufficiency of present regulations. Significant correlations (95% C.I.) were: gender (r_s = -0.23) (male = 1, female = 2) and age (r_s = 0.23) with attitude; gender with belief in Army's need (r_s = -0.33); and gender (r_s = -0.24), income (r_s = 0.28), and education (r_s = 0.24) with belief in sufficiency of present regulations. Therefore, it appears that the nonrepresentativeness of the sample's sociodemographic characteristics may also affect the representativeness of the beliefs and attitudes. In Chapter 5 - Results, the findings of this research are compared with a previous community survey (Intercept Research Corporation, 1994) about the UMCDF. This comparison is to determine if the findings of this research are consistent with previous findings to add credence to the generalizability of this research's results.

4.6 Data Editing, Coding, and Analysis Methods for Questionnaire A

When the completed questionnaires were received, the responses were edited and coded. The responses were then entered into the data analysis program (SPSS) and analyzed. The analysis methods to test Hypothesis #1 to #6 and answer the associated research questions are given in Table 4.4. Preliminary analysis indicated that the data are not normally distributed, therefore, the analysis used nonparametric statistical tests. The results from the analysis of Questionnaire A are presented and discussed in Chapter 5

Table 4.4 Hypotheses and Associated Research Questions with their Analysis Methods for Questionnaire A

Hypotheses and Associated Research Questions	Analysis method
Introduction: Are the data clean? Are the variables normally distributed?	• Descriptive statistic . frequencies, mean, variance, range, kurtosis, skewness for attitude (var002), taken action (var009), motivations for action taken (var033-var049), strictness of present regs (var051) and preferred strictness (var052), effects (var053-var070), need (var123, var128), sociodemographics (var155-var166)
Generally, what are the characteristics of respondents?	• Descriptive statistics: frequencies, mean, variance, range, kurtosis, skewness • Spearman's correlation matrix for sociodemographic variables
Generally, what are their attitudes and beliefs about the facility?	• Frequencies of attitude, present and preferred strictness of present regs, net effects, community Army need, sufficiency of site design
HYPOTHESIS #1: Respondents are more likely to believe that the planning and design of the facility is the best possible if they: a) believe that the facility is needed by the community and b) believe that the facility is needed by the Army. **NULL:** There is no significant correlation between perceived need with the perceived sufficiency of design.	• Spearman's correlation between sufficiency of design and a) community's need and b) Army's need
HYPOTHESIS #2: The net effect of the facility is more likely to be determined as positive by respondents if they: a) believe that the site is the best place to put the facility and b) believe that the facility has been designed the best way possible. **NULL:** There is no significant correlation between perceived net facility effect the perceived sufficiency of site or design.	• Spearman's correlation between net effect and a) sufficiency of site and b) sufficiency of design
HYPOTHESIS #3: Respondents are more likely to have a favourable attitude towards the facility if they: a) believe that the net effect of the facility is positive, b) believe that risk perception variables are positive, c) believe that present regulations are sufficient, and d) are low on the environmental concern scale. **NULL:** Attitude is not significantly correlated with perceived net effect of facility, risk perception, nor beliefs about present regulations.	• Spearman's correlation between attitude and beliefs about: a) net effect, b) risk perception variables, c) sufficiency of present regulations, d) environmental concern scale, and e) to k) sociodemographic variables.
HYPOTHESIS #4: Respondents are more likely to take actions towards the facility if they: a) hold strongly positive or negative attitudes towards the facility, b) consider the facility effects to be important to their community, c) consider the facility effects to be important to them, d) feel personal responsibility, e) have personal resources available, f) have personal knowledge/expertise, g) believe that the facility is/isn't needed, h) expect that their actions will have some effect. **NULL:** There is no significant correlation with motivations for action with the level of action taken.	• Spearman's correlation between action/level of action and a) strength of attitude, b) importance of effects to community, c) importance of effects to self, d) feel personally responsible, e) available personal resources, f) personal knowledge/expertise, g) believe facility is/isn't needed, and h) expectation of effect.

Table 4.4 Hypotheses and Associated Research Questions with their Analysis Methods for Questionnaire A (continued)

Hypotheses and Associated Research Questions	Analysis method
Are the facility effects inter-related? Which effects contribute most to the net facility effect	• Spearman's correlation matrix of all facility effects
How do opponents, neutrals, and supporters rate the facility effects? Are these ratings significantly different?	• Frequencies of evaluations of effects, average of negative effects • t-test for differences of ratings of facility effects between supporters, neutrals, and opponents
Are there nonparametric correlation's between attitude and facility effects?	• Cross-tabs of attitude (+, +/-, -) with facility effects • Spearman's correlation of effects on attitude
HYPOTHESIS #5: Respondents attitude and actions toward the facility is correlated with general beliefs and values about decision making, methods of apportioning risk, who they trust to manage risk. **NULL:** There is no correlation between attitude and actions with general beliefs and values.	• Spearman's correlation between attitude and action with general beliefs and values
HYPOTHESIS #6: Respondents are more likely to believe that the facility is needed, the site and design are sufficient, the net effect is positive, the risk perception variables are positive, the present regulations are sufficient, be low on the environmental concern scale, have a positive attitude towards the facility, and take more action against the facility if the respondents: a) are older, b) have fewer children under 18 living at home, c) are male, d) have a lower income, e) have less education, f) hold a more liberal political ideology, g) live farther from the waste facility, and h) have worked for the U.S. Armed Forces or live with someone who has. **NULL:** There is no correlation between beliefs, attitude, and action with sociodemographic variables.	• Spearman's correlation between sociodemographics and beliefs about Army need, community need, sufficiency of site and design, net effect, risk perception variables, present regulations, environmental concern scale, attitude, and action

4.7 Development of Questionnaire B to Test Hypothesis #7 to #9

The purpose of Questionnaire B is to test residents' preferences of engineering intervention measures to address their concerns determined by Questionnaire A. Hypothesis #7 to #9 are developed in Chapter 3 to answer the research questions: What measures do residents prefer to redesign the facility and why? Will the implementation of their preferred measures make the facility more acceptable to them? Questionnaire B is the method by which data was collected for these hypotheses variables. Table 4.5 states Hypothesis #7 to #9 and the method of measuring the hypotheses variables in the questionnaire.

Table 4.5 Statement of Hypotheses and Null Hypotheses and Method of Measuring the Hypotheses Variables for Questionnaire B

Hypotheses and Null Hypotheses	Method of Measuring Hypotheses Variables
HYPOTHESIS #7: Implementing engineered intervention measures which address the respondents' most negatively rated concerns improve respondents' attitude toward the facility the most. **NULL:** There is no correlation between the rating of effects and the change in attitude with the implementation of the preferred intervention measures to address those effects.	**Rating of Effects of Concern** • retest rating of effects of concern, forced-choice 9 point Likert response (positive neutral negative) **Ranking of Measures** • develop measures to address each impact of concern by intervening along the cause-effect sequence; rank preferences of measures to address each effect **Change of Attitude** • initial attitude "How much do you support or oppose facility?"; forced-choice 9 point Likert response (oppose neither support) • final attitude "If #1 measure was included in the facility design, how much do you support or oppose facility?"; forced-choice 9 point Likert response (oppose neither support) • change in attitude attitude with the implementation of #1 measure to address each effect minus initial attitude
HYPOTHESIS #8: There are significant differences in the ranking of measures depending if the respondent is in the a) loss domain, or b) neutral or in the gain domain with respect to their reference point for each facility effect. **#8a:** If the respondent is in the loss domain with respect to their reference point they will prefer: need definition first to define their reference point, then impact reduction measures to reduce their present loss, and lastly compensation measures to increase the effect beyond their reference point. **#8b:** If the respondent is at or near their reference point or in the gain domain with respect to their reference point, they will prefer: need definition first to define their reference point, then compensation measures to further increase the benefits from the facility. **NULL:** There are no differences in the ranking of measures depending if the respondent is in the loss or gain domain with respect to their reference point.	**Location with respect to Reference Point** 1. choice between two plans to manage losses and gains in each effect - Plan A: risk averse, Plan B: risk seeking rate effect of concern; close-ended 9 point Likert response (positive neutral negative); open-ended "What did you compare the effect against?"; satisfaction with status quo - forced-choice with 9 point Likert response (dissatisfied/neither satisfied) to determine if status quo is at the reference point **Ranking of Measures** • develop measures to address each impact of concern by intervening at various points along the physical cause-effect chain; rank preferences of measures to address each effect

Table 4.5 Statement of Hypotheses and Null Hypotheses and Method of Measuring the Hypotheses Variables for Questionnaire B (continued)

HYPOTHESIS #9: Respondents are more likely to prefer engineered intervention measures which intervene at upstream points along the physical cause-effect sequence, preferring need definition, then prevention, control, mitigation, and lastly, compensation **NULL:** There is no consistent ranking of intervention measures depending upon the intervention point of the measures along the cause-effect sequence.	**Ranking of Measures** • as above

In Questionnaire A, respondents were asked to rate how the facility would affect various factors in their community. These facility effects were arranged along the cause effect sequence and included changes to environmental media, reception/exposure, and endpoint effects (see Figure 4.1). From these effects, three endpoint effects were chosen to be addressed in Questionnaire B with engineering intervention measures. The selection of these effects is discussed next.

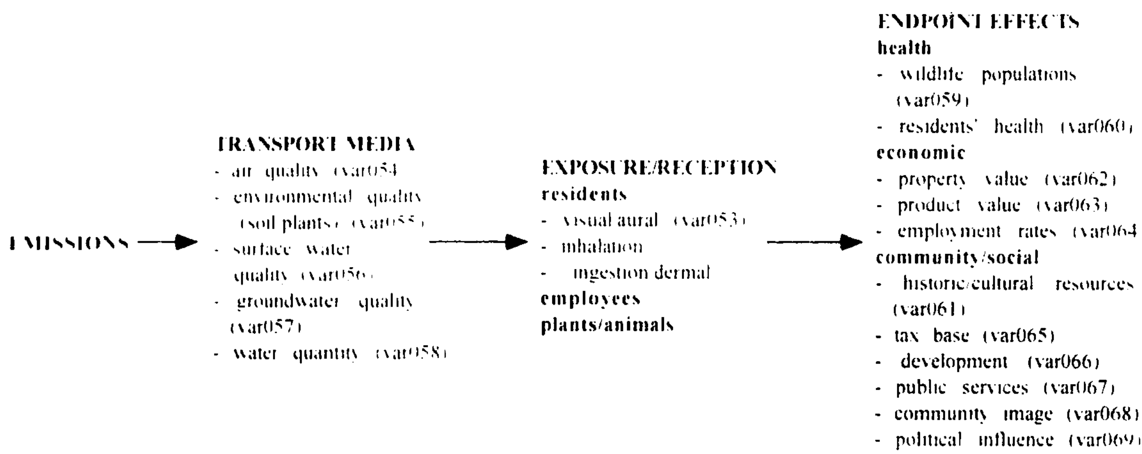

Figure 4.1 Facility Effects Rated in Questionnaire A

One environmental medium was chosen through which facility emissions are transported. This simplified the cause-effect pathways for the researcher, making it easier to redesign the facility to regulate emissions to that medium. This also simplified the hypothesis testing. The criteria for choosing the single transport medium were that: 1) the effect was rated significantly different by residents with different attitudes; 2) the effect was significantly correlated with attitude - addressing the effect was more likely to make respondents attitude more favourable; 3) the effect was alterable through realistic engineering intervention measures - making it possible to redesign to address the effect; and 4) the effect was readily measurable predictable to assure reliability.

Engineering measures were developed to address endpoint facility effects. Designing for independent endpoint effects simplifies the development of measures to address those effects and simplifies the testing of the hypothesis. Also, designing directly for effects to transport media would alter other downstream effects. Analysis of the rating of the facility effects from Questionnaire A, indicated that all of the effects are significantly intercorrelated. Since the effects are inter-related, the measures to address each effect also alter other facility effects. This interaction is reduced by choosing effects which are relatively independent from each other. Criterion 5) is that the effects had distinguishable physical cause-effect pathways which were strongly and significantly correlated with the chosen transport medium and chosen effects were relatively independent from each other. This assures that the effect is related to contaminant transport through the air medium and that the effects are independent from each other.

Pease et al. (1993) have also found that impacts may be evaluated differently depending on the scale of the impact. Impacts that affect at the social/community level are evaluated differently than impacts which affect at the personal level (Pease et al., 1993). The final criterion is: 6) that the effects vary in scale - some impacts affect at the personal level while some impacts affect at the social/community level.

The facility effects were evaluated according to these decision criteria in Table 4.6. For the first criterion, the mean ratings of the facility effects by residents with different attitudes toward the facility are given. Significant differences in the rating of the effects are indicated by the superscript a, b, and c. For the second criterion, effects which are significantly correlated with attitudes for the residents with different attitudes towards the facility are given. For the third and fourth criteria, effects which are predictable and have realistic interventions are indicated by √.

Table 4.6 Evaluating the Transport Medium and Endpoint Effects for which to Address through Engineering Interventions

Facility Effects		1. Mean Rating* of Effects by Residents with Different Attitudes and by all Residents**				2. Effects Significantly (95% C.I.) Correlated with Attitude for Residents with Different Attitudes				3. Effects which are Predictable	4. Effects with Realistic Interventions	5. cause-effect pathways		6. scale of affect ****
		oppose (n=16)	neither support nor oppose (n=25)	support (n=50)	all (n=91)	oppose (r_s)	neither support nor oppose (r_s)	support (r_s)	all (r_s)			correlate w/AQ (100% C.I.)	correlate w/ other effects ***	
- air quality	var054	1.81^{b}	2.24^{c}	2.88^{bc}	2.51	0.55		0.27	0.45	√	√			
- environmental quality	var055	1.63^{b}	2.26^{c}	2.88^{bc}	2.49	0.59		0.27	0.49	X	√			
- surface water quality	var056	1.94^{b}	2.17^{c}	2.92^{bc}	2.54			0.37	0.47	√	√			
- ground water quality	var057	2.19	2.17^{c}	2.82^{c}	2.54			0.35	0.40	√	√			
- water quantity	var058	2.25	2.48	2.76	2.60				0.27	√	√			
- noise	var053	2.86	2.67^{c}	3.00^{c}	2.89				0.22	√	√			
- wildlife populations	var059	1.56^{ab}	2.38^{a}	2.82^{b}	2.43				0.40	X	√	0.6587	1	P & S
- residents' health	var060	1.69^{b}	2.30	2.69^{b}	2.41				0.40	X	√	0.6742	1	P
- historic/cultural resources	var061	2.56	2.64	2.98	2.81				0.28	X	√	0.3957		P & S
- property value	var062	2.31^{b}	2.71	3.24^{b}	2.93	0.61			0.32	√	√	0.3647	2	P
- product value	var063	2.19	2.87	2.82	2.72	0.51			0.30	X	√	0.5213	2	P
- employment rates	var064	2.93^{ab}	3.84^{a}	4.18^{b}	3.89				0.42	√	X	-	3	P
- tax base	var065	2.77^{b}	3.39	3.66^{b}	3.45	0.59			0.26	√	X	-	3	S
- development	var066	2.67^{b}	3.33^{c}	3.76^{bc}	3.46				0.34	X	√	-	3	S
- public services	var067	2.57	3.04	3.18	3.04				0.21	X	√	-	3	S
- community image	var068	2.00^{b}	2.76^{c}	3.39^{bc}	2.98				0.41	X	√	0.4577	3	S
- political influence	var069	2.20^{ab}	2.88^{a}	3.16^{b}	2.92				0.29	X	X	-	3	S
- other factors	var070	2.50	2.80	3.36	3.10					X	X	-		-
- net effect	var071	1.38^{ab}	2.60^{ac}	4.14^{bc}	3.23			0.36	0.73	X	X	0.4447		-

*1 = very negative effect, 2 = somewhat negative effect, 3 = neither positive nor negative effect, 4 = somewhat positive effect, 5 = very positive effect

**significant (95% C.I) difference using t-test for independent samples of means of ratings between: a = opposing and neutral residents, b = opposing and supporting residents, and c = neutral and supporting residents

***each number indicates a grouping of inter-correlations (from Spearman correlation matrix)

****affect at the P=personal level and S=social level

The overall sufficiency of each transport medium to meet the criteria is tabulated in Table 4.7 with: 1) one point for each significant difference in the rating by residents with different attitudes, 2) one point for each significant correlation between the effect and attitude for residents with different attitudes and for all residents, 3) one point for predictability, and 4) one point for realistic interventions. From this, the air medium was chosen as the transport route. Air is the primary transport route: the majority of the facility emissions are to air through which the contaminants are transported to other media (see Chapter 4 for the description of the emissions and transport).

Table 4.7 - Overall Rating of Facility Effects to Meet Decision Criteria in Table 4.6

Facility Effects		**Rating of each effect in meeting Decision Criteria**						
		1.	**2.**	**3.**	**4.**	**5.**	**6.**	**Total**
Emission/Transport								
- air quality	var054	2	3	1	1			7
- environmental quality	var055	2	3	0	1			6
- surface water quality	var056	2	2	1	1			6
- ground water quality	var057	1	2	1	1			5
- water quantity	var058	0	1	1	1			3
Reception/Exposure								
- noise	var053	1	1	1	1			4
Endpoint Effects								
- wildlife populations	var059	2	1	0	1	1	P & S	4
- residents' health	var060	1	1	0	1	1	P	4
- historic/cultural resources	var061	0	1	0	1	1	P & S	3
- property value	var062	1	2	1	1	1	P	6
- product value	var063	0	2	0	1	1	P	4
- employment rates	var064	2	1	1	0	0	P	4
- tax base	var065	1	2	1	0	0	S	4
- development	var066	2	1	0	1	0	S	4
- public services	var067	0	1	0	1	0	S	2
- community image	var068	2	1	1	0	1	S	5
- political influence	var069	2	1	0	0	0	S	3
- other factors	var070	0	0	0	0	0	-	-
- net effect	var071	3	2	0	0	1	-	-

The endpoint effects were also evaluated by the criteria in Table 4.6. For the fifth criterion, groupings of intercorrelations between endpoint effects were determined with: 1) wildlife populations with residents' health, 2) property value with product value, and 3) employment rates, tax base, development, public services, community image, and political influence. For the sixth criterion, the scale of the effect is indicated by P=personal level and S=social level. The overall sufficiency of each endpoint effect to meet the decision criteria is tabulated in Table 4.7. Within each intercorrelation grouping of effects, the effect which best met the decision criteria was chosen (i.e. the effect with highest total rating), while representing both personal and social scales of effect. Using this logic, the effects chosen to be addressed with engineering interventions were: effect on residents' health, effect on property value, and effect on community image as affected through the air transport medium.

The respondents' beliefs about effects to residents' health, property value, and community image were chosen to be addressed through engineering measures. Then, the measures themselves were designed to test Hypothesis #7 to #10. Briefly, these hypotheses state:

Hypothesis #7: Respondents will prefer measures which are seen as addressing the effects of greatest concern to them.

Hypothesis #8: Respondents will prefer measures depending on their location with respect to their reference point.

Hypothesis #9: Respondents will prefer measures which intervene at upstream points along the physical cause-effect chain.

To test the hypotheses, the measures must vary by: the facility effects which they address (residents' health, property value, or community image) and their intervention points along the physical cause effect chain while attempting to control any confounding variables. As given in Figure 3.1, the types of measures which intervene at various points are: need definition; preventing the impact by altering the characteristics of the inputs and site; controlling the impacts by regulating an emission to the environment; mitigating the impact by reducing the impact after it has occurred; and compensating the impact by paying affected individuals or providing alternate goods for residual impacts.

There are several confounding variables identified from a review of the literature by which respondents may evaluate facility design and engineering intervention measures. This set of possible confounding variables were controlled for in the presentation of engineering intervention measures to respondents and in their subsequent evaluation and ranking of those measures. The confounding variables were controlled by: 1) including the variables in the description of the measures and 2) controlling for the variables by holding them constant in the design or in respondents' evaluation process. In the interview, the description of the measures were given to the respondents on a set of cards - with one measure per card. Finally, the possible influence of the confounding variables was checked by probing respondents which variables were used to evaluate the intervention measures. Checking for the influence of confounding variables does not reduce their influence, but only makes the researcher aware of their influence. Table 4.8 gives a listing of the possible confounding variables, the references, and whether or not the variables were included or controlled.

Table 4.8 Listing of Confounding Variables and their Treatment

Criteria	**Reference**	**1) Included**	**2) Controlled For**
cost	USEPA, 1982; Davos et al., 1993; Barron, 1992	- not included - community does not directly pay for facility, required measures will be implemented regardless of cost	- tell respondents all measures cost about the same
ease of implementa-tion	USEPA, 1982; Davos et al., 1993; Barron, 1992; Sorensen et al., 1987; Kunreuther et al., 1993; Farago et al., 1989	- included - likely a prime concern although residents are not responsible for the implementation of the measures	- tell respondents that measures can and will be implemented as described on the cards
need for addressing impact	Sorensen et al., 1987; Gregory and Kunreuther, 1990; Kunreuther et al., 1993; Ostry et al., 1993	- included - one of the engineering intervention measures to be tested for	- give respondents need as one of type of measures
effectiveness	USEPA, 1982; Davos et al., 1993; Barron, 1992; Sorensen et al., 1987; Gregory and Kunreuther, 1990; Kunreuther et al., 1993; Portney, 1984; Hallman and Wandersman, 1995; Ostry et al., 1993; Farago et al., 1989; Nieves et al., 1992	- included - how well effect is addressed is likely a prime concern to residents	- tell respondent all measures are about equally effective in addressing the effect
certainty	Sorensen et al., 1987; Hallman and Wandersman, 1995; Barron, 1992	- included - likely a prime concern, make all measures 100% certain	- make all measures 100% certain

Table 4.8 Listing of Confounding Variables and their Treatment (continued)

Criteria	Reference	1) Included	2) Controlled For
secondary/ indirect effects	USEPA, 1982	- not included	- tell respondents to only consider what is on the cards
comparison with alternatives	Zeiss and Atwater, 1987; Kunreuther et al., 1993; Ostry et al., 1993	- not included	- tell respondents to only consider what is on the cards
timing of measures in cause effect sequence	Gregory and Kunreuther, 1990; Portney, 1985; McQuaid-Cook and Simons, 1989; Smail, 1985; Zeiss, 1991; Nieves et al., 1992; Zeiss and Atwater, 1987; O'Hare et al., 1983; Centaur Associates, 1979; Bord et al., 1985; Johnson, 1987; Bacow and Milkey, 1982; Duberg et al., 1980; Mank, 1991; Greenberg et al., 1984; McClelland et al., 1990; Carter, 1987; Kemp, 1992; Ehrenfeld et al., 1989	- included - vary intervention point by varying type of measures	- not controlled - this is a hypothesis to be tested
local control	Sorensen et al., 1987; Johnson, 1987; Dorius, 1993; Kemp, 1992; Centaur Associates, 1983; O'Hare et al., 1983; McQuaid-Cook and Simons, 1989; Zeiss and Paddon, 1991; Zeiss, 1991; Carter, 1987; Bord et al., 1985; Zeiss and Atwater, 1987; Nieves et al., 1992	- not included	- tell respondents to only consider what is on the cards - make measures equally controllable by residents
voluntariness	Sorensen et al., 1987; Kunreuther et al., 1993; Bord and O'Connor, 1992; Farago et al., 1989	- not included	- tell respondents to only consider what is on the cards - make measures equally voluntary
trust in regulator and or proponent	Gregory and Kunreuther, 1990; Zeiss and Atwater, 1987; Kunreuther et al., 1993; Bord and O'Connor, 1992; Hallman and Wandersman, 1995; Ostry et al., 1993; Farago et al., 1989	- not included	- tell respondents to only consider what is on the cards

Table 4.8 Listing of Confounding Variables and their Treatment (continued)

Criteria	Reference	1) Included	2) Controlled For
knowledge by exposed	Sorensen et al., 1987; Johnson, 1987; Zeiss and Atwater, 1987; Bord and O'Connor, 1992; Ostry et al., 1993, Farago et al., 1989	- not included	- tell respondents to only consider what is on the cards - make knowledge of measures as equal as possible by giving same information to respondents
equity, fairness	Sorensen et al., 1987; Davos et al., 1993; Gregory and Kunreuther, 1990; Zeiss and Atwater, 1987; Kunreuther et al., 1993; Hallman and Wandersman, 1995; Ostry et al., 1993; Nieves et al., 1992	- not included	- tell respondents to only consider what is on the cards - make measures as equitable as possible, all respondents within Immediate Response Zone and are potentially affected

Engineering intervention measures were developed to address each facility effect (residents' health, property value, and community image), represent each type of engineering intervention measure (need definition, prevention, control, mitigation, and compensation), and to control for possible confounding variables. A Step-Matrix/Reverse Network was completed for the UMCDF to determine the cause-effect sequence resulting in the facility effects (see Appendix A). Possible intervention measures along this cause-effect sequence were identified (see Figure 3.1). The engineering interventions developed to test Hypothesis #7 to #9 are given next in Tables 4.9 to 4.11.

Table 4.9 Measures to Address Impacts to Residents' Health

Type of Measure	Description

Need Definition define the need for the facility and change the facility design to fulfill those needs	**IT MUST BE SHOWN THAT INCINERATION FACILITY IS NEEDED**
	• before the facility is allowed to be built, studies must show that the facility is needed to improve residents' health by:
	  • destroying the chemical munitions is safer than continuing to store them
	  • destroying them at the Depot is safer than shipping them to another site
	  • destroying them with incineration is safer than using any other method

Prevention alter characteristics of the inputs and site	**REMOVE EXPLOSIVES FROM MUNITIONS BEFORE TRANSPORTING THEM TO THE INCINERATOR** • before the munitions from an igloo are transported to the incinerator, a mobile, automated disassembly machine will be set up at the storage igloo that is being emptied • the machine will remove the fuses, bursters, and explosives from the munitions to prevent an explosion during transportation which may cause a large release of chemical agent which would impact residents' health
Control alter the facility design and operations to regulate the emission of a contaminant and regulate the occurrence of an impact	**MORE FILTERS ON THE STACKS** • add more filters on the stacks to further reduce air emissions during operation of the incinerator and control impacts to residents' health

Mitigation alter exposure by cleaning up environmental contamination which occurs	**IMPROVE CSEPP**
	• during the operation of the facility, reduce residents' exposure to chemical agent in an emergency by improving the Chemical Stockpile Emergency Preparedness Program (CSEPP) by giving:
	  • more funding to emergency response programs
	  • all residents in the Immediate Response Zone an evacuation route and emergency procedures and a gas mask for sheltering-in-place

Compensation alter attitude with the provision of monetary payments or an alternate good	**ARMY ASSUMES LIABILITY** • rewrite the legislation so that the Army is fully liable for damage to residents' health from the facility caused by anything (earthquakes, terrorism, or a fault of their contractor operating the facility) • if the facility harms residents health, set up a payment plan to compensate them a set amount of money for different types of harm like a life insurance policy (so much money for temporary loss of eyesight, so much for impaired breathing, etc.)

Table 4.10 Measures to Address Impacts to Property Value

Type of Measure	Description

Need Definition: define the need for the facility and change the facility design to fulfill those needs	**ASSESS PROPERTY VALUE IMPACTS**
	• before the facility is built, studies must show that the facility is needed to improve property values by:
	    • the employment of 550 workers during construction and 740 new jobs during operation
	    • the local work force will be stabilized and the demand for permanent housing will increase which will improve local property values

Prevention: alter characteristics of the inputs and site	**CONTROL LOCAL DEVELOPMENT**
	• before and during the operation of the facility, any losses in property value will be prevented by putting together a community development plan so that:
	    • development is controlled, communities do not become quickly overdeveloped
	    • any new homes which are built are permanent and in wel' planned sub-divisions

Control: alter the facility design and operations to regulate the emission of a contaminant and regulate the occurrence of an impact	**GRANTS FOR PROPERTY IMPROVEMENTS**
	• during the operation of the facility, any losses in property value will be controlled by providing cash grants to owners for maintaining and improving the properties within the Immediate Response Zone
	• grants may be for:
	    • drilling water wells, irrigation systems, landscaping, fencing
	    • additions, upgrades
	    • or anything else

Mitigation: alter exposure by cleaning up environmental contamination which occurs	**DEVELOP A PROPERTY VALUE PROTECTION PROGRAM**
	• to offset any losses in property value during the operation of the facility
	• develop a property value protection program to:
	    • assess the fair market value for a property
	    • pay the difference between the fair market value and selling price at the sale of the property
	    • buy the property from the owner for the fair market value if the property has been on the market for more than 6 months

Compensation: alter attitude with the provision of monetary payments or an alternate good	**COMPENSATION TO PROPERTY OWNERS** • if there is an impact to property values during the operation of the facility, pay annual compensation (e.g. 10% of property tax) to homeowners within Immediate Response Zone • to compensate owners for any direct or indirect damage to their property

Table 4.11 Measures to Address Impacts to Community Image

Type of Measure	Description

Need Definition define the need for the facility and change the facility design to fulfill those needs	**STUDY COMMUNITY DEVELOPMENT AND IMAGE**
	• before the facility is built, studies must show that the facility is needed to improve the community image by:
	  • providing stable, high technological employment: 550 jobs during construction and 740 jobs during operation
	  • increasing the property tax base and cost-sharing initiatives to improve the capacity of schools, upgrading roads, and improving hospitals, police, and fire departments

Prevention: alter characteristics of the inputs and site	**CREATE POSITIVE PUBLICITY ABOUT THE FACILITY**
	• before and during the operation of the facility, help prevent any impacts to community image by demonstrating with positive local, state-wide, and federal media publicity that the local communities are:
	  • leaders in responsibly dealing with environmental issues
	  • encouraging more technical development and insuring local population growth and stability
	  • improving local technical expertise

Control: alter the facility design and operations to regulate the emission of a contaminant and regulate the occurrence of an impact	**IMPROVE APPEARANCE OF FACILITY**
	• control any impacts to community image by designing and maintaining the facility so that it has an attractive appearance with:
	  • a clean, landscaped entrance gate
	  • planting trees and screening along the perimeter of the Depot, so that the facility

Mitigation: alter exposure by cleaning up environmental contamination which occurs	**IMPROVE IMAGE OF COMMUNITIES**
	• off-set any impacts to community image during the operation of the facility by giving funding to beautify the local communities and develop tourist attractions:
	  • hire people for regular litter collection
	  • upgrade main streets with paving stones for sidewalks, new light standards with hanging flower baskets, and plant trees
	  • create and maintain a wildlife preserve
	  • develop an 18-hole golf course

Compensation: alter attitude with the provision of monetary payments or an alternate good	**IMPROVE LAW ENFORCEMENT** • if there is an impact to community image during the operation of the facility, give funding to Umatilla and Morrow Counties to improve the local law enforcement

Finally, to test Hypothesis #8, respondents' location with respect to their reference point must be determined. Since, Prospect Theory states that effects are evaluated in separate mental accounts (Kahneman and Tversky, 1979) with different attributes being evaluated on different value curves, a reference point must be determined for each effect (health, property value, and community image). A review of the literature indicates that previous researchers have framed the question for the respondent instead of determining how the respondent frames the issue for him or herself - thus superimposing a frame and influencing the respondent's own. Researchers frame the question as a loss or gain then give a choice between a risk averse or risk seeking alternative which are statistically comparable, which is also framed as a loss or gain (deaths vs. lives saved). Fischhoff (1983) attempts to determine respondent's preferred reference point by offering respondents a series of three alternate frames (each with two alternatives) of comparable problems, asking them to select the frame that seems the most natural. However, Tversky and Kahneman (1981) state that individuals "are normally unaware of alternative frames and of their potential effects on the relative attractiveness of options" (p. 457) and the respondent may be unable to consciously choose between alternate frames (Fischhoff, 1983). Therefore, there is no proven gaming method of determining respondents' location with respect to their reference point. This has been stated as a limitation of Prospect Theory (Gregory et al., 1993)

Referring back to the theoretical construct, can a method be developed to determine the respondent's location with respect to their reference point? On the Prospect Theory value curve, people may be either: 1) in the loss domain, 2) at or near their reference point, or 3) in the gain domain for each facility effect (See Figure 3.2). Prospect Theory states that people are risk seeking if they are in the loss domain and they are risk averse if they are in the gain domain (Kahneman and Tversky, 1979). Therefore, the question stated that there will be a loss from the present state with two options to manage the loss: Plan A is risk averse and Plan B is risk seeking. Next, the question stated that there will be a gain from the present state with two options to manage the gain: Plan A is risk averse and Plan B is risk seeking. The risk averse/neutral/seeking question for each facility effect read as follows:

a) Suppose that, beyond the planners' control, the facility will cause a more <u>negative</u> effect on residents' health than was originally expected. Suppose, there are two plans to manage this effect on residents' health. *give card, read each* Which plan do you prefer, A or B?

Plan A	there will be 3 more deaths in 100 years in Umatilla and Morrow Counties than were expected
Plan B	there is a 1/3 chance that there will be 9 more deaths in 100 years and a 2/3 chance that there will be no more deaths than were expected

a) Suppose that, beyond the planners' control, the facility will cause a more <u>positive</u> effect on residents' health than was originally expected. Suppose, there are two plans to manage this effect on residents' health. *give card, read each* Which plan do you prefer, A or B?

Plan A	will save 3 more lives in 100 years in Umatilla and Morrow Counties than were expected
Plan B	will have a 1/3 chance to save 9 more lives in 100 years and a 2/3 chance to save no more lives than were expected

Looking at Figure 4.2, if respondents are in loss domain (at point 1), they will be risk seeking on both the loss and the gain question as they will be in their loss domain. If respondents are at or near their reference point (at point 2), they will be risk seeking on the loss question because they are in the loss domain and risk averse on the gain question because they will be in the gain domain. And if respondents are in the gain domain (at point 3), then they will be risk averse on both the loss and gain question because they will be in the gain domain on both losses and gains. Using this method to determine respondents' location with respect to their reference point for each facility effect, respondents are categorized as being 1) risk seeking (i.e. choose plan B for losses and gains) or as 2) risk neutral (i.e. choose plan B for losses and plan A for gains) or risk averse (i.e. choose plan A for losses and gains):

The definition of the reference point offers a second possible method of determining the respondents' location with respect to their reference point. Tversky and Kahneman (1981) define the reference point as "...a neutral reference outcome, which is assigned a value of zero..." from which "outcomes are expressed as positive or negative deviations (gains or losses)" (p. 454). Facility effects are defined as the change caused by facility to the baseline state. From this, respondents may judge the facility effects on a scale as being positive or negative from their neutral reference point (assigned to a value of zero). Marsh and Carducci (1978) support this assumption with their finding that the zero or break-e [illegible] simulated game were always anchored at the neutral center point of the category rating scale. Introduction of an extremely positive "win" made other "wins" seem less favourable and "losses" more favourable by comparison. However, the rating of the zero point remained unchanged, which contradicts the adaptation-level premise (Marsh and Parducci, 1978). Therefore, if the effect is rated as negative, then they are in the loss domain with respect to their reference point. Likewise, if the effect is rated as positive, then they are in the gain domain with respect to their reference point. Consideration of a large gain or loss may alter the relative magnitude of gains and losses relative to the neutral reference point, however, the sign of the losses or gains will not change.

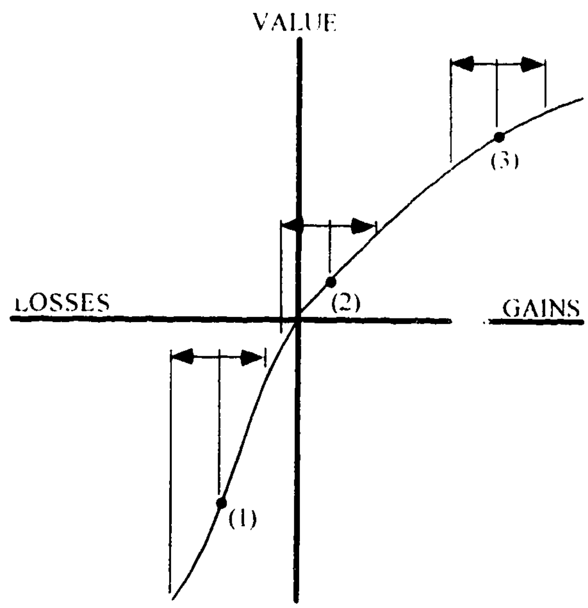

Figure 4.2 Determining Respondents' Location with Respect to their Reference Point

To "look for trouble"(Fischhoff, 1991) it must be asked whether respondents really assign a value of zero to their reference point? What if they assign the status quo a value of zero and their reference point is at another point above or below the status quo? An open-ended question can be used to check if they are using status quo as their reference point: "Why do you think that the facility would have a (positive/negative/neutral) effect on (residents' health)?" Further, respondents are asked the closed-ended question "How satisfied are you with your (health)?" to check if they are satisfied with status quo or if they have another desired state which they may be using as their reference point.

According to Fischhoff (1991), Prospect Theory assumes that people have partially articulated values: "People have stable but incoherent perspectives, causing divergent responses to formally equivalent forms." (p. 840). If the respondent has an articulated reference point then he or she may be able to answer the open-ended question about what is used as the reference point: "When you say that the facility will have a (positive/neutral/negative) effect on the health of local residents, what are you comparing against?" Fischhoff (1991) also states that the treatment for dealing with partially articulated values is: "looking for trouble" by using multiple methods and "asking for trouble" by using open ended questions.

The second method of determining respondents' location is to determine if they rate the effects as being positive (in the gain domain or neutral) or negative (in the loss domain). Then, the open-ended questions determine if the respondents are using the status quo as their reference point, if they are satisfied with status quo, and if they have a desired state which may be their reference point.

Finally, all the questions included in Questionnaire B were compiled and ordered to be logical and minimize ordering bias. All the closed-ended and open-ended methods of determining if respondents were in the loss domain or neutral and gain domain were included in Questionnaire B to allow the comparison of methods to "look and ask for trouble" (Fischhoff, 1991). First, respondents were asked their attitude towards the facility as it was currently designed, if their attitude has changed, how and why, and how likely they think it was that the facility would be built. Then, effects to residents health were addressed with the risk averse/risk seeking question to determine if respondents were in the loss domain, neutral, or in the gain domain. Then, respondents were asked to evaluate the effect to residents' health, asking for their rationale and reference point in the evaluation. Next, the measures to address effects to residents' health were given to the respondents. Respondents were asked to rank the measures in their order of preference and asked for their rationale in the ranking. Finally, respondents were asked if their attitude would change with the implementation of the #1 measure for health and their satisfaction with their current health. Effects to property value, then to community image were addressed with a parallel set of questions as for residents' health. The questionnaire concluded by asking, generally, what would make the facility more acceptable to them and asking for any comments or questions. Questionnaire B is given in Appendix C. The administration of Questionnaire B is discussed in the next section.

4.8 Administering Questionnaire B

The sample for Questionnaire B was drawn from the list of Questionnaire A respondents who expressed interest in participating in the second phase of the research. This is a voluntary sample. From Questionnaire A results, attitude was the most significant variable which correlated with beliefs and values. Therefore, the sample was chosen to represent the three attitude groups: opposing, neutral, and supporting. The sample size was chosen to meet the requirements of the statistical analysis methods. The statistical methods used were Spearman's correlation ($n \geq 10$), t-test ($n \geq 30$, however, insensitive to non-normality), and Kruskal-Wallis test for differences in ranking ($n \geq 5$ for each subgroup). Therefore, it was preferred that the total sample size be greater than 30 with at least 5 opponents, 5 neutrals, and 5 supporters. Taking into account non-response, 35 individuals were sampled with 11 opponents, 12 neutrals, and 12 supporters. Respondents' attitude toward the facility, from Questionnaire A, was 19% opposed, 26% neither supported nor opposed (neutral), and 52% supported. Therefore, the Questionnaire B sampling over represented opposing and neutral respondents.

To increase the response rate, an introductory letter was sent 10 days prior to the interview week. Upon arrival in the area, the sample was telephoned to set up an interview time, date, and location. To make the interview easier, respondents were given response categories for each closed-ended questions on a card. Each engineering measure was also given on a card to allow respondents to handle the measures as they ranked them.

4.9 Response Rate and Generalizability of Results for Questionnaire B

In total, 23 interviews were completed (7 opponents = 30% of the respondents, 6 neutrals = 26% of the respondents, and 10 supporters = 43% of the respondents). Compared with the residents' attitudes given in Questionnaire A, opposing and neutral residents were over represented. The overall response rate for Questionnaire B was 66%. Residents' reasons for not participating included: unwillingness to be interviewed, feelings that they were not adequately informed, or unavailability during the interview week. Since this is a voluntary sample, the respondents of Questionnaire B were not representative of the Questionnaire A respondents nor the general population and cannot be generalized to those groups.

4.10 Data Editing, Coding, and Analysis Methods for Questionnaire B

When the interviews were completed, the responses were edited and coded. The variables numbers are given in the margins of Questionnaire B in Appendix C along with the codes for the open-ended responses. The responses were then entered into the data analysis program (SPSS) and analyzed. The analysis methods to test Hypothesis #7 to #9 and answer the associated research questions are given in Table 4.12. Preliminary analysis indicated that the data are not normally distributed, therefore, the analysis used nonparametric statistical tests. The results of the analysis are presented and discussed in Chapter 5.

Table 4.12 Hypotheses and Associated Research Questions with their Analysis Methods for Questionnaire B

Hypotheses and Research Questions	Analysis method
Introduction: What are respondents' attitudes? Have their attitudes changed since completing Questionnaire A?	• Frequencies of Questionnaire A (var002) and initial Questionnaire B attitude (var003) • Spearman's correlation of var002 and var003
Do respondents think the building of the facility is likely	• Frequencies of likelihood that facility will be built (var007)
How do respondents rate facility effects? Do the Ques. B attitude groups rate the effects similarly to the Ques. A attitude groups? Do the different attitude groups rate effects significantly differently?	• Frequencies and t-tests of ratings of health effects, property value effects, and community image effects by different attitude groups (support, neutral, and oppose)
Which effect is most influential on respondents' overall attitude?	• Spearman's correlation between each facility effect and Ques. A and Ques. B attitude

Table 4.12 Hypotheses and Associated Research Questions with their Analysis Methods for Questionnaire B (continued)

Hypotheses and Research Questions	Analysis method
HYPOTHESIS #7: Implementing engineered intervention measures which address the respondents' most negatively rated concerns improve respondents' attitude toward the facility the most. **NULL:** There is no correlation between the rating of effects and the change in attitude with the implementation of the preferred intervention measures to address those effects.	• Average change in attitude with the implementation of the preferred measure to address each effect • Spearman's correlation between each facility effect and change in attitude with the implementation of the preferred measure to address that effect
Is the changing of respondents' attitudes correlated with their initial attitude	• Spearman's correlation between the changes in attitude with the implementation of the each preferred measure and initial attitude in Ques. B
If the respondents' attitude will change with the implementation of one measure are they more likely to change attitude with the implementation of other measures?	• Spearman's correlation between the changes in attitude with the implementation of the each preferred measure
HYPOTHESIS #8: There are significant differences in the ranking of measures depending if the respondent is in the a) loss domain, or b) neutral or in the gain domain with respect to their reference point for each facility effect. **#8a:** If the respondent is in the loss domain with respect to their reference point they will prefer: need definition first to define their reference point, then impact reduction measures to reduce their present loss, and lastly compensation measures to increase the effect beyond their reference point. **#8b:** If the respondent is at or near their reference point or in the gain domain with respect to their reference point, they will prefer: need definition first to define their reference point, then compensation measures to further increase the benefits from the facility. **NULL:** There are no differences in the ranking of measures depending if the respondent is in the loss or gain domain with respect to their reference point.	• Kruskal-Wallis nonparametric test to determine significant differences in ranking between k-independent samples between those: a) in the loss domain and b) those in neutral or gain domain.
Does the rating of facility effects as a measure of location with respect to reference point explain differences in the ranking of measures?	• Kruskal-Wallis nonparametric test to determine significant differences in ranking between k-independent samples between those who rank measures as: a) negative, b) neutral, or c) positive • does satisfaction with status quo correlate with rating of facility effects as positive, negative, or neither? Spearman's correlation between
Is the status quo being used as the reference point in judging the facility effects as positive, negative, or neither, or is another ideal reference state being used?	• Spearman's correlation between satisfaction with status quo with rating of facility effects as positive, negative, or neither
Are different methods of determining respondents' location with respect to their reference point related?	• Spearman's correlation between methods of determining location with respect to reference point: a) risk seeking/averse and b) rating of effect.

Table 4.12 Hypotheses and Associated Research Questions with their Analysis Methods for Questionnaire B (continued)

Hypotheses and Research Questions	Analysis method
HYPOTHESIS #9: Respondents are more likely to prefer engineered intervention measures which intervene at upstream points along the physical cause-effect sequence: preferring need definition, then prevention, control, mitigation, and lastly, compensation. **NULL:** There is no consistent ranking of intervention measures depending upon the intervention point of the measures along the cause-effect sequence.	• Frequencies of rankings of measures for each effect • Chi-square test to determine significant differences in rankings of need definition, prevention, control, mitigation, and compensation
Is there any indication why respondents rank the measures like they do?	• Rationales given in the ranking of measures

4.11 Summary

This chapter reviews the research methodology. First, the Umatilla Chemical Demilitarization Incineration Facility was selected for study. The facility was chosen for the validity and reliability of testing the hypotheses, for the generalizability of the results, and for practical considerations to complete the research. It was decided to complete the research in two phases: Questionnaire A and Questionnaire B. The research was completed in two phases to follow the logical grouping of hypotheses, to use information from Questionnaire A to develop Questionnaire B, and to allow more appropriate measurement and analysis methods for the two groupings of hypotheses.

Questionnaire A was a self-administered questionnaire which dealt with testing Hypothesis #1 to #6. These hypotheses consider residents' beliefs, values, attitudes, and actions towards the proposed facility. Questionnaire A is given in Appendix B. The final sample size was 102 respondents for a 22% response rate. The response rate is low, effectively making the sample voluntary instead of random. This limits the generalizability of the results. The data editing, coding, and analysis methods for Questionnaire A were discussed.

Questionnaire B was an interview which dealt with Hypothesis #7 to #9. These hypotheses consider residents' preferences of additional engineering intervention measures to address their concerns and residents' change in attitude with the implementation of their preferred measures. Questionnaire B is given in Appendix C.

The final sample size was 23 respondents for a 66% response rate. This sample is voluntary. The results only represent the opinions of those who responded. Residents who oppose the facility and residents who neither support nor oppose the facility were oversampled to bias respondents against finding the facility acceptable through any re-engineering. The data editing, coding, and analysis methods for Questionnaire B were also discussed.

The next chapter, Chapter 5, gives the results of the hypotheses testing. The significance of the results are discussed for the theories that they test and for facility siting and design.

5. Presentation, Discussion, and Significance of Results

5.1 Introduction

This chapter presents and discusses the results of the hypotheses testing. The study facility - the Umatilla Chemical Demilitarization Incineration Facility (UMCDF) was chosen and described (see Chapter 2). Then, the research hypotheses were developed from the pertinent facility siting and design theories (see Chapter 3). A discussion of the research methods was given (see Chapter 4). The results are discussed and considered in the context of the facility and community characteristics. Consideration of the context gives a greater understanding of what concerns residents around the facility and why. Conclusions and implications of this research for waste facility siting and design is considered in the final chapter (see Chapter 6).

The results of testing each hypothesis are given (see Figure 5.1). Hypothesis #1 to #6 address the initial response of residents (beliefs, values, attitudes, and actions) toward the facility. Hypothesis #7 to #9 address residents' preferences for engineering intervention measures to redesign the facility. Next, these findings are related to the theories from which they are drawn and the limitations are discussed.

5.2 Results of Testing the Hypotheses

The conceptual framework (developed in Chapter 3) structures the research hypotheses drawn from the engineering/risk assessment and social science theoretical approaches (see Figure 5.1). This framework attempts to explain the beliefs, values, attitudes, actions, and preferences of residents during the facility siting and design process. As stated earlier, this framework does not assume causation between variables only correlation.

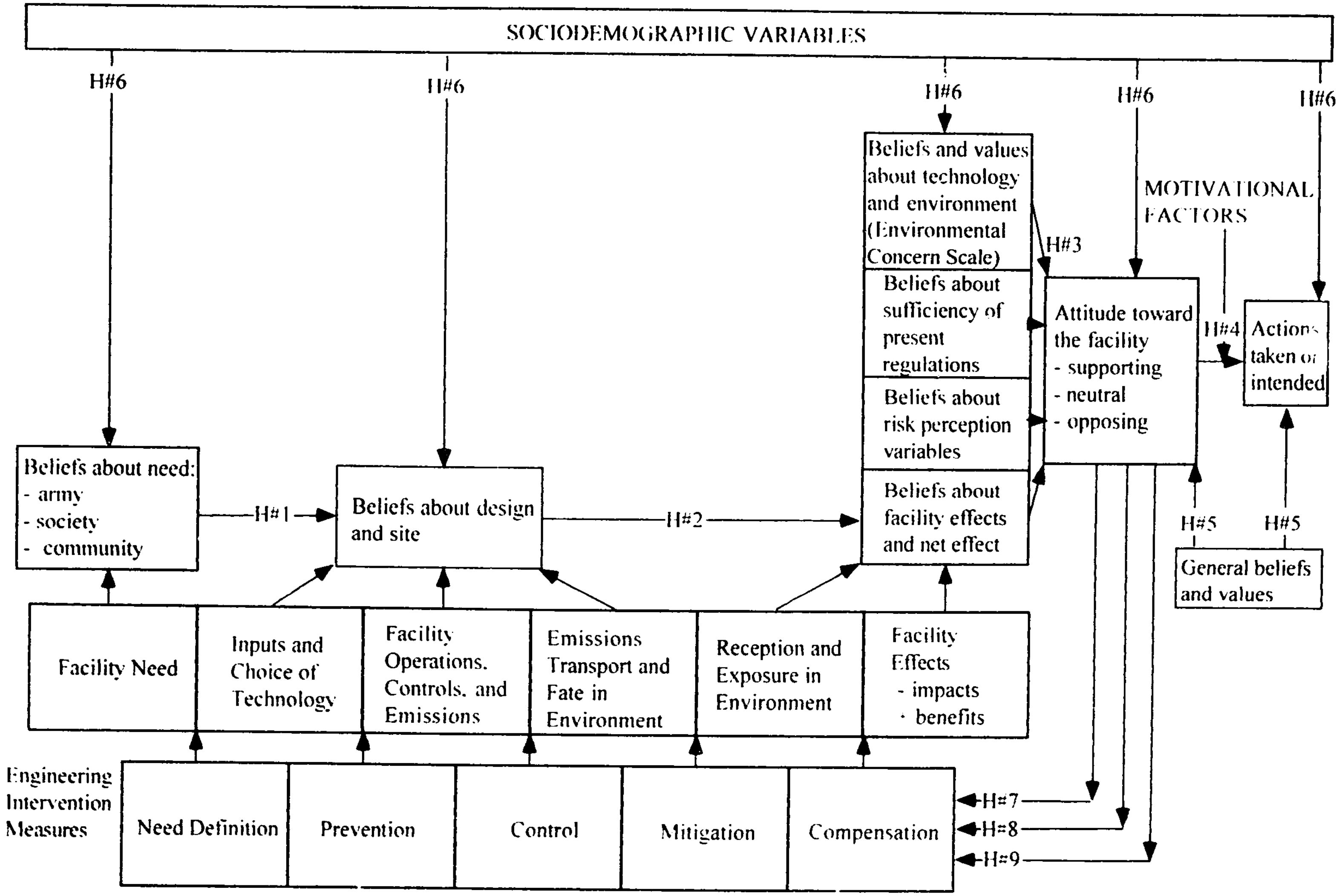

Figure 5.1 Conceptual Framework Developed from Engineering/Risk Assessment and Social Science Theoretical Approaches and the Associated Research Hypotheses

The findings of this research are compared with a previous community survey (Intercept Research Corporation, 1994) about the UMCDF. This comparison is to determine if the findings of this research are consistent with previous findings. The Intercept Research Corporation Survey (1994) was completed for the Oregon Department of Environmental Quality. The sample consisted of 400 completed telephone interviews. The telephone numbers were randomly selected and the participants were pre-screened to assure that respondents were 18 years or older and to obtain equal gender representation. The response rate is not given. To compare results, first the questions and responses are stated for Intercept Research Corporation (1994) then for this research. Correlations of the responses to sociodemographic variables are discussed.

HYPOTHESIS #1: Respondents are more likely to believe that the planning and design of the facility is the best possible if they: a) believe that the facility is needed by the community, and b) believe that the facility is needed by the Army.

Hypothesis #1 addresses the beginning of the sequence of beliefs about need to beliefs about planning/design and operations (see Figure 5.1). The data support this hypothesis. Beliefs about the sufficiency of the design are significantly (95% C.I.) and strongly correlated with the belief that the facility is needed by the community ($r_s = 0.66$) and the belief that the facility is needed by the Army ($r_s = 0.61$).

The residents' beliefs about need are compared with Intercept Research Corporation's (1994) findings (see Table 5.1). Intercept's questions address the need for safe disposal of chemical weapons and the need to protect residents' health and the environment. This research's questions are more general, asking about the Army's need and the community's need, leaving the definition of need to the respondent. For their questions, Intercept forces respondents to either agree or disagree on the telephone. This research allows respondents to neither agree nor disagree to the questions on a self-administered questionnaire. If respondents are not given the time to fully consider the question and articulate their viewpoint, then their responses may be arbitrary and inconsistent (Fischhoff, 1991).

Table 5.1 Comparing Residents' Beliefs about the Need for the Facility as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents Agree	Neither	Disagree	DK/NR
Do you agree or disagree that there is a need to build a facility of this type so that we may safely dispose of Umatilla Army Depot's aging stockpile of chemical weapons (Intercept Research Corporation, 1994)	87%		8%	5%
Do you agree or disagree that the process for destroying this chemical weapons stockpile should move ahead because leaving the weapons in place endangers the environment and public safety (Intercept Research Corporation, 1994)	78%		13%	10%
How much do you agree or disagree that the incinerator is needed by the Army?	60.8%	20.6%	14.7%	3.9%
How much do you agree or disagree that the incinerator is needed by local residents?	38.3%	27.5%	40.4%	3.9%

DK = Don't Know, NR = No Response

The percentage of respondents who agree that the facility is needed by the Army's need is comparable to the percentage agreeing with Intercept's two need questions. However, respondents are less likely to agree that the facility is needed by local residents. Intercept finds that men and individuals under 35 years of age are more likely to agree that there is a need to build a facility of this type. They also find that men and individuals with some college are more likely to agree that the facility process is needed to protect the environment and public safely. This research also finds that men are significantly (95% C.I.) more likely to agree that the facility is needed by the Army ($r_s = 0.36$). However, there was no significant correlation of age and education with need

HYPOTHESIS #2: The net effect of the facility is more likely to be determined as positive by respondents if they: a) believe that the site is the best place to put the facility and b) believe that the facility has been designed the best way possible.

This hypothesis looks at the correlation of beliefs about planning/design and beliefs about site with beliefs about the net effect by the facility (see Figure 5.1). The rating of the net effect of the facility is significantly (95% C.I.) and strongly correlated with the belief that the site is the best place ($r_s = 0.68$) and the belief that the facility is designed the best way possible ($r_s = 0.67$). The results support Hypothesis #2.

The residents' beliefs about sufficiency of Incineration as a destruction technology from this research are compared with Intercept Research Corporation's (1994) findings (see Table 5.2). Intercept's question on the sufficiency of incineration compare the safety and cost effectiveness of incineration to other available technologies. This research's question is more general asking if the incinerator has been designed to best minimize impacts and maximize benefits. A comparable percentage of residents agree and disagree with the two statements. Intercept finds that men and respondents with some college education are more likely to agree that incineration is the safest and most cost effective method. This research also finds that men are significantly (95% C.I.) more likely to agree that the facility has been designed the best way possible (r_s = 0.20) but finds no significant correlation with education.

Table 5.2 Comparing Residents' Beliefs about the Sufficiency of Incineration as a Destruction Technology as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents Agree	Neither	Disagree	DK/NR
Do you agree or disagree that of the existing technologies available for destroying this chemical weapons stockpile, incineration is the safest and most cost-effective method (Intercept Research Corporation, 1994)	47%		14%	39%
How much do you agree or disagree that the Chemical Demilitarization Incinerator has been planned and designed in the best way to minimize the negative effects and maximize the positive effects?	49%	25.5%	20.6%	5%

DK = Don't Know, NR = No Response

HYPOTHESIS #3: Respondents are more likely to have a favourable attitude towards the facility if they: a) believe that the net effect of the facility is positive, b) believe that risk perception variables are positive, c) believe that present regulations are sufficient, and d) are low on the environmental concern scale.

Hypothesis #3 looks at the beliefs which correlate with attitude towards the facility (see Figure 5.1). Beliefs that the net facility effect is positive, beliefs that the risk perception variables are positive, beliefs that present regulations are sufficient, and the environmental concern scale are all significantly (95% C.I.) correlated with attitude. The net facility effect is most strongly correlated (r_s = 0.72) with attitude, followed by the believed sufficiency of existing regulations (r_s = 0.68). The risk perception variables are moderately correlated with attitude and in the hypothesized direction: facility is not dreaded (r_s = 0.69), risks are known to exposed (r_s = 0.67), accidents are easily cleaned (r_s = 0.65), facility will protect future generations (r_s = 0.62), siting and design process is fair/equitable (r_s = 0.62), Army is trustworthy (r_s = 0.54), DEQ is trustworthy (r_s = 0.54), facility will not have chronic health effects (r_s = 0.52), risks are known to planners (r_s = 0.45), local residents have control over the siting and design process (r_s = 0.40), facility will not have acute health effects (r_s = 0.38), facility will not have catastrophic effects (r_s = 0.38), the siting and design process is voluntary (r_s = 0.36), and risks from the facility are not increasing (r_s = 0.33). The general environmental concern scale is moderately correlated (r_s = -0.27) with attitude. The greater residents' general environmental concern the less likely they are to support the facility being built. Therefore, the results support Hypothesis #3 - that the rating of net facility effect, attitude towards present regulations, risk perception variables, and general environmental concern are correlated with residents' attitude towards the facility.

Residents' trust in the Army as determined by this research are compared with Intercept Research Corporation's (1994) findings (see Table 5.3). Intercept's question asks about the trust in the Army to comply with regulations while this research asks about the overall trustworthiness of the Army. The percentage of respondents who disagree that the Army can be trusted are comparable. Intercept finds that men and individuals older than 65 years of age are more likely to believe that the Army can be trusted. This research also finds that the trustworthiness of the Army is significantly (95% C.I.) correlated with age (r_s = 0.25) but not correlated with gender.

Table 5.3 Comparing Residents' Trust in the Army as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents			
	Agree	Neither	Disagree	DK/NR
Do you agree or disagree that the United States Army can be trusted to comply with all state and federal regulations to protect the environment and public safety (Intercept Research Corporation, 1994)	56%		39%	6%
How much do you agree or disagree that the Army is trustworthy?	31.3%	25.5%	37.3%	6%

DK = Don't Know, NR = No Response

Residents' trust in the Oregon Department of Environmental Quality as determined by this research are compared with Intercept Research Corporation's (1994) findings (see Table 5.4). Intercept's question asks about the trust in the Oregon Department of Environmental Quality (DEQ) to oversee the permit process while this research asks about the overall trustworthiness of the DEQ. The percentage of respondents who disagree that the DEQ can be trusted are comparable. Intercept finds respondents younger than 55 years old and college graduates are more likely to believe that the DEQ can be trusted. This research finds no significant correlations between the trustworthiness of the DEQ and any sociodemographic variables.

Table 5.4 Comparing Residents' Trust in the Oregon Department of Environmental Quality as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents			
	Agree	Neither	Disagree	DK/NR
Do you agree or disagree that the Oregon Department of Environmental Quality can be trusted to oversee the permit process to guarantee that adequate environmental safeguards are implemented for the operation of the proposed chemical weapons incineration facility (Intercept Research Corporation, 1994)	53%		33%	14%
How much do you agree or disagree that you can trust the regulator, the Oregon Department of Environmental Quality?	24.5%	28.4%	42.1%	5%

DK = Don't Know, NR = No Response

Residents' belief in the sufficiency of present regulations as determined by this research are compared with Intercept Research Corporation's (1994) findings (see Table 5.5). Intercept's questions ask directly about the sufficiency of the existing regulations. This research uses an indirect method, where sufficiency of regulations equals preferred strictness minus present strictness. Intercept finds that 45% of respondents believe the present regulations are sufficient while this research only finds that 36% of respondents believe that the regulations are too strict or strict enough. Intercept finds that men, respondents over 35 years of age, and respondents with some college education are more likely to agree that the present regulations are sufficient. This research also finds that the belief that regulations should be more strict is significantly (95% C.I) more likely to be held by men (r_s = 0.29) and respondents with a higher income (r_s = 0.25). This research finds that education and income are significantly correlated (r_s = 0.49), it is not known if Intercept asked respondents for their income. If they did not, then the income effects may be acting through education.

Table 5.5 Comparing Residents' Belief in the Sufficiency of Existing Regulations as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents			
	Agree	Neither	Disagree	DK NR
Do you agree or disagree that existing state and federal regulations for emissions into the air are sufficient to provide for the safe operation of the proposed chemical weapons incineration facility (Intercept Research Corporation, 1994)	45%		29%	27%
	should be less strict	strict enough	should be more strict	DK NR
a) How strict do you think the restrictions and standards are now for the incineration of chemical weapons? b) How strict do you think the restrictions and standards should be for the incineration of chemical weapons? sufficiency of existing regulations = b - a	5.9%	30.5%	49.9%	19.6%

DK = Don't Know, NR = No Response

Residents' attitude towards the facility as determined by this research are compared with Intercept Research Corporation's (1994) findings (see Table 5.6). These two questions are not readily comparable. Intercept Research Corporation asks about "concern" and this research asking about "attitude". But the results indicate that residents hold a more favourable attitude towards the facility in September, 1995 than they did in August, 1994. Intercept Research Corporation (1994) found that women, individuals from 18 to 34 years of age, and those with a high school education were more concerned about the proposed facility. This research also finds a significant correlation (95% C.I.) between attitude and gender (r_s = -0.26) - women are more likely to oppose the incinerator. There is also a positive significant correlation (95% C.I.) between attitude and age (r_s = 0.24) for residents - younger people are more likely to oppose the facility. This is comparable with Intercept's finding that younger people are more concerned about the facility. This research finds no significant correlation between attitude and level of education.

Table 5.6 Comparing Residents' Attitude towards the Facility as Reported by Intercept Research Corporation (1994) with this Research's Findings

Question	% Respondents						
	5 very concerned	4	3	2	1 not concerned	DK	mean rating
On a scale of one to five, how concerned are you personally with this proposed chemical weapons incineration facility? (Intercept Research Corporation, 1994)	27%	10 %	18%	15%	28%	3%	2.94
	5 strongly oppose	4	3	2	1 strongly support	DK NR	mean rating
Do you support or oppose the Chemical Demilitarization Incinerator being built at the Umatilla Army Depot?	10%	9%	26%	27%	25%	2%	1.49

DK = Don't Know, NR = No Response

HYPOTHESIS #4: Respondents are more likely to take actions towards the facility if they: a) hold strongly positive or negative attitudes towards the facility, b) consider the facility effects to be important to their community, c) consider the facility effects to be important to them, d) feel personal responsibility, e) have personal resources available, f) have personal knowledge/expertise, g) believe that the facility is/isn't needed, and h) expect that their actions will have some affect.

Hypothesis #4 looks at the motivations to actions taken or intended (see Figure 5.1). The motivational variables which are significantly (95% C.I.) correlated with the level of action taken are: the feeling of personal responsibility to take action ($r_s = 0.40$), the belief that actions will have some effect ($r_s = 0.39$), the importance of the facility effect to self ($r_s = 0.38$), strength of attitude (rs = 0.37), and the availability of personal resources such as time and money ($r_s = 0.28$). Marginally correlated (90% C.I.) are personal knowledge/expertise, attitude (opponents are more likely to take or intend to take more actions), and belief that the facility is not needed by the community. The importance of the facility effects to the community, the general belief that the facility is needed, and the specific belief that the facility is needed by the Army are not significantly correlated with action. Therefore, the results support the hypotheses.

HYPOTHESIS #5: Respondents' attitude and actions toward the facility are correlated with general beliefs and values about decision making, methods of apportioning risk, who they trust to manage risk.

This hypothesis assumes that residents hold general beliefs and values about technology, the environment, and managing risk which are related to the residents' attitudes and actions. The scale items are cross-correlated with attitude and actions. Table 5.8 gives the significant correlations. It can be seen that there appears to be two groupings of responses based upon attitude. Residents who support the facility are more likely to support mandatory conscription in the Armed Forces and support authority. They are also more likely to support economic growth and trust experts to manage risk. Residents who oppose the facility are more likely to be ambivalent about social expectations, prefer to make decisions for themselves, believe in equality, and support a community based decision making process. Therefore, the results support the hypothesis. Some general beliefs and values are related to specific attitudes and actions toward the facility.

Table 5.7 Significant (95% C.I.) Spearman's Correlations between General Beliefs and Values with Attitude and Action

General Beliefs and Values Items	Attitude towards facility	Level of Action
I think that every able-bodied citizen should have to serve some time in the Armed Forces.	0.39	
Employees should always accept decisions made by their managers.	0.25	
The police should have the right to listen in on private telephone conversations when investigating crime.		-0.34
Economic growth is the best way to improve the quality of life.	0.31	-0.36
Experts are best able to manage risk effectively - they know the facts better than anyone.	0.21	
I would rather put up with something than bother with the hassles of politics.		-0.27
I don't like having to act the way that other people expect me to act.	-0.21	
I don't like other people to make decisions for me.	-0.25	
If people in this country were treated more equally we would have fewer problems.	-0.35	
No one person or agency can make decisions for an entire community.	-0.30	
A community's resources must be managed by the whole community, not just by a few people.	-0.32	

Significance of the Results for the Theory of Reasoned Action, Risk Perception Variables, and Altruism Theory

In the conceptual framework (see Figure 5.1), the Theory of Reasoned Action, including Risk Perception variables, and Altruism Theory describe the individual's response towards the facility. The theories state that beliefs and values contribute to the individual's attitude and that motivational variables induce the individual to take actions. The testing of Hypothesis #1 to #4 support the Theory of Reasoned Action and Altruism Theory. Beliefs about the Army's need are significantly correlated with beliefs about the planning and design of the facility. Beliefs about the planning and design of the facility and beliefs about the site are significantly correlated with beliefs about the net facility effect. The net facility effect, risk perception variables, belief that existing regulations, and environmental concern are all significantly correlated with attitude. General beliefs and values about risk management also correlate with attitude and action.

When respondents sort out their beliefs, how do they weigh the facility effects to evaluate the net facility effect? All the facility effects (except for noise) are significantly (95% C.I.) correlated with the net effect: surface water quality (r_s = 0.51), residents' health (r_s = 0.47), community image (r_s = 0.47), air quality (r_s = 0.46), environmental quality (r_s = 0.44), employment (r_s = 0.43), political influence (r_s = 0.40), wildlife populations (r_s = 0.40), groundwater quality (r_s = 0.41), property value (r_s = 0.37), development (r_s = 0.37), tax base (r_s = 0.35), public services (r_s = 0.31), product value (r_s = 0.30), historic and cultural resources (r_s = 0.27), and water quantity (r_s = 0.25). The facility effects are also significantly intercorrelated. To sort out the relative influence of each facility effect on the evaluation of the net effect, the effects were put into a multiple regression equation with net effect as the dependent variable. From the multiple regression equation, only the effect on local employment rates (β = 0.50) is significantly (95% C.I.) related to the evaluation of the net effect. When respondents evaluate the overall effect from the facility, increased local employment appears to outweigh any other factor including environmental/air quality and health.

To show the concerns of residents, the average rating of each of the facility effects is given for supporting, neither supporting nor opposing, and opposing residents (see Figure

5.2). For the rating of the effects. 5 = very positive effect. 4 = somewhat positive effect. 3 = no effect at all. 2 = somewhat negative effect. and 1 = very negative effect. This figure shows that. on average. supporting residents think that the facility will have a slight negative effect on environmental factors and a positive effect on economic and community factors. The greatest positive effect is to employment which appears to govern in their evaluation of the net effect. Neutral residents rate the environmental effects as being more negative and the economic and community effects to be less positive and even slightly negative. Their evaluation of the net facility effect appears to be more in line with their rating of the other facility effects. Opposing residents rate all the effects as negative especially the effects to environmental quality. wildlife populations. and residents' health. Opponents consider the net facility effect to be more negative than the effects. Therefore. this figure shows that employment rates are of primary importance for supporting residents. Supporting residents' focus on employment rates appears to outweigh any concerns of neutral and opposing residents. as shown by the multiple regression analysis.

The majority of the hypothesized motivational variables are significantly correlated with the level of action taken or intended. The significantly correlated motivational variables are: strength of attitude: importance of the facility effects to self: feeling of personal responsibility to take action; the availability of personal resources such as time. money. and energy: and the expectation that their actions will have some effect. Marginally correlated with the level of action taken or intended are: having personal knowledge and expertise about the facility. technology. or the political process and the belief that the facility is not needed by local residents.

How does attitude relate to the types of actions taken or intended? To answer this question. attitude is cross tabulated with the actions taken or intended to discover patterns of action (see Table 5.7). Actions taken or intended by ≥50% of respondents holding that attitude are shaded. From this table, it can be seen that the majority of residents who strongly oppose the facility take action - from talking to friends and neighbours to attending demonstrations. Over 50% of slight opponents talk to neighbours. attend open houses. and read technical information. Respondents who neither support nor oppose or

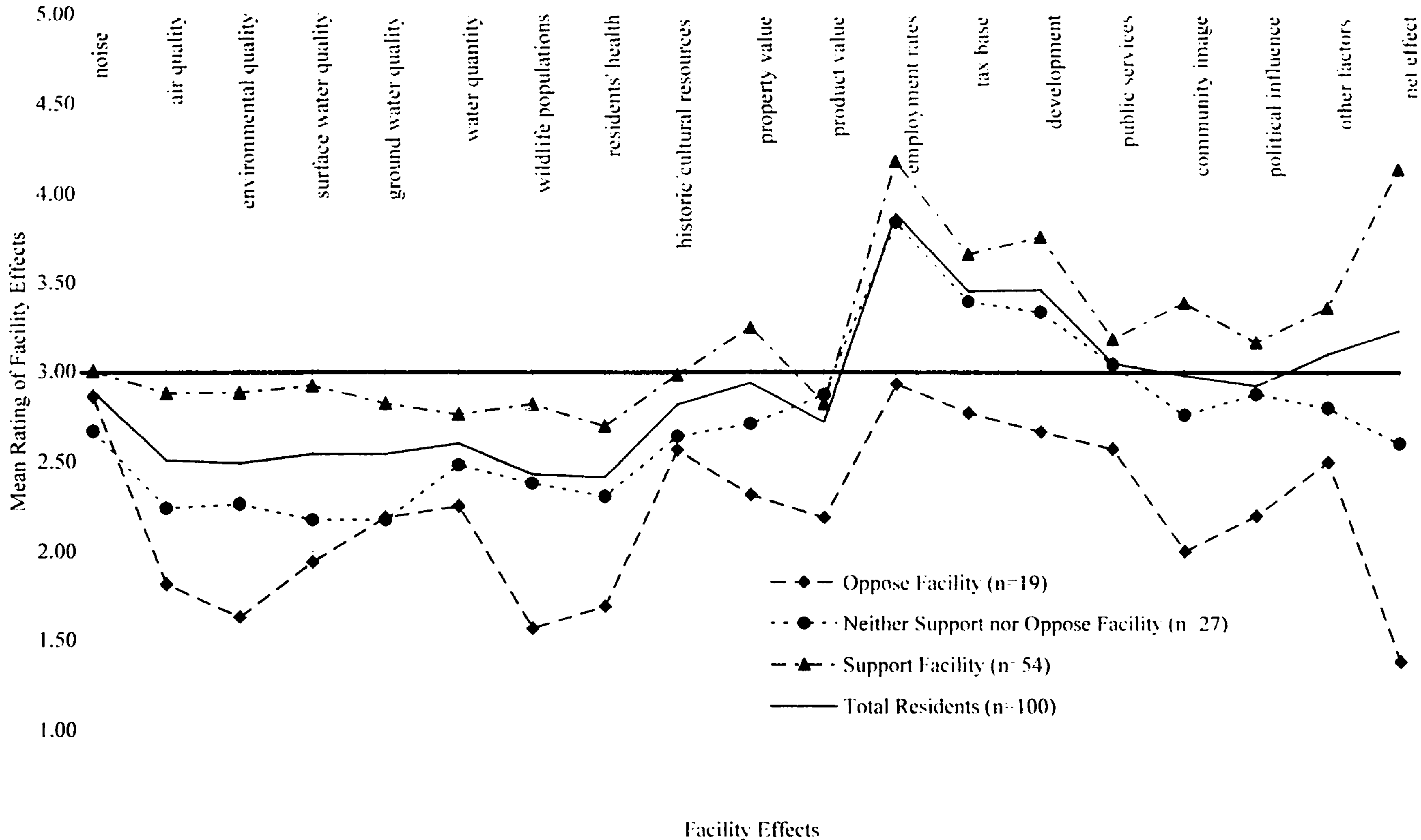

Figure 5.2 Rating of the Facility Effects by Residents with Different Attitudes toward the Facility

who slightly support the facility are less likely to take action. The majority of strong supporters talk to friends and neighbours and read technical information.

Table 5.8 Cross Tabulations of Attitude with Actions Taken and Actions that Might Be Taken for Respondents

ACTIONS	Strongly Oppose (n = 10)		Oppose (n = 9)		Neither Support nor Oppose (n = 27)		Support (n = 28)		Strongly Support (n = 26)	
	taken % on (#)	might take % on (#)	taken % on (#)	might take % on (#)	taken % on (#)	might take % on (#)	taken % on (#)	might take % on (#)	taken % on (#)	might take % on (#)
• talk to friends and neighbours	90% (9)	10% (1)	56% (5)	44% (4)	19% (5)	15% (4)	32% (9)	7% (2)	73% (19)	31% (8)
• write/telephone editor, public official, or company	60% (6)	20% (2)	22% (2)	33% (3)	0% (0)	0% (0)	11% (3)	7% (2)	15% (5)	15% (5)
• sign/circulate petition	50% (5)	30% (3)	22% (2)	33% (3)	0% (0)	4% (1)	0% (0)	7% (2)	8% (2)	23% (6)
• vote for/against candidate for public office	60% (6)	30% (3)	33% (3)	44% (4)	0% (0)	4% (1)	0% (0)	11% (3)	27% (7)	31% (8)
• attend open houses and hearings	50% (5)	20% (2)	56% (5)	33% (3)	7% (2)	11% (3)	11% (3)	14% (4)	42% (11)	35% (9)
• speak at open houses or hearings	50% (5)	10% (1)	11% (1)	11% (1)	4% (1)	0% (0)	4% (1)	4% (1)	27% (7)	15% (4)
• join or contribute money to organization	40% (4)	20% (2)	44% (4)	33% (3)	4% (1)	4% (1)	0% (0)	7% (2)	12% (3)	12% (3)
• read technical information	60% (6)	40% (4)	67% (6)	44% (4)	19% (5)	19% (5)	25% (7)	14% (4)	65% (17)	31% (8)
• attend public demonstration	50% (5)	40% (4)	22% (2)	33% (3)	4% (1)	7% (2)	4% (1)	7% (2)	8% (2)	12% (3)
• participate in a lawsuit	20% (2)	40% (4)	11% (1)	22% (2)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	4% (1)

From this table it appears that although the opponents may be a small group, they have been much more active than residents who neither support nor oppose, slightly support, and strongly support. Further, more than 40% of opponents intend to talk to friends and neighbours, vote for/against candidates for public office, read technical information, attend public demonstrations, and participate in a lawsuit. The opposing residents intend to continue their actions against the facility.

HYPOTHESIS #6: Respondents are more likely to believe that the facility is needed, the site and design are sufficient, the net effect is positive, the risk perception variables are positive, the present regulations are sufficient, be low on the environmental concern scale, have a positive attitude towards the facility, and take less action against the facility if the respondents: a) are older, b) have fewer children under 18 living at home, c) are male, d) have a lower income, e) have less education, f) hold a less liberal political ideology, g) live farther from the waste facility, and h) have worked for the U.S. Armed Forces or live with someone who has.

The significant (95% C.I.) effect of sociodemographic characteristics on beliefs, attitude, and action is also explored and presented in Table 5.9. Women are more likely to oppose the facility (r_s = 0.26) and believe that the design is not the best possible (r_s = 0.20), the facility is not needed by the Army (r_s = 0.36), and that existing regulations are not sufficient (r_s = 0.29). Older respondents are more likely to support the facility (r_s = 0.24). Respondents with higher household incomes are more likely to believe that present regulations are sufficient (r_s = 0.24). Respondents who have been employed by the Armed Forces or live with some who has are more likely to support the facility (r_s = 0.33), believe that the design is the best possible (r_s = 0.36), the site is the best possible (r_s = 0.29), the Army needs the facility (r_s = 0.31), the community needs the facility (r_s = 0.33), and that the existing regulations are sufficient (r_s = 0.28). Liberal politics are correlated with environmental concern (r_s = 0.28). Length of residency in the area, home ownership, having children under 18 years old in the home, level of education, and distance from facility are not significantly correlated to beliefs, values, attitudes, and actions.

As discussed earlier, the findings of this research are comparable with Intercept Research Corporation's (1994) survey of residents around the UMCDF. There is variation in the wording of questions and response categories between with Intercept's survey and this research. Also, Intercept discusses their results quantitatively and does not give correlations nor significance levels so they may be reporting statistically nonsignificant findings. Regardless, this research finds comparable correlations of sociodemographic variables with attitude, belief that the facility is needed by the Army and by the community, trust in the Army, belief in the sufficiency of incineration to destroy the stockpile, and belief that existing regulations are sufficient. Intercept Research Corporation (1994) found that women, individuals from 18 to 34 years of age, and those with a high school education were more concerned about the proposed facility. This research also finds that women (rs = 0.26) and younger respondents (r_s = 0.24) are significantly (95% C.I.) more likely to be opposed to the facility but finds no correlation between attitude and level of education.

Table 5.9 Significant (95% C.I.) Spearman's Correlations (r_s) between Sociodemographic Variables with Beliefs, Values, Attitudes, and Actions

Beliefs, Values, Attitudes, and Actions	Age	Gender (1 = male, 2 = female)	Income	Politics (1=conservative, 5=liberal	Worked for U.S. Armed Forces
army need		-0.36			0.31
community need					0.33
site sufficient					0.29
design sufficient		-0.20			0.36
net effect					
risk perceptions					
regulations sufficient		0.29	0.24		0.287
environmental concern				0.28	
attitude	0.24	0.26			0.33
level of action					

Intercept finds that men and individuals under 35 years of age are more likely to agree that there is a need to build a facility of this type. They also find that men and individuals with some college are more likely to agree that the facility process is needed to protect the environment and public safely. This research also finds that men are significantly (95% C.I.) more likely to agree that the facility is needed by the Army (r_s = 0.36); but finds no significant correlation of age and education with need. Intercept finds that men and individuals older than 65 years of age are more likely to believe that the Army can be trusted. This research also finds that the trustworthiness of the Army is significantly (95% C.I.) correlated with age (r_s = 0.25) and being employed by the Armed Forces or living with someone who has (r_s = 0.26) but not correlated with gender. Intercept finds respondents younger than 55 years old and college graduates are more likely to believe that the DEQ can be trusted. This research finds no significant correlations between the trustworthiness of the DEQ and any sociodemographic variables.

Intercept finds that men and respondents with some college education are more likely to agree that incineration is the safest and most cost effective method. This research also finds that men are significant (95% C.I.) more likely to agree that the facility has been designed the best way possible (r_s = 0.20) but finds no significant correlation with education. Intercept finds that men, respondents over 35 years of age, and respondents with some college education are more likely to agree that the present regulations are sufficient. This research also finds that to the belief that regulations are sufficient is significantly (95% C.I) more likely to be held by men (r_s = 0.29) and respondents with a higher income (r_s = 0.25). This research finds that education and income are significantly correlated (r_s = 0.49). It is not known if Intercept asked respondents for respondents' income. If they did not, then the income effects may be acting through education.

Therefore, the findings of this research are comparable with Intercept Research Corporation's (1994) survey of residents around the facility. Given differences in the questions, response categories, and analysis methods, comparable correlations are found between sociodemographic variables and attitude, belief that the facility is needed by the Army and by the community, trust in the Army, belief in the sufficiency of incineration to destroy the stockpile, and belief that existing regulations are sufficient.

This research also finds that sociodemographic variables are significantly (95% C.I.) correlated with the separate risk perception variables. Women are more likely to believe that accidents are not easily cleaned (r_s = 0.22), risks are not known to planners (r_s = 0.26), risks are increasing (r_s =0.26), risks are not known to exposed (r_s = 0.30), risks are chronic (r_s = 0.22), the facility is dreaded (r_s = 0.27), and accidents would be catastrophic and acute (r_s = 0.35). Older respondents are more likely to believe that the risks are known to exposed (r_s = 0.28). Longterm residents are more likely to believe that the risks are not voluntary (r_s = 0.21) and the risks are known to exposed (r_s = 0.22). Respondents with children under 18 years of age are significantly (95% C.I.) more likely to believe that the risks are not known to exposed (r_s = 0.23) and that the process is not fair (r_s = 0.21). Respondents with liberal politics are more likely to believe that accidents are not easily cleaned (r_s = 0.28) and the risks are not known to planners (r_s =0.27). Respondents with higher incomes are more likely to believe that local residents have no control (r_s = 0.22). Respondents with higher incomes are more likely to believe that the process is not voluntary (r_s = 0.40). not fair (r_s = 0.21). and that residents have no control (r_s = 0.36). Respondents employed by the Armed Forces or with living with someone who has been are more likely to believe that the facility will protect future generations (r_s = 0.35). the risks are known to those exposed (r_s = 0.35). not dread the facility (r_s = 0.34). the process is fair (r_s = 0.33). accidents will not be catastrophic (r_s = 0.28). the Army is trustworthy (r_s = 0.26). there will be no chronic risks from the facility (r_s = 0.25). and accidents are easily cleaned (r_s = 0.25). Finally. respondents who live farther from the facility are more likely to believe that local residents can control the siting process (r_s = 0.28).

Previous researchers have found that sociodemographic variables correlate with attitude and actions towards environmental issues. Correlated with environmental attitudes and actions are age (the younger the more concerned) (Howe. 1990; Hamilton. 1985; Van Liere and Dunlap. 1980). having children under 18 years of age living at home (Howe. 1990: Hamilton. 1985). gender (women more concerned) (Scott and Willits. 1994: Howe. 1990: Pilisuk et al.. 1987: Gould et al.. 1988: Hamilton. 1985: Van Liere and Dunlap. 1980). income (Scott and Willits. 1994: Vining and Ebreo. 1990: Van Liere and Dunlap. 1980). education (Scott and Willits. 1994; Pilisuk et al.. 1987; Van Liere and Dunlap. 1980). distance to waste site (Howe. 1990). and political ideology (democrats and liberals more concerned) (Scott and Willits. 1994; Gardner et al.. 1982; Van Liere and Dunlap. 1980). This research finds that only a liberal political ideology is significantly correlated with the environmental concern scale. There is no significant correlation between the environmental concern scale and any other sociodemographic variable. Women and younger respondents are significantly more likely to oppose the facility (also consistent with previous findings).

This research finds no significant correlations of any sociodemographic variables with action. regardless of correlations of sociodemographic variables with beliefs. values. and attitudes. Conversely. the motivational factors are correlated with the level of action taken. It appears that an individual's sociodemographic variables affect how that person views the facility. But, for that person to take or intend to take actions toward the facility, he or she must feel personally motivated to take action, believe that actions will have some effect, and have the available time and money. Sociodemographic variables alone do not determine who will or will not take action toward a proposed facility.

HYPOTHESIS #7: Implementing engineered intervention measures which address the respondents' most negatively rated concerns improve respondents' attitude toward the facility the most.

Hypothesis #7 looks at residents' change in attitude with the implementation of the measures which address their greatest concerns. In Questionnaire B, the overall rating of effects to residents' health is 2.34, property value is 2.66, and community image is 2.42 (where 1 = very negative effect, 3 = neither positive nor negative effect, and 5 = very positive effect). The changes in attitude (final attitude minus initial attitude) with the implementation of the #1 residents' health measure is 0.72, with the #1 property value measure is 0.66, and with the #1 community image measure is 0.60. Qualitatively, these results indicate that effects to residents' health are rated the lowest and the change in attitude with the implementation of the #1 preferred measure to address residents' health is the greatest.

To quantitatively test this hypothesis, residents' change in attitude with the implementation of their #1 preferred measure for each facility effect is correlated with the rating for that effect. To disprove the associated null hypothesis, there should be a significant negative correlation between the rating of the effect and the change in attitude (i.e. the more negative the rating of the effect, the greater the increase in attitude by implementing the #1 preferred measure to address that effect). Only the rating of community image effects is significantly (95% C.I.) correlated with the change in attitude with the implementation of the #1 preferred measure for community image effects (r_s = 0.56). This finding has the opposite sign from what was hypothesized. These results indicate that the more positive the rating of community image effects the greater the increase in attitude with the implementation of the preferred community image measure. A paired sample t-test shows that neither the effects nor the changes in attitude are rated significantly differently by residents. The lack in variability in the rating of effects and the change in attitude may account for the insignificance of the correlations.

Hypothesis #8: There are significant differences in the ranking of measures depending if the respondent is: a) in the loss domain or b) neutral or in the gain domain with respect to their reference point for each facility effect.

This hypothesis considers residents' preferences of measures as a function of their perception of the facility effects relative to their reference point. As stated in Chapter 4, two methods have been developed to determine if residents are in the loss domain or neutral or in the gain domain. To test this hypothesis, it is determined if there are significant differences in the ranking of measures depending if residents are in the loss domain or neutral or in the gain domain using the two developed methods.

The first method uses the categorization of respondents as being risk seeking or risk averse/neutral to determine their location with respect to their reference point. The frequency of individuals being risk averse, risk neutral, or risk neutral is given for effects to residents' health, property value, and community image in Table 5.10. The ranking of measures is cross-tabulated against whether the residents are risk seeking or risk neutral/averse (see Tables 5.11 to 5.13). The Kruskal-Wallis test is used to determine if there are significant differences in the ranking of measures depending if the respondent is risk seeking or risk neutral/averse. Using this test, there are no significant differences (within 95% C.I.) in the ranking of measures for effects to residents' health, property value, or community image depending if residents' are risk seeking or risk neutral/averse.

Table 5.10 Frequency of Responses from Residents Categorized as Risk Averse, Risk Neutral, or Risk Seeking for Effects to Residents' Health, Property Value, and Community Image

Facility Effects	Frequency of Responses % total respondents (number of respondents)			
	risk seeking*	risk neutral**	risk averse***	excluded****
residents' health	26% (6)	26% (6)	26% (6)	22% (5)
property value	30% (7)	17% (4)	26% (6)	26% (6)
community image	30% (7)	13% (3)	17% (4)	39% (9)

*risk seeking categorization - respondent chooses risk seeking option (Plan B) for both loss and gain questions
**risk neutral categorization - respondent chooses risk seeking option (Plan B) for loss question and risk averse option (Plan A) for gain question
***risk averse categorization - respondent chooses risk averse option (Plan A) for both loss and gain questions
****respondent who is not categorized as being risk seeking, risk neutral, or risk averse

Table 5.11 Number of Residents' Ranking of Engineering Intervention Measures to Address Residents' Health Effects Cross-Tabulated against Whether the Residents are Risk Seeking or Risk Neutral/Averse

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse
#1	3	6	1	2	0	0	1	2	1	2
#2	2	2	2	5	0	2	1	0	1	2
#3	0	0	0	2	4	4	1	3	1	2
#4	0	0	2	2	1	1	3	4	0	4
#5	1	2	1	0	1	4	0	2	3	2

Table 5.12 Number of Residents' Ranking of Engineering Intervention Measures to Address Property Value Effects Cross-Tabulated against Whether the Residents are Risk Seeking or Risk Neutral/Averse

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse
#1	1	0	2	3	1	1	2	2	1	1
#2	2	1	1	0	1	2	0	1	3	3
#3	1	1	0	0	4	3	0	2	2	1
#4	2	2	1	2	0	1	4	2	0	2
#5	1	3	3	2	1	0	1	2	1	0

Table 5.13 Number of Residents' Ranking of Engineering Intervention Measures to Address Community Image Effects Cross-Tabulated against Whether the Residents are Risk Seeking or Risk Neutral/Averse

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse	risk seeking	risk neutral or risk averse
#1	1	4	3	4	0	0	3	0	0	2
#2	1	2	2	2	0	2	0	1	4	3
#3	3	0	0	1	1	4	2	3	1	2
#4	2	2	1	1	1	1	1	4	2	2
#5	0	2	1	2	5	3	1	2	0	1

The second method of determining whether residents are in the loss, neutral, or gain domain uses residents' rating of facility effects as negative, neutral, or positive. The ranking of measures is cross-tabulated against residents rating of measures as negative or neutral/positive (using only those responses where status quo is stated as the reference point). These results are given in Tables 5.14 to 5.16. The Kruskal-Wallis test is used determine if there are significant differences in the ranking of measures depending on the rating of the effects. Using this test, there are no significant differences (95% C.I.) in the ranking of measures for effects to residents' health, property value, or community image.

Table 5.14 Residents' Ranking of Engineering Intervention Measures to Address Residents' Health Effects Cross-Tabulated against Residents' Rating of Health Effects

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect
#1	0	6	1	1	0	0	0	2	0	2
#2	1	1	0	4	0	1	0	1	0	4
#3	0	2	0	0	0	5	1	3	0	1
#4	0	1	0	5	1	0	0	2	0	3
#5	0	1	0	5	1	0	0	2	0	3

Table 5.15 Residents' Ranking of Engineering Intervention Measures to Address Property Value Effects Cross-Tabulated against Residents' Rating of Property Value Effects

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect
#1	1	1	3	5	0	2	2	1	1	2
#2	1	4	1	0	2	3	2	0	1	4
#3	0	2	0	0	5	3	0	5	2	1
#4	2	3	2	2	0	2	1	3	2	1
#5	3	1	1	4	0	1	2	2	1	3

Table 5.16 Residents' Ranking of Engineering Intervention Measures to Address Community Image Effects Cross-Tabulated against Residents' Rating of Community Image Effects

Ranking of measure	Need Definition		Prevention		Control		Mitigation		Compensation	
	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect	-ve effect	neutral or +ve effect
#1	3	1	3	3	0	0	1	[illegible]	0	0
#2	0	0	4	1	1	1	0	0	2	3
#3	1	2	0	0	2	0	2	2	2	1
#4	1	2	0	1	1	1	4	1	1	0
#5	2	0	0	0	3	3	0	1	2	1

Significance of the Results for Prospect Theory

Prospect Theory considers residents' evaluation of the facility effects and their formation of their attitude towards the facility. Each facility effect is valued as a gain or loss relative to the individual's reference point for that effect. Hypothesis #7 considers individual's mental accounting, whereby the facility effects are evaluated on separate value curves. To reduce a negative effect and improve the individual's attitude, the engineering measure must be seen as addressing the loss on the same value curve. Hypothesis #7 states that implementing engineering intervention measures which address residents' most negatively rated effects are likely to be most effective in improving their attitude toward the facility. To disprove the associated null hypothesis, there must be a significant negative correlation between the rating of the facility effect and the change in attitude after implementing #1 preferred measure for that effect (i.e. the more negative the rating of the effect, the greater the improvement in attitude with the implementation of the #1 preferred measure to address that effect).

Hypothesis #7 was not supported. The only significant correlation was between the rating of community image effects and the improvement in attitude with the implementation of the preferred community image measure (r_s = 0.56). This positive correlation was opposite from what was expected. The more negative the rating of community image effects, the smaller the change in attitude with the implementation of the preferred measure to address community image.

The engineering intervention measures may be judged by criteria other than by the effect which they address. This research attempted to control the influence of confounding variables in the evaluation of the engineering intervention measures. Regardless, probing the respondents for their rationale in ranking the measures indicated that the respondents evaluated the measures by several alternate criteria. Alternate evaluation criteria include: practicality, level of government intervention (belief in a free market approach), perceived effectiveness in addressing the effect (even though all measures were stated as being equally effective), perception of bribery, mistrust of the Army, and effectiveness of the measure in addressing another need. These alternate evaluation criteria may affect the change in attitude with the implementation of the preferred measure.

Hypothesis #8 considers respondents' ranking of measures depending on whether they are in: 1) the loss domain or 2) neutral or in the gain domain. To disprove null hypothesis #8, there should be significant differences in the ranking of engineering intervention measures depending on the respondents' location with respect to their reference point. If respondents are in the loss domain, they will prefer need definition first to set their reference point, then impact reduction measures to reduce the losses, then compensation measures to increase the benefits beyond their reference point. If respondents are in the gain domain, they will prefer need definition first to set their reference point, then compensation measures to further increase the benefits from the facility.

Two methods were developed to determine individuals' location with respect to their reference point for each facility effect. The first method is determining if respondents are risk seeking or risk neutral/averse for losses and gains which relies on the shape of the value curve. Using the first method, the null hypothesis cannot be disproved. There are no significant differences in the ranking of engineering intervention measures for residents' health effects, property value effects, and community image effects.

Why is there a lack of support for this hypothesis - is there a problem with the theory, a problem with the measurement method, or both? Schneider (1992) and Knetsch (1995) review numerous studies which test and use Prospect Theory. They find ample support that people tend to be risk aversive for gains and risk seeking for losses. This is also supported by this research. The majority of respondents choose the risk seeking option for losses and the risk averse option for gains (see Table 5.17). The shape of the hypothesized value function has also been shown to hold for numerous individual and group decision making processes in basic and applied contexts such as negotiation, industry, national security, social dilemmas, and health care (Schneider, 1992; Knetsch, 1995). The theory appears to hold.

Table 5.17 Percentage of Respondents Who Choose the Risk Seeking or Risk Averse Options for Gain and Loss Questions

Changes to Facility Effects	% respondents (n) choosing risk averse option (Plan A)	% respondents (n) choosing risk seeking option (Plan B)
Residents' Health - loss	47.8% (11)	52.2% (12)
Residents' Health - gain	52.2% (12)	47.8% (11)
Property Value - loss	56.5% (13)	43.5% (10)
Property Value - gain	34.8% (8)	65.2% (15)
Community Image - loss	52.2% (12)	47.8% (11)
Community Image - gain	43.5% (10)	56.5% (13)

The categorization of respondents as 1) risk seeking or 2) risk neutral/averse omits 5 to 9 respondents (see Table 5.10). These respondents were risk averse for losses and risk seeking for gains. This is inconsistent with the theory. Although Prospect Theory applies to the majority of individuals, the theory does not explain individual choices very well (Schneider, 1992; Abelson and Levi, 1985). Respondents discussed their rationales when choosing between the risk seeking and risk averse options for the questions. The respondents stated that they wanted to know the magnitude of the loss so that they could plan for it. Conversely, if there was going to be a gain - the bigger the better. Therefore, respondents' risk management methods may govern their choice between the risk averse and risk seeking options.

There may also be problems with the measurement method. First, the question may have been misunderstood. In choosing between the risk averse/seeking options, some respondents chose the most realistic option and not their most preferred option: "Yes, I think that 9 people could die". When reminded to choose their preferred option, the respondents could not differentiate between most preferred and most realistic. Second, respondents may have been using criteria other than probability to evaluate the options. Many individuals stated that they wanted property values to decrease to reduce their annual property taxes. Therefore, a gain in property value was actually viewed as a loss. Third, respondents were uncomfortable or unfamiliar in evaluating options for saving or losing lives and community image. They may have randomly chosen an option just to answer the question quickly (Schneider, 1992). The consideration of options may be more comfortable and familiar in terms of real property. Fourth, the first question which stated the effects as a loss may have framed the second question on gains, and biased the results (Gregory et al., 1993). Respondents are instructed to consider losses and gains from "what was originally expected". However, based on the loss question respondents may have adapted their reference point to reframe the gain question as a reduction of loss and make respondents more likely to choose the risk seeking option. To check for this framing effect, the responses to the loss question are correlated with the responses to the gain question - no significant correlations were found. Finally, the sample size (n = 23) may have been too small to reveal statistically significant correlations. The Kruskal-Wallis test relies on the Chi-square statistic which requires at least 5 cases in each cell. With the small sample size, the use of the Kruskal-Wallis test is questionable. In conclusion, this method of determining if respond[illegible] are in the loss domain or the neutral/gain domain may have problems due to [illegible]als who may be generally risk averse or risk seeking, a misunderstanding of the question, the evaluation of the options by criteria other than probability, a conflict in choosing options for lives and community image, framing effects, and the small sample size.

The second method is rating the facility effects as being negative or neutral/positive and checking what they are using as their reference point, which relies on the definition of the reference point. Using this method, there are no significant differences in the ranking of measures depending on the rating of the facility effects for residents' health effects, property value, or community image effects.

Only those responses were used where the respondent stated that they were using the status quo as their reference point. However, respondents may not use a consistent reference point to judge facility effects. It is then erroneous use respondents' evaluation of the facility effects to determine if they are in the loss domain or the neutral/gain domain. Respondents were asked what they used as their reference point to determine if they were using status quo. Some respondents' were aware of their reference point. Many respondents were not aware of their reference point. From this open-ended question, the possible range of reference points became apparent (see Table 5.18). To determine if the facility will have a negative, positive, or neutral effect, residents use status quo conditions, trust in the Army, no weapons or facility existing at the Depot at all. transporting the weapons elsewhere. and worst case conditions as their reference point.

Table 5.18 Respondents' Stated Reference Points for Evaluating the Facility Effects

Facility Effects	Negative Effect	Neither Negative nor Positive Effect (Neutral)	Positive Effect
residents' health	- past experiences and distrust of the Army, expectation that this facility will be like other Army-run facilities - nothing at the Depot - no weapons, no facility at all - nothing at the Depot - transporting the weapons elsewhere - status quo - continued storage	- trust of the Army - proven competence at Depot - status quo - present health with continued storage, present concentrations in the environment - worst case conditions	- status quo - continued storage - transporting the weapons elsewhere
property value	- nothing at the Depot - no weapons, no facility at all - status quo - current storage - facility will increase salience of the weapons	- status quo - present property value trends with current storage	- status quo - present property value trends with current storage
community image	- nothing at the Depot - no weapons, no facility at all - status quo - current storage is presently invisible - incinerator will have a stack; status quo already has a negative effect	- trust of the Army - proven competence at Depot - status quo - present property value with continued storage	- status quo - continued storage, present community image

Respondents' may view their present health as positive relative to their reference point: "I'm healthier than I expected to be at this age. I could be dead". The facility effect to residents' health is rated as being negative: "With this facility, I'll have a greater risk of getting cancer". Respondents are not using 'death' to evaluate health effects. There are few, if any, health effects which are worse than death. Instead, residents' health is being judged as negative relative to status quo. From this, it appears respondents' reference point may shift from the minimum required for survival (not dead) to an expectation level (I would be healthier if I exercised regularly and quit smoking) to the status quo condition (present health). Therefore, using respondents' rating of the facility effects to determine their location relative to their reference point is misleading. This method would only determine respondents' location with respect to one reference point of the many possible reference points. Respondents may not continue to use that reference point in further valuations.

As stated earlier, the engineering intervention measures may be judged by criteria other than by the effect which they address and by whether they define the reference point (need definition), reduce losses (prevention, control, mitigation), and increase benefits (compensation). Probing the respondents for their reasons for ranking the measures identifies the influence of confounding variables. The confounding variables would obscure any relationship between respondents' preference of measures and their location with respect to their reference point.

HYPOTHESIS #9: Respondents are more likely to prefer engineered intervention measures which intervene at upstream points along the physical cause-effect sequence: preferring need definition, then prevention, control, mitigation, and lastly, compensation.

This hypothesis considers that preferences for engineering intervention measures are ordered by a causal hierarchy - the definition of need is preferred, then prevention, control, mitigation, and lastly compensation. A frequency analysis is completed to determine if there are patterns in the rankings of measures consistent with a causal hierarchy. Figures 5.3 to 5.5 give the frequency distributions of the rankings of measures for residents' health, property value, and community image, respectively.

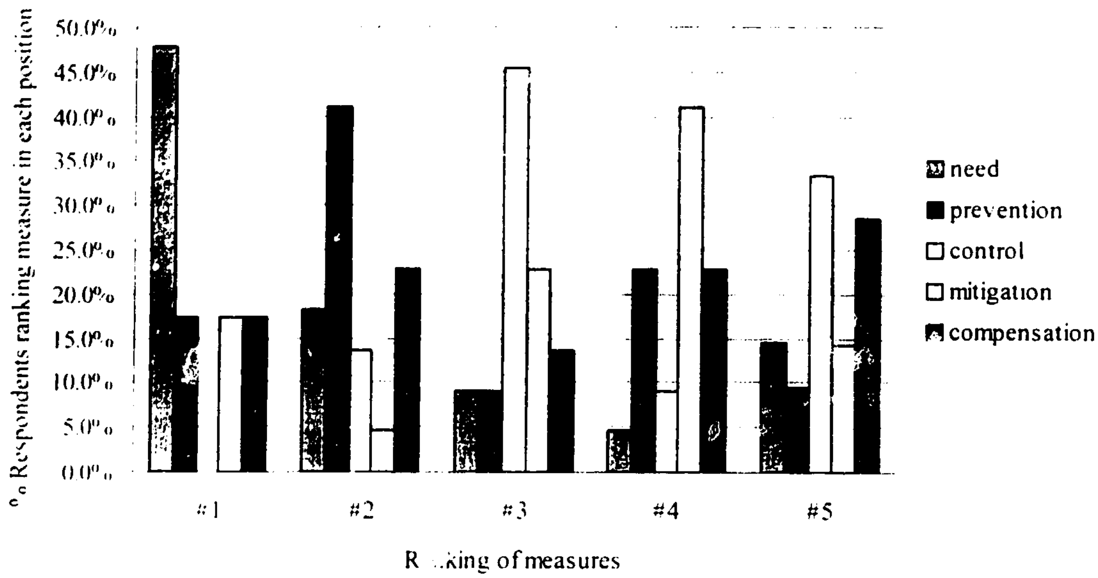

Figure 5.3 Ranking of Measures to Address Effects to Residents' Health

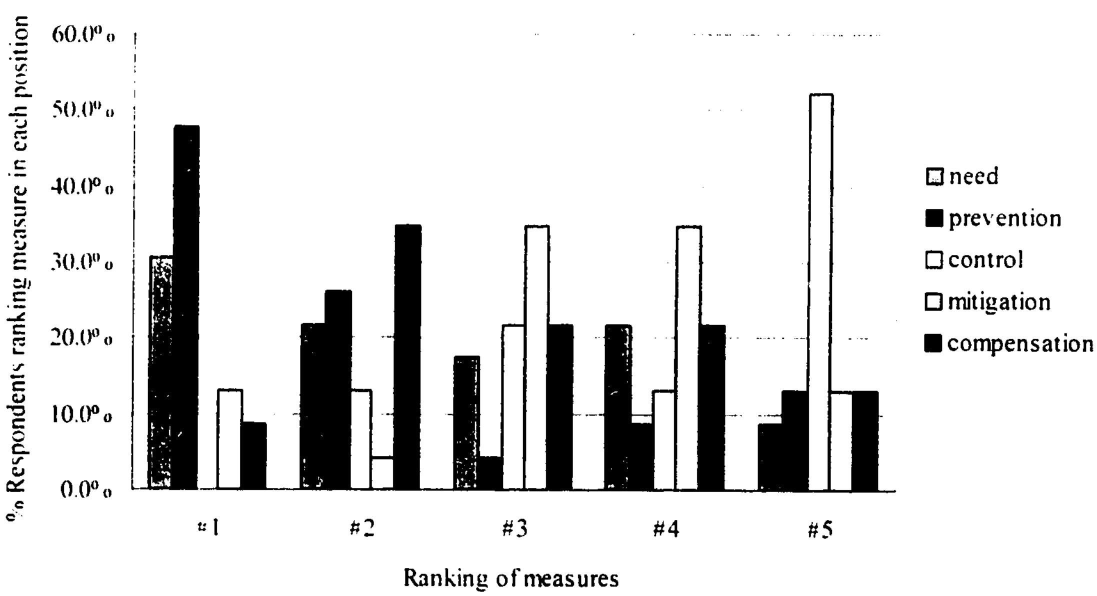

Figure 5.4 Ranking of Measures to Address Effects to Property Value

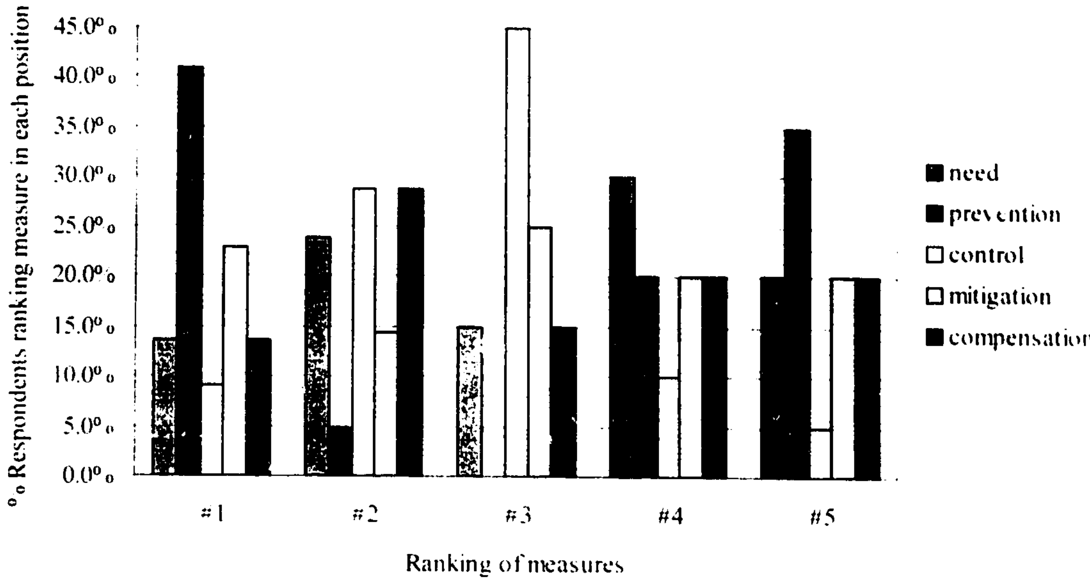

Figure 5.5 Ranking of Measures to Address Effects to Community Image

It can been seen in Figure 5.3 that there appears to be a causal hierarchy in the ranking of measures to address residents' health. However, there is not a clear ranking pattern for property value and community image (see Figures 5.4 and 5.5). There is partial qualitative support for Hypothesis #9. Residents appear to prefer upstream interventions for measures which address effects to residents' health only.

A Chi-square test is used to quantitatively determine if there are significant differences in the ranking of measures to address each effect. The differences in the ranking of measures are not significant at the 95% C.I. level. However, the use of the Chi-square test is questionable, as it requires a minimum of 5 cases in each cell. This condition is not fulfilled with the small sample size (n=23).

Significance of Results for Engineering/Risk Assessment Approaches

Hypothesis #9 tests whether respondents have linear beliefs about the cause-effect sequence by which they evaluate the engineering intervention measures. There is qualitative evidence for a causal hierarchy in preference of engineering intervention measures. Due to the small sample size, any differences in rankings of measures are not significant. To address effects to residents' health, respondents preferred need definition measures, then prevention, control, mitigation, and compensation last. When asked why they ranked the measures in that order, respondents stated that: "the measures are put in the order that they would logically occur in a chronology", "I'd rather prevent accidents than pay for them later", and "prevention is better than compensation". The measures appear to be preferred in the chronological order of implementation. The ranking of the measures and the open-ended rationales given for the rankings indicates that respondents have beliefs about a chronological cause-effect sequence by which they evaluate the engineering intervention measures. Respondents also prefer upstream engineering measures because they are considered to be more effective, the upstream measures are not the responsibility of the residents, and the probability of an impact may appear to be more remote.

However, the measures to address property value and community image do not appear to be ranked according to a causal hierarchy. It may be that respondents do not have explicit beliefs about the cause-effect sequence, consistent with the engineering/risk assessment approaches. Respondents may also evaluate the property value and community image intervention measures by other criteria. The measures are evaluated in terms of: practicality, level of government intervention (belief in a free market approach), perceived effectiveness in addressing the effect, perception of bribery, mistrust of the Army, and effectiveness in addressing another need which confounds the ranking of the measures.

5.3 Summary

This chapter presented and discussed the results of the hypotheses testing. These findings were related to the theories from which they are drawn and the limitations were discussed. The first six hypotheses addressed residents' beliefs, values, attitudes, and actions during the ongoing facility siting and design process. The testing of these hypotheses supported the Theory of Reasoned Action, Altruism Theory, and risk perception variables - beliefs and values contribute to the individual's attitude and that motivational variables induce the individual to take actions. The last three hypotheses addressed residents' preferences for engineering intervention measures to redesign the facility. Hypothesis #7 and #8 are drawn from Prospect Theory. The theory itself appears to hold - explaining the response of the majority of individuals as risk seeking for losses and risk averse for gains. However, Hypotheses #7 and #8 were not supported. Hypothesis #9 tested whether respondents have linear beliefs about the cause-effect sequence (as defined by engineering/risk assessment approaches) by which they evaluate the engineering intervention measures. The results give some qualitative support for a causal hierarchy in preference of engineering intervention measures.

Conclusions for this research are drawn in the last chapter, Chapter 6. The ability of these theories to describe the response of residents during the siting and design process of the UMCDF is discussed. Finally, the significance of these results is extended to facility siting and design processes. Principles are developed for environmental engineers and planners to design waste facilities which are more acceptable to residents in the host community.

6. Conclusions

6.1 Introduction

The purpose of this research was to determine how engineers can design a proposed waste facility to make it more acceptable to host community residents by addressing their concerns about the facility. To fulfill this purpose, there were four objectives. The first objective was to derive hypotheses from relevant engineering and social science theories to predict residents' response to the waste facility's effects and to the engineering intervention measures. This objective was completed in Chapter 3 - Review of Waste Facility Siting and Design Theory to Develop Research Hypotheses.

The second objective was to test the hypothesized predictions about residents' response to a proposed waste facility. The third objective was to determine the accuracy of the theoretical engineering design principles in predicting which engineering intervention measures will make the waste facility more acceptable to host community residents. The methodology of testing the hypotheses was discussed in Chapter 4 and the results of hypotheses testing were presented and discussed in Chapter 5. A summary of the findings for the second and third objective are given in the following sections of this chapter.

The fourth objective was to evaluate the results and extract principles for environmental engineers to design more acceptable waste facilities. Based upon the results from this research, siting and design principles are developed for environmental engineers and planners to design and site waste facilities in the final section of this chapter. Fulfilling this fourth objective also fulfills the purpose of this research.

6.2 Residents' Response to the Proposed Waste Facility

The second objective of this research was to test the hypothesized predictions about residents' response to a proposed waste facility. The Theory of Reasoned Action, Altruism Theory, and risk perception variables explain the beliefs about the facility, along the engineering risk assessment cause-effect sequence, which contribute to attitude and action. The data gleaned from Questionnaire A support the Theory of Reasoned Action, Risk Perception variables, and Altruism Theory. Residents have beliefs and values about the physical cause-effect sequence (need, design, site, effects, risk perceptions) which correlate with their attitude. Attitude and motivational variables are related to the level of action taken by residents. However, the statistical analysis can only show correlation of the elements along the sequence, not causation. Further support for causation comes from the preference of intervention measures which intervene upstream along this causal sequence (Hypothesis #9).

Further, this research's results completed in September, 1995 are comparable to those found by Intercept Research Corporation in August, 1994. This research and Intercept used different methods of administering the questionnaires (self administered questionnaire vs. telephone interviews), different questions, response categories, and analysis methods. This research was also completed one year after Intercept's research. Regardless, comparable distributions are found for attitude/concern toward the facility, belief that the facility is needed, trust in the Army, trust in the DEQ, sufficiency of incineration, and sufficiency of regulations. Therefore, it appears that this research which used a small (n = 102), nonrandom, unrepresentative sample of residents gives results comparable to Intercept's research with a larger (n=400) random sample. The similarity in the results between the two studies suggests that this research from the small, voluntary sample may be more representative of the general population around the facility than was originally thought.

For residents to support the proposed Umatilla Chemical Demilitarization Incineration Facility (UMCDF), they are more likely to believe several things along the cause-effect sequence. They believe that the facility is needed by the Army and by the community. They believe that the facility has been designed the best way possible and that the Depot is the best place to put the facility. They also believe that the existing regulations are sufficient and that the net effect from the facility is positive. When evaluating the net effect of the facility, the jobs from the construction and operation of the facility seems to outweigh any other facility effect. Supporters are also more likely to rate the risk perception variables as positive. Supporters are more likely to believe that the facility is not dreaded, risks known to exposed, accidents are easily cleaned, facility will protect future generations, process is equitable, and Army and DEQ is trustworthy. Supporters are also more likely to believe in mandatory conscription in the Armed Forces, trust others to manage risk, and focus on economic benefits to improve the quality of life. The environmental concern scale is only moderately correlated with attitude. Residents who neither support nor oppose the facility appear to need more information about the facility. They are unsure of the issues and would like an independent source of information as they do not trust the Army or the DEQ.

Opposing residents question the very need for the facility, believing that the Chemical Weapons Convention Treaty need not be ratified, the Congressional mandate can be revised, and that the weapons can be stored safely for another 120 years. They are more likely to believe that incineration is not the best method for destroying the weapons and that alternate destruction technologies should be developed. They are also more likely to believe that the Depot is not the best place to put the facility. The munitions should not be destroyed at each site but should be shipped to a single central facility. Opponents are also significantly more likely to believe that present regulations are too lax. The net effect from the facility is negative. The facility will negatively affect all environmental, economic, and community factors. Moreover, the opponents dread the facility and believe that all the risks are unknown, accidents will not be easily cleaned, and will affect future generations. They also distrust the Army and DEQ and believe that the process is not fair and equitable. Opponents are more likely to believe in equality, a community decision making process, and avoiding social obligations. Opponents are more likely to have taken actions towards the facility and intend to continue to take action. Motivations for action are feelings of personal responsibility, the belief that the actions will have some effect, the importance of the effects to self, the strength of attitude, and availability of personal resources. Women and younger respondents tend to oppose the facility.

6.3 Residents' Preferences for Engineering Intervention Measures

The third objective was to determine how residents want their concerns about the facility addressed. The evaluation of engineering intervention measures is considered by Prospect Theory and by the engineering/risk assessment causal sequence. This research shows a lack of support for Prospect Theory. Methodological difficulties may have obscured any support for the theory. There is difficulty in quantitatively defining respondents' reference point and their location with respect to their reference point. Adequately controlling confounding variables in their ranking of engineering intervention measures is also a difficulty. Further research should attempt to address these difficulties.

Residents do appear to have beliefs about the engineering/risk assessment cause-effect sequence and use a causal hierarchy to evaluate the engineering intervention measures. To address effects to residents' health, most respondents prefer: #1 to define the Army's need, community's need, and general social need and design the facility to address those needs; #2 to prevent impacts from occurring by altering the characteristics of the wastestream, inputs, and site; #3 to control impacts by altering the facility design and operation to regulate emissions; #4 to mitigate impacts which have occurred, and #5 compensate any remaining impacts. This causal hierarchy is not as apparent for addressing effects to property value and community image. This may indicate that residents do not have salient cause-effect beliefs for these effects or that they have more important criteria by which they evaluate the engineering intervention measures for these effects.

6.4 Principles for the Design of Waste Facilities

The purpose of this research was to determine how engineers can design a proposed waste facility to make the facility more acceptable to residents and increase the likelihood that the facility will be built. The fourth objective was to develop siting and design principles from the findings of this research which fulfills the purpose of this research. Following is a statement of each principle with a review of the results and a discussion of the significance for siting and design processes.

Principle #1: The need for the facility must be identified an[illegible] ded in the facility design

Residents' attitude towards the facility improves with the recognition of the Army's and the community's need for the facility. Residents' attitude is significantly (95% C.I.) and strongly correlated with the belief that the facility is needed by the community (r_s = 0.80) and the belief that the facility is needed by the Army (r_s = 0.69). The Army's reasons for proposing the UMCDF were legislative and service needs. The Army must destroy the unitary chemical stockpile by the year 2004 to fulfill the Congressional mandate in the Department of Defense Authorization Act of 1985. Incineration is the only proven technology capable of acceptably destroying the complete munitions stockpile by the deadline. The local residents need the facility to remove the risk to their health from continued storage of the munitions at the Depot. The munitions are leaking and there is a risk that the M55 rockets may auto-ignite. The community also has an economic need for the facility. The local area is among the poorest areas in Oregon. The facility would bring 550 jobs during construction and 740 new jobs during operation. Further, the UMCDF is also required by society to meet an international agreement with other countries. Need definition was the most preferred measure to address effects to residents' health by 47.8% of respondents. Other researchers have also found that defining the need for the facility is important to residents' beliefs and attitude towards the facility (Zeiss and Lefsrud, 1995; Lober and Green, 1994; Kunreuther et al., 1993; Armour, 1991; Gregory et al., 1991).

What does this imply for siting and design processes? First, environmental engineers must identify the all the proponents' reasons for the facility. Second, engineers must also identify residents' needs or salient losses in the community. Seeking public needs data is positively correlated with the enhancement of the planning dialogue, improving public education programs, and identifying the public's goals and negatively correlated with the success of the siting attempt (Ellis and Disinger, 1981).

Finally, engineers must determine how the proposed facility can be designed or sited to address the community's needs. Residents' beliefs about the need for the facility are related to their beliefs about the sufficiency of the facility design and their attitude towards the facility. The facility must be designed to meet their needs for residents to believe that the facility has been designed the best way possible to minimize the impacts and maximize the benefits. For example, the host community must recognize that a hazardous waste facility is needed to safely dispose of wastes which are currently being disposed of illegally. The waste facility could accept household hazardous wastes to further protect the health of local residents.

Principle #2: The choice of site and facility design must be seen as the best possible

Residents who believe that the site and design are the best possible are more likely to have a favourable attitude towards the facility. Residents' attitude toward the facility is significantly (95% C.I.) and strongly correlated with the belief that the site is the best possible ($r_s = 0.77$) and that the design is the best possible ($r_s = 0.65$). The importance of the best possible site and design to residents' attitude has also been found by others (Easterling, 1992; Kraft and Clary, 1991; Clapham, 1990; Gould et al., 1988).

Environmental engineers and planners must assure that the best site is chosen and that the community is aware of the selection process. The selection of the best site must be based upon the ability to meet the needs while minimizing impacts and maximizing benefits. A list of siting criteria must be developed from the proponent's, society's, and the community's needs for the facility. Environmental and safety needs may require a minimum distance from the facility to residences, schools, and hospitals and the exclusion of flood areas, naturally occurring wetlands, and seismic zones. Legislative needs would require adherence to all regulatory standards. Service needs may require access to a major transportation route to haul the wastes. Economic needs may require that the facility be sited away from residences to prevent property value impacts. Societal needs may be to equitably distribute the impacts and benefits from the facility. The list of siting criteria must be used to evaluate alternative sites and be open for public review. The use of consistent siting criteria demonstrates to residents that the site is the best possible option to meet the needs for the facility while minimizing the impacts and maximizing the benefits.

Environmental engineers must go through a similar evaluation process when choosing the technology and design of the facility. The selection of the best technology and design should be based upon the ability to meet the proponent's, the community's, and society's needs while minimizing impacts and maximizing benefits. A list of selection criteria can be developed based upon the needs for the facility. Service needs require a technology which irreversibly decontaminates the entire wastestream. Environmental needs require minimizing the possibility of environmental impacts and assuring that the operator has a history of compliance with the applicable laws and regulations. Again, the application of objective selection criteria must demonstrate to the residents that the chosen technology is the best possible to meet the needs while minimizing the impacts and maximizing the benefits.

Principle #3: The net effect from the facility must be seen as positive

Residents who rate the net facility effect as positive are more likely to hold a more favourable attitude towards the facility. Residents' attitude towards the facility is significantly (95% C.I.) and strongly correlated to their rating of the net facility effect ($r_s = 0.72$). Others have also found that the greater the net perceived risk, the more unacceptable the technology or the regulation of the technology, and the greater the opposition (Lober, 1995; Hallman and Wandersman, 1995; Vaughan, 1993; Fort et al., 1993; Flynn et al., 1992; Kunreuther et al., 1990; Gould et al., 1988; Gardner et al., 1982; Fischhoff et al., 1978).

Residents' consider several facility effects when evaluating the overall net effect from the facility. For the UMCDF, all the facility effects were significantly correlated with the net facility effect. Health issues were not residents' only concern. Residents were also concerned about economic issues, and community/social issues such as stigma. The residents will oppose the facility if their complete range of concerns are not adequately being addressed. Other researchers have also found that residents are concerned about a range of facility effects (Zeiss and Atwater, 1991; Farago et al., 1989).

For environmental engineers to maximize the net effect from the facility the complete set of facility effects must be considered. Engineers must not only consider the health risk from the facility, but also the affect that the facility may have on the local economy and community. Engineering intervention measures must be developed to address the range of residents' concerns about the facility effects to assure that the net effect from the facility is positive (Kunreuther et al., 1993).

To make the net effect from the facility more positive, impact reduction measures must be used to reduce the negative effects and compensation used to increase the positive effects. There is some evidence that residents prefer to address their concerns in chronological order starting with the need for the facility; then preventing, controlling, and mitigating impacts; and compensating any remaining impacts last. Addressing the impacts in this chronological order also addresses the previously mentioned issues of need, sufficiency of site and design, and the net facility effect. The need for the facility must be defined first. The need for the facility determines the goals that the facility must fulfill and provides criteria by which the options for facility inputs, design, and operations are evaluated. Second, the inputs and site must be altered to prevent impacts from occurring. The site must be considered the best place to put the facility. Third, control measures must regulate the emissions into the environment to reduce impacts from the facility. The final design of the facility and existing regulations must be seen as the best possible to prevent and control the facility impacts. Fourth, mitigation measures must be sufficient to reduce any impacts which do occur. Compensation is preferred last to pay for or provide alternate goods for impacts which cannot be further reduced.

Principle #4: The implementation of residents' most preferred measures improves facility acceptance

This research found that implementing residents' most preferred engineering intervention measures to address their concerns made the facility more acceptable to them. Implementing residents' most preferred measure to address effects to residents' health, property value, and community image improved their attitude an average of 0.72, 0.66, and 0.60 (out of 9), respectively. An improvement in residents' attitude with the implementation of their preferred measures has also been found by others (Portney, 1991; Zeiss, 1991; Elliott, 1984; Ellis and Disinger, 1981).

After identifying residents' needs and concerns, engineers must determine how residents how they prefer to have their concerns addressed. Engineers can determine residents' preferences indirectly by using theoretical predictions, or directly by asking them. This research provides evidence that residents prefer to address their concerns about residents' health in chronological order starting with the need for the facility; then preventing, controlling, and mitigating impacts; and compensating any remaining impacts last. Based upon these findings, sets of engineering intervention measures can be developed to intervene along the cause-effect sequence to manage the facility effects. This research also shows that asking residents about their preferences and implementing their preferred measures makes the facility more acceptable to them.

This research finds that the risk perception variables are significantly (95% C.I.) correlated with attitude towards the facility (from r_s = 0.67 to r_s = 0.33). Other researchers have also found that residents' risk perception variables are correlated with their attitude (Lober, 1995; Hallman and Wandersman, 1995; Vaughan, 1993; Fort et al., 1993; Flynn et al., 1992; Kunreuther et al., 1990; Gould et al., 1988; Gardner et al., 1982; Fischhoff et al., 1978).

Including residents in the siting and design process may also reduce their risk perceptions from the facility. Opposing residents are more likely to believe that the facility is dreaded, risks are unknown, accidents are not easily cleaned, the facility will not protect future generations, and the proponent and regulator are not trustworthy. An open siting and design process serves to increase the trustworthiness of the proponent and the regulator, make the process more fair and equitable, increase knowledge of the risks, and increase local control and voluntariness (Hadden, 1991; Ellis and Disinger, 1981).

Finally, the four design principles gleaned from this research must be incorporated into the facility siting and design processes to effectively alter the end product. The basic concepts of engineering design include: 1) identifying the need as precisely as possible or necessary, 2) analyzing the problem or need - the limitations and evaluation criteria, 3) developing a conceptual design and generating alternatives, and 4) evaluating and selecting among the alternatives. Principle #1 from this research identifies the community's need for the facility and incorporates the community's needs as part of the limitations or evaluation criteria by which to evaluate alternatives. Principle #2 states that the chosen site and facility design must meet the decision criteria better than any other alternative. Principle #3 states that the net effect from the facility must be positive - i.e. the chosen site and facility design must be better than the 'no action' alternative. Principle #4 considers the residents as partners in the evaluation and selection of engineering intervention measures in making the facility more acceptable to them. In summary, the design principles developed from this research offer environmental engineers and planners tangible methods to incorporate residents' beliefs, values, and attitudes into the siting and design process to effectively alter the waste facility and it more acceptable.

7. References

(1994, May 18). Sierra Club Joins Anti-Incineration Effort at Chem Stockpile Sites. Defense Environmental Alert, p. 23.

(1995, November 16). Army Studying Alternatives to Incinerating Nerve Gas. Tri-City Herald. Tri-Cities, Washington, p. A4.

(1995, October 18). Depot Records 100th 'Leaker'. East Oregonian, p. A3.

(1995). Umatilla Chemical Demilitarization Facility (UMCDF) Resource Conservation and Recovery Act (RCRA) Application. U.S. Army.

Abelson, R. P. and A. Levi (1985). Decision Making and Decision Theory. Handbook of Social Psychology. New York, NY, Random House. Third, ed. 231.

Ajzen, I. and M. Fishbein (1980). Understanding Attitudes and Predicting Social Behavior. Englewood-Cliffs, NJ, Prentice-Hall.

Alhakami, A. S. and P. Slovic (1994). "A Psychological Study of the Inverse Relationship between Perceived Risk and Perceived Benefit." Risk Analysis **14**(6): 1085-1096.

Armour, A. M. (1991). "The Siting of Locally Unwanted Land Uses: Towards a Cooperative Approach." Progress in Planning **35**: 1-74.

ASME (1988). Hazardous Waste Incineration: A Resource Document. New York, American Society of Mechanical Engineers.

Babbie, E. (1992). Survey Research Methods. Belmont, CA, Wadsworth Publishing Co.

Bacow, L. S. and J. R. Milkey (1982). "Overcoming Local Opposition to Hazardous Waste Facilities: The Massachusetts Approach." Harvard Environmental Law Review **6**: 265-305.

Baldassare, M. and C. Katz (1992). "The Personal Threat of Environmental Problems as Predictors of Environmental Practices." Environment and Behavior **24**(5): 602-616.

Barron, W. F. (1992). "Evaluating Alternative Environmental Control Measures: The Case of Industrial Sulfur Dioxide in Hong Kong." Journal of Environmental Management **35**: 229-238.

Bord, R. J. and R. E. O'Conner (1992). "Determinants of Risk Perceptions of a Hazardous Waste Site." Risk Analysis **12**(3): 411-416.

Bord, R. J., P. J. Ponzurick, and W.F. Witzig (1985). "Community Response to Low-Level Radioactive Waste: A Case Study of an Attempt to Establish a Waste Reduction and Incineration Facility." IEEE Transactions on Nuclear Science **NS-32**(6): 4466-4472.

Bostram, A., B. Fischhoff, and M. Granger-Morgan (1992). "Characterizing Mental Models of Hazardous Processes: A Methodology and Application to Radon." Journal of Social Issues **48**(4): 85-100.

Brunner, C. R. (1984). Incineration Systems: Selection and Design. New York, Van Nostrand Reinhold Company.

Camerer, C. F. and H. Kunreuther (1989). "Decision Processes for Low Probability Events: Policy Implications." Journal of Policy Analysis and Management **8**(4): 565-592.

Canter, L. W. (1978). Environmental Impact Assessment. New York, McGraw-Hill.

Canter, L. W., J. M. Robertson, and R.M. Westcott (1991). "Identification and Evaluation of Biological Impact Mitigation Measures." Journal of Environmental Management **33**: 35-50.

Carlson, K. A. (1991). "What Happens and What Counts: Resident Assessments of Prison Impacts on their Communities." Humboldt Journal of Social Relations **17**(1&2): 211-237.

Carnes, S. A., E. D. Copenhaver,E. J. Soderstrom, J. Sorensen, E. Peelle, J. H. Reed, and D. J. Bjornstad (1983). Incentives and the Siting of Radioactive Waste Facilities. Regional and Urban Studies Section, Energy Division, Oak Ridge National Laboratory.

Carr, F. H. and L. A. Rich (1988). "Chemical Weapons are for Burning." Chemical Week **March 16**: 84, 88.

Carter, L. J. (1987). "Siting the Nuclear Waste Repository: Last Stand at Yucca Mountain." Environment **29**(8): 8-13, 26-32.

Centaur-Associates (1979). Siting of Hazardous Waste Management Facilities and Public Opposition. Hazardous Waste Management Division, Office of Solid Waste, U.S. Environmental Protection Agency.

Clapham, W. B. (1990). "Some Approaches to Assessing Environmental Risk in Siting Hazardous Waste Facilities." The Environmental Professional **12**: 32-39.

Cockle, R. (1994, August 11). Group Accuses Army of Exaggerating M55 Risk. Oregonian.

Covello, V. T. (1983). "The Perception of Technological Risks: A Literature Review." Technological Forecasting and Social Change **23**: 285-297.

Cox, R. A. and D. H. Slater (1984). State-of-the-Art of Risk Assessment of Chemical Plants in Europe. Low-Probability High-Consequence Risk Analysis: Issues, Methods, and Case Studies. New York, Plenum Press. 257-283.

Dake, K. (1991). "Orienting Dispositions in the Perception of Risk: An Analysis of Contemporary Worldviews and Cultural Biases." Journal of Cross-Cultural Psychology **22**(1): 61-82.

Dake, K. (1992). "Myths of Nature: Culture and the Social Construction of Risk." Journal of Social Issues **48**(4): 21-37.

Dake, K. and A. Wildavsky (1991). Individual Differences in Risk Perception and Risk-Taking Preferences. The Analysis, Communication, and Perception of Risk. New York, Plenum Press. 15-24.

Davis, C. (1984). "Substance and Procedure in Hazardous Waste Facility Siting." Journal of Environmental Systems **14**(1): 51-62.

Davos, C. A., W. A. Thistlewaite, and E. C. Paik (1993). "Air Quality Management: Participatory Ranking of Control Measures and Conflict Analysis." Journal of Environmental Management **37**: 301-311.

De Young, R. (1986). "Some Psychological Aspects of Recycling: The Structure of Conservation Satisfactions." Environment and Behavior **18**(4): 435-449.

Dorius, N. (1993). "Land Use Negotiation: Reducing Conflict and Creating Wanted Land Uses." American Planning Association Journal Winter: 101-106.

Douglas, M. (1985). Risk Acceptability According to the Social Sciences. New York, Russell Sage Foundation.

Duberg, J. A., M. L. Frankel, and C. M. Niemszewski (1980). "Siting of Hazardous Waste Management Facilities and Public Opposition." Environmental Impact Assessment Review **1**(1): 84-89.

Early, C. (1994). Math Error Proves M55 Rockets Will Keep. Hermiston Herald. Hermiston, 3.

Easterling, D. (1992). "Fair Rules for Siting a High-Level Nuclear Waste Repository." Journal of Policy Analysis and Management **11**(3): 442-475.

Eden, S. E. (1993). "Individual Environmental Responsibility and its Role in Public Environmentalism." Environment and Planning A **25**: 1743-1758.

Ehrenfeld, J. R., E. P. Craig, and J. Nash (1989). "Waste Incineration: Confronting the Sources of Disagreement." Environmental Impact Assessment Review **9**: 305-315.

Elliott, M. L. P. (1984). "Improving Community Acceptance of Hazardous Waste Facilities through Alternative Systems for Mitigating and Managing Risk." Hazardous Waste **1**(3): 397-410.

Ellis, R. A., and J. F. Disinger (1981). "Project Outcomes Correlate with Public Participation Variables." Water Pollution Control Federation **53**(11): 1564-1567.

Ember, L. (1990). "Chemical Weapons Disposal: Daunting Challenges Still Ahead." Chemistry and Engineering **August 13**: 9-19.

Environmental-Research-Foundation (1992). Waste Wars: The Army Opens a New Front. Rachel's Hazardous Waste News. Annapolis, MD.

Farago, K., A. Vari, and J. Vecsenyi (1989). "Not in my Town: Conflicting Views on the Siting of a Hazardous Waste Incinerator." Risk Analysis **9**(4): 463-471.

Fischhoff, B. (1983). "Predicting Frames." Journal of Experimental Psychology: Learning, Memory, and Cognition **9**(1): 103-116.

Fischhoff, B. (1991). "Value Elicitation: Is There Anything in There?" American Psychologist **46**(8): 835-847.

Fischhoff, B., C. Hohenemser, R. E. Kasperson, and R. W. Kates (1978). "Handling Hazards." Environment **20**(7): 16-37.

Fischhoff, B., P. Slovic, S. Lichtenstein, S. Read, and B. Combs (1978). "How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits." Policy Sciences **9**: 127-152.

Fishbein, M. and I. Ajzen (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, MA, Addison-Wesley Publishing Company.

Fiske, A. P. (1992). "The Four Elementary Forms of Sociality: Framework for a Unified Theory of Social Relations." Psychological Review **99**(4): 689-723.

Flynn, J., W. Burns, C. K. Mertz, and P. Slovic (1992). "Trust as a Determinant of Opposition to a High-Level Radioactive Waste Repository: Analysis of a Structural Model." Risk Analysis **12**(3): 417-429.

Fort, R., R. Rosenman, and W. Budd (1993). "Perception Costs and NIMBY." Journal of Environmental Management **38**: 185-200.

Fowler, F. J., Jr. (1993). Survey Research Methods - Revised Edition. Newbury Park, Sage Publications.

Froming, W. J., L. Allen, and R. Jensen (1985). "Altruism, Role-Taking, and Self-Awareness: The Acquisition of Norms Governing Altruistic Behavior." Child Development **56**: 1223-1228.

Functowicz, S. O. and J. R. Ravetz (1985). Three Types of Risk Assessment. Risk Analysis in the Private Sector. New York, Plenum Press.

G.A.O. (1985). Chemical Munitions: Cost Estimates for Demilitarization and Production. United States General Accounting Office.

G.A.O. (1990). Chemical Weapons: Stockpile Destruction Delayed a the Army's Prototype Disposal Facility. United States General Accounting Office.

G.A.O. (1991). Chemical Weapons: Stockpile Destruction Cost Growth and Schedule Slippages Are Likely to Continue. United States General Accounting Office.

G.A.O. (1994). Chemical Weapons Disposal: Plans for Nonstockpile Chemical Warfare Materiel Can Be Improved. United States General Accounting Office.

G.A.O. (1994a). Chemical Weapons Destruction: Advantages and Disadvantages of Alternatives to Incineration. United States General Accounting Office.

G.A.O. (1994b). Chemical Weapons: Stability of the U.S. Stockpile. United States General Accounting Office.

G.A.O. (1994c). Chemical Weapons Stockpile: Army's Emergency Preparedness Program Has Been Slow to Achieve Results. United State General Accounting Office.

Gamba, R. J. and S. Oskamp (1994). "Factors Influencing Community Residents' Participation in Commingled Curbside Recycling Programs." Environment and Behavior **26**(5): 587-612.

Gardner, G. T., A. R. Tiemann, L. C. Gould, D. R. DeLuca, L. W. Doob, J. A. J. Stolwijk (1982). "Risk and Benefit Perceptions, Acceptability Judgments, and Self-Reported Actions toward Nuclear Power." Journal of Social Psychology **116**: 179-197.

Goldenhar, L. M. and C. M. Connell (1993). "Understanding and Predicting Recycling Behavior: An Application of the Theory of Reasoned Action." Journal of Environmental Systems **22**(1): 91-103.

Gould, L. C., G. T. Gardner, D. R. DeLuca, A. R. Tiemann, L. W. Doob, and J. A. J. Stolwijk (1988). Perceptions of Technological Risks and Benefits. New York, Russell Sage Foundation.

Greenberg, M. R. and R. F. Anderson (1984). Hazardous Waste Sites: The Credibility Gap. New Brunswick, NJ, Rutgers.

Gregory, R., J. Flynn, and P. Slovic. (1995). "Technological Stigma." American Scientist **83**(3): 220-223.

Gregory, R. and H. Kunreuther (1990). "Successful Siting Incentives." Civil Engineering **April**: 73-75.

Gregory, R., S. Lichtenstein, and D. MacGregor (1993). "The Role of Past States in Determining Reference Points for Policy Decisions." Organizational Behavior and Human Decision Processes **55**: 195-206.

Gregory, R. and R. Mendelsohn (1993). "Perceived Risk, Dread, and Benefits." Risk Analysis **13**(3): 259-272.

Gunter, V. J. and B. Finlay (1988). "Influences on Group Participation in Environmental Conflicts." Rural Sociology **53**(4): 498-505.

Hadden, S. G. (1991). "Public Perception of Hazardous Waste." Risk Analysis **11**(1): 47-57.

Hagey, J. (1996a, January 23). Umatilla Depot Contents Unveiled. Tri-City Herald. Tri-Cities, Washington, p. A3.

Hagey, J. (1996b, January 31). Incinerator Safety Worries Morrow. Tri-City Herald. Tri-Cities, Washington, p. A5.

Hagey, J. (1996c, January 20). Experts Answer Questions on Army Depot Incinerator. Tri-City Herald. Tri-Cities, Washington, p. A4.

Hallman, W. K. and A. Wandersman (1992). "Attribution of Responsibility and Individual and Collective Coping with Environmental Threats." Journal of Social Issues **48**(4): 101-118.

Hallman, W. K. and A. H. Wandersman (1995). "Present Risk, Future Risk or No Risk? Measuring and Predicting Perceptions of Health Risks of a Hazardous Waste Landfill." Health, Safety, and Environment : 261-280.

Hamilton, L. C. (1985). "Concern about Toxic Wastes: Three Demographic Predictors." Sociological Perspectives **28**(4): 463-486.

Hartman, R. S., M. J. Doane, and C. K. Woo (1991). "Consumer Rationality and the Status Quo." Quarterly Journal of Economics **106**: 141-162.

Hohenemser, C., R. E. Kasperson, and R. W. Kates (1985). Causal Structure. Perilous Progress: Managing the Hazards of Technology. Boulder, Westview Press. 25-42.

Hopper, J. R. and J. M. Nielsen (1991). "Recycling as Altruistic Behavior: Normative and Behavioral Strategies to Expand Participation in Community Recycling Program." Environment and Behavior **23**(2): 195-220.

Howe, H. L. (1990). "Public Concern about Chemicals in the Environment: Regional Differences Based on Threat Potential." Public Health Reports **105**(2): 186-195.

Intercept Research Corporation (1994). Umatilla Army Depot Community Assessment Survey. Oregon Department of Environmental Quality.

Johnson, B. B. (1987). "Public Concerns and the Public Role in Siting Nuclear and Chemical Waste Facilities." Environmental Management **11**(5): 571-586.

Johnson, B. B. and P. Slovic (1994). "Improving Risk Communication and Risk Management: Legislated Solutions or Legislated Disasters?" Risk Analysis **14**(6): 905-.

Kahneman, D., J. L. Knetsch, and R. H. Thaler (1991). "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias." Journal of Economic Perspectives **5**(1): 193-206.

Kahneman, D. and A. Tversky (1979). "Prospect Theory: An Analysis of Decision under Risk." Econometrica **47**(2): 263-291.

Kahneman, D. and A. Tversky (1984). "Choices, Values, and Frames." American Psychologist **39**(4): 341-350.

Kartez, J. D. (1989). "Rational Arguments and Irrational Audiences: Psychology, Planning, and Public Judgment." American Planning Association Journal : 445-456.

Katzev, R. D. and A. U. Pardini (1987). "The Comparative Effectiveness of Reward and Commitment Approaches in Motivating Community Recycling." Journal of Environmental Systems **17**(2): 93-113.

Kemp, R. (1992). The Politics of Radioactive Waste Disposal. Manchester, Manchester University Press.

Kimball, D. and B. Glass (1991). "Assessing the Damage." Nuclear Times (Spring): 38-41.

Kneale, G. W. and A. M Stewart (1993). "Reanalysis of Hanford Data: 1944-1986 Deaths." American Journal of Industrial Medicine **23**: 371-389.

Knetsch, J. L. (1995). "Assumptions, Behavioral Findings, and Policy Analysis." Journal of Policy Analysis and Management **14**(1): 68-78.

Knetsch, J. L. (1990). "Environmental Policy Implications of Disparities between Willingness to Pay and Compensation Demanded Measures of Values." Journal of Environmental Economics and Management **18**: 227-237.

Kraft, M. E. and B. B. Clary (1991). "Citizen Participation and the NIMBY Syndrome: Public Response to Radioactive Waste Disposal." Western Political Quarterly **44**: 299-328.

Krause, D. (1993). "Environmental Consciousness: An Empirical Study." Environment and Behavior **25**(1): 126-142.

Krimsky, S. (1992). The Role of Theory in Risk Studies. Social Theories of Risk. Westport, CT, Praeger. 3-22.

Krimsky, S. and D. Golding (1992). Social Theories of Risk. Westport, CT, Praeger.

Kunreuther, H., D. Easterling, W. Desvousges, and P. Slovic (1990). "Public Attitudes towards Siting a High-Level Nuclear Waste Reposit[illegible]da." Risk Analysis **18**(4): 469-484.

Kunreuther, H., K. Fitzgerald, and T. Aarts (1993). "[illegible]us Facilities: A Test of the Facility Siting Credo." Risk Analysis **13**(3): 301-3[illegible]

Kunreuther, H. and P. Portney (1991). "Wheel of Fortune: A Lottery/Auction Mechanism for Siting of Noxious Facilities." Journal of Energy Engineering **117**(3): 125-132.

Lipman, T. W. (1994, December 2). Army Finds Deficiencies at Utah Chemical Weapons Incinerator. The Washington Post. Washington, D.C., p. A4.

Lober, D. J. (1995). "Why Protest?: Public Behavioral and Attitudinal Response to Siting a Waste Disposal Facility." Policy Studies Journal **23**(3): 499-518.

Lober, D. J. and D. P. Green (1994). "NIMBY or NIAMBY: A Logit Model of Opposition to Solid Waste Disposal Facility Siting." Journal of Environmental Management **40**: 33-50.

Mank, B. C. (1991). "The Two-Headed Dragon of Siting and Cleaning up Hazardous Waste Dumps: Can Economic Incentives or Mediation Slay the Monster?" Environmental Affairs **19**: 239-285.

March, J. G. and Z. Shapira (1992). "Variable Risk Preferences and the Focus of Attention." Psychological Review **99**(1): 172-183.

Marsh, H. W. and A. Parducci (1978). "Natural Anchoring at the Neutral Point of Category Rating Scales." Journal of Experimental Social Psychology **14**: 193-204.

McClelland, G. H., W. D. Schulze, and B. Hurd (1990). "The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site." Risk Analysis **10**(4): 485-497.

McQuaid-Cook, J. and C. S. Simons (1989). "Development and Operation of a Waste Management System in Alberta, Canada." Waste Management and Research **7**: 219-227.

Meyers, S. (1995, November 15). New Nerve Gas Disposal Technology not for Umatilla. East Oregonian, p. A3.

Meyers, S. (1996a, January 25). Binary Weapons: Army Depot Stores 95 percent of Nations' 'Non-Lethal' Cache. East Oregonian, p. A1, A7

Meyers, S. (1996b, January 22). Weapons Stockpile Numbers Revealed. East Oregonian, p. A1, A7.

Morgan, M. G. (1990). Choosing and Managing Technology-Induced Risk. Readings in Risk. Washington, D.C., Resources for the Future. 17-28.

Motameni, R. and T. W. Falcone (1990). "The Application of Martin Fishbein's Theory of Reasoned Action in Solid Waste Management and Recycling." Journal of Resource Management and Technology **18**(3&4): 144-150.

Mountain West Research (1989). Yucca Mountain Socioeconomic Project Preliminary Findings: 1989 Nevada State Telephone Survey. State of Nevada Agency for Nuclear Projects/Nuclear Waste Projects Office.

Nagel, E. (1961). The Structure of Science: Problems in the Logic of Scientific Explanations. New York, Harcourt, Brace, and World.

Nathan, S. (1994). "Burning Debate over Poison Stockpiles." Chemistry and Industry **March 7**: 168.

Niessen, W. R. (1978). Combustion and Incineration Processes: Applications in Environmental Engineering. New York, Marcel Dekker, Inc.

Nieves, L. A., J. J. Himmelberger, S. J. Ratick, and A. L. White (1992). "Negotiated Compensation for Solid-Waste Disposal Facility Siting: An Analysis of the Wisconsin Experience." Risk Analysis **12**(4): 505-511.

O'Hare, M. (1977). ""Not on my Block you Don't": Facility Siting and the Strategic Importance of Compensation." Public Policy **25**(4): 407-458.

O'Hare, M., L. Bacow, and D. Sanderson (1983). Facility Siting and Public Opposition. New York, NY, Van Nostrand Reinhold Company.

Oliver, S. (1995-96). personal communication.

Ostry, A. S., C. Hertzman, and K. Teschke (1993). "Risk Perception Differences in a Community with a Municipal Solid Waste Incinerator." Canadian Journal of Public Health **84**(5): 321-324.

Pease, P. W., M. Bieser, and M. E. Tubbs (1993). "Framing Effects and Choice Shifts in Group Decision Making." Organizational Behavior and Human Decision Processes **56**: 149-165.

Piliavin, J. A. and D. Libby (1986). "Personal Norms, Perceived Social Norms, and Blood Donation." Humboldt Journal of Social Relations **13**(1&2): 159-194.

Pilisuk, M., S. Hillier-Parks, and G. Hawkes (1987). "Public Perception of Technological Risk." The Social Science Journal **24**(4): 403-413.

Portney, K. E. (1984). "Allaying the NIMBY Syndrome: The Potential for Compensation in Hazardous Waste Treatment Facility Siting." Hazardous Waste **1**(3): 411-421.

Portney, K. E. (1985). "The Potential of the Theory of Compensation for Mitigating Public Opposition to Hazardous Waste Treatment Facility Siting: Some Evidence from Five Massachusetts Communities." Policy Studies Journal **14**(1): 81-89.

Raloff, J. (1994). "Incinerator Under Fire: Safety Questions Swirl at a Facility Designed to Burn Chemical Weapons." Science News **146**: 394-395, 399.

Rayner, S. (1984). "Radiation Hazards in Hospital: A Cultural Analysis of Occupational Risk Perception." Royal Anthropological Institute News (60): 10-14.

Rayner, S. (1991). "A Cultural Perspective on the Structure and Implementation of Global Environmental Agreements." Evaluation Review **15**(1): 75-102.

Rayner, S. (1992). Cultural Theory and Risk Analysis. Social Theories of Risk. Westport, CT, Praeger. 83-115.

Rayner, S. and R. Cantor (1987). "How Fair is Safe Enough? The Cultural Approach to Societal Technology Choice." Risk Analysis **7**(1): 3-9.

Renn, O. (1992). "Risk Communication: Towards a Rational Discourse with the Public." Journal of Hazardous Materials **29**: 465-519.

Rife, R., T. W. Thomas, D. W. Norburg, R. L. Fournier, F. G. Rinker, and M. S. Bonomo (1989). "Chemical Demilitarization: Disposing of the Most Hazardous Wastes." Environmental Progress **8**(3): 167-175.

Rodricks, J. V. (1992). Calculating Risks: Understanding the Toxicity and Human Health Risks of Chemicals in our Environment. Cambridge, Cambridge University Press.

Rubel, F. N. (1974). Incineration of Solid Wastes. Park Ridge, NJ, Noyes Data Corporation.

Samuelson, W. and R. Zeckhauser (1988). "Status Quo Bias in Decision Making." Journal of Risk and Uncertainty **1**: 7-59.

Schafer, D. (1994). Utah Incinerator Makes Hermiston Group Wary - Whistleblower Claims Safety Problems Plague Army Plant for Destroying Chemical Weapons. Tri-City Herald. Tri-Cities, Washington, A4.

Schneider, K. (1994). House to Probe Utah Nerve Gas Incinerator Study. Oregonian.

Schneider, S. L. (1992). "Framing and Conflict: Aspiration Level Contingency, the Status Quo, and Current Theories of Risky Choice." Journal of Experimental Psychology: Learning, Memory, and Cognition **18**(5): 1040-1057.

Schwartz, S. H. (1973). "Normative Explanations of Helping Behavior: A Critique, Proposal, and Empirical Test." Journal of Experimental Social Psychology **9**: 349-364.

Scott, D. and F. K. Willits (1994). "Environmental Attitudes and Behavior: A Pennsylvania Survey." Environment and Behavior **26**(2): 239-260.

Silton, T. (1993). "Out of the Frying Pan... Chemical Weapons Incineration in the United States." The Ecologist **23**(1): 18-24.

Slovic, P. (1987). "Perception of Risk." Science **236**: 280-285.

Slovic, P. (1992). Perceptions of Risk: Reflections on the Psychometric Paradigm. Social Theories of Risk. Westport, CT, Praeger. 117-152.

Smail, H. E. (1985) Solid Waste Facility Siting - Community Aspects and Incentives. Management of Toxic and Hazardous Wastes. Chelsea, MI, Lewis Publishers. 45-63.

Sorensen, J., J. Soderstrom, E. Copenhaver, S. Carnes, and R. Bolin (1987). Impacts of Hazardous Technology: The Psycho-Social Effects of Restarting TMI-1. Albany, State University of New York Press.

Thaler, R. (1980). "Toward a Positive Theory of Consumer Choice." Journal of Economic Behavior and Organization **1**: 39.

Thaler, R. (1985). "Mental Accounting and Consumer Choice." Marketing Science **4**(3): 199-214.

Theodore, L. and J. Reynolds (1987). Introduction to Hazardous Waste Incineration. New York, John Wiley and Sons.

Thompson, M. (1983). Postscript: A Cultural Basis for Comparison. Risk Analysis and Decision Processes: The Siting of Liquefied Energy Gas Facilities in Four Countries. Berlin, Heidelberg, New York, Tokyo, Springer-Verlag. 232-278.

Thompson, M. and A. Wildavsky (1982). A Proposal to Create a Cultural Theory of Risk. The Risk Analysis Controversy: An Institutional Perspective, IIASA, Laxenburg Austria, 145-160.

Tversky, A. and D. Kahneman (1981). "The Framing of Decisions and the Psychology of Choice." Science **211**(211): 453-458.

U.S. Department of Commerce, Bureau of the Census. (1990) [illegible] of the Population, Census of the Population, Vol. 1. U.S. Government Printing Office, Washington, D.C.

U.S. Department of Commerce, Bureau of the Census (1994). County and City Data Book, U.S. Government Printing Office, Washington, D.C.

U.S. Army. (1995). Disposal of Chemical Agents and Munitions Stored at the Umatilla Depot Activity, Oregon. Program Manager for Chemical Demilitarization, Aberdeen Proving Ground, MD.

U.S.E.P.A. (1982). Using Compensation and Incentives when Siting Hazardous Waste Management Facilities: A Handbook. U.S. Environmental Protection Agency.

Upton, A. C., R. E. Shore, and N. H. Harley (1992). "The Health Effects of Low-Level Ionizing Radiation." Annual Reviews of Public Health **13**: 127-150.

USDA (1995). Food Safety and Agricultural Recovery. U.S. Department of Agriculture, Food Safety and Inspection Service, Office of Emergency Planning.

Van Liere, K. D. and R. Dunlap (1978). "Moral Norms and Environmental Behavior: An Application of Schwartz's Norm-Activation Model to Yard Burning." Journal of Applied Social Psychology **8**(2): 174-188.

Van Liere, K. D. and R. E. Dunlap (1980). "The Social Bases of Environmental Concern: A Review of Hypotheses, Explanations, and Empirical Evidence." Public Opinion Quarterly **44**: 181-197.

Vaughan, E. (1993). "Chronic Exposure to an Environmental Hazard: Risk Perceptions and Self-Protective Behavior." Health Psychology **12**(1): 74-85.

Vining, J. and A. Ebreo (1990). "What Makes a Recycler? A Comparison of Recyclers and Nonrecyclers." Environment and Behavior **22**(1): 55-73.

Wallace, W. (1971). The Logic of Science in Sociology. Chicago, Aldine.

Wartenberg, D. and C. Chess (1992). "Risky Business: The Inexact Art of Hazard Assessment." The Sciences (March/April): 17-21.

Washburn, S. T., J. Brainard, and R. H. Harris (1989). "Human Health Risks of Municipal Solid Waste Incineration." Environmental Impact Assessment Review **9**: 181-198.

Watson, A. (1995). Chemical, Physical, and Toxicological Properties of Agent Stockpiled at Umatilla Depot Activity. Health Sciences Research Division.

Webler, T., H. Rakel, O. Renn, and B. Johnson (1995). "Eliciting and Classifying Concerns: A Methodological Critique." Risk Analysis **15**(3): 421-436.

Webster, F. E., Jr. (1975). "Determining the Characteristics of the Socially Conscious Consumer." Journal of Consumer Research **2**(12): 188-196.

Weenig, M. W. H., T. Schmidt, C. J. H. Midden (1990). "Social Dimensions of Neighborhoods and the Effectiveness of Information Programs." Environment and Behavior **22**(1): 27-54.

Weigel, R. and J. Weigel (1978). "Environmental Concern: The Development of A Measure." Environment and Behavior **10**(1): 3-15.

Wildavsky, A. and K. Dake (1990). "Theories of Risk Perception: Who Fears What and Why?" Daedalus **119**(4): 41-60.

Williams, E. A., A. K. Massa, D. H. Blau, and H. R. Schaal (1983). Siting of Major Facilities: A Practical Approach. New York, McGraw-Hill Book Company.

Zeiss, C. (1991). "Community Decision Making and Impact Management Priorities for Siting Waste Facilities." Environmental Impact Assessment Review **11**: 231-255.

Zeiss, C. (1993). Waste Facility Impact Screening with Stepmatrix-Reverse Network. Alberta Health

Zeiss, C. and J. Atwater (1987). "Waste Facilities in Residential Communities: Impacts and Acceptance." Journal of Urban Planning and Development **113**(1): 19-96.

Zeiss, C. and J. Atwater (1991). "Waste Disposal Facilities and Community Response: Tracing Pathways from Facility Impacts to Community Attitude." Canadian Journal of Civil Engineering **18**: 83-96.

Zeiss, C. and J. Atwater (1993). "A Case Study of Nuisance Impact Screening for Municipal Waste Landfill Planning." Environmental Technology **14**: 1101-1115.

Zeiss, C. and L. Lef[illegible]5). Analytical Framework for Waste-Facility Siting. Journal of Urban Planning and [illegible]opment **121**(4): 115-145.

Zeiss, C. and L. Lefsrud (1994). Waste Facility Siting Framework: Development and Validation. Office of the U.S. Nuclear Waste Negotiator.

Zeiss, C. and B. Paddon (1992). "Management Principles for Negotiating Waste Facility Siting Agreements." Journal of the Air and Waste Management Association **42**(10): 1296-1304

APPENDIX A - STEP-MATRICES AND REVERSE NETWORKS FOR THE UMATILLA CHEMICAL DEMILITARIZATION INCINERATION FACILITY (UMCDF)

Interface 0 - Facility Needs and Benefits	
Needs	Benefits
1. chemical munitions are degrading and leaking small quantities of agent vapor • 363 "leakers" found prior to 1984 • 91 "leakers" since 1994 • all "leakers" have been overpacked • 13 overpacked "leakers" have begun to leak again (Tri-Cities Herald 7/09/94, Hermiston Herald 13/09/94) • 9 more "leakers" found (East Oregonian 29/02/95, Hermiston Herald 4/04/95) 2. stabilizers in rocket propellants are degrading and may auto-ignite - there is controversy as to how long munitions can be safely stored 3. destruction of chemical munitions is mandated by public law 99-145 (Department of Defense Authorization Act, 1996) and amended by public law 100-456 to have stockpile destroyed by 2004	1. jobs for an area with unemployed labor force • 550 jobs during peak construction period (pg. 4-7, UMDA EIS, 1992) • 450 new jobs in community indirectly related to facility which would support 6% of local population with new jobs (pg. 4-7 to 4-8, UMDA EIS, 1992) 2. jobs would have indirect effects in local development, tax base, and public services (pg. 4-21, UMDA EIS, 1992)

Inputs	Constituents of Concern	Quantity	Interface I - Facility Operations										
			Storage in Igloos	Munition Transport	Storage in CHB	Unpack in MDB	Defuse. Punch. Drain	Deactivation Furnace and PAS	Metal Parts Furnace and PAS	Dunnage Incinerator and PAS	Liquid Incinerator and PAS	Brine Reduction Area and PAS	Tank Container Storage Handling
M23 land mines	VX, fuse, burster, dunnage	process 70 mun/hr	●	●	●	●	●	●	●	●	●	•	●
ton containers	HD	process 1.54 mun/hr	●	●	●	●	●	•	●	•	●	•	●
M55 rockets	GB, VX, fuse, burster, propellant dunnage	process 38.8 mun/hr	●	●	●	●	●	●	•	●	●	•	●
155 mm and 8" projectile	GB, VX, burster, dunnage	process 157 and 57 mun/hr	●	●	●	●	●	●	●	●	●	•	●
Bombs and spray tanks	GB, VX, dunnage	process 7.3 and 1.0 mun/hr	●	●	●	●	●	•	●	●	●	•	●
process water, steam		2000 gal/hr	•	•	•	•	●	●	●	●	●	●	●
electricity			•	•	●	●	●	●	●	●	●	●	●
decontaminating solution			•	•	●	●	●	●	●	●	●	●	●

Inputs	Constituents of Concern	Quantity	Interface I - Facility Operations										
			Storage in Igloos	Munition Transport	Storage in CHB	Unpack in MDB	Defuse. Punch. Drain	Deactivation Furnace and PAS	Metal Parts Furnace and PAS	Dunnage Incinerator and PAS	Liquid Incinerator and PAS	Brine Reduction Area and PAS	Tank/Container Storage Handling
hydrochloric acid			•	•	•	•	•	●	●	●	●	•	●
fuel gas/oil/LPG			•	●	•	•	•	●	●	●	●	●	●
brine			•	•	•	•	•	●	●	•	●	●	●
spent C, filters, solid waste			•	•	•	•	•	•	•	●	•	•	●
liquid lab waste			•	•	•	•	•	•	•	•	●	•	●
personnel			●	●	●	●	● (crossed out)	● (crossed out)	● (crossed out)	● (crossed out)	● (crossed out)	●	●
trucks			•	●	●	•	•	•	•	•	•	•	●
forklifts and cranes			●	●	●	●	•	•	•	•	•	•	●

	Interface II - Emission - Transport								
	AIR			WATER		SOIL	VECTORS		
	gaseous	particulates	light/ noise	surface	ground		vehicle	animal	human
background levels	△	●	△						
Tank/ Container Storage Handling	[○]	[○]	○						
Brine Reduction Area and Pollution Abatement System	[●]	[●]	•						
Liquid Incinerators &Pollution Abatement System	[●]	[●]	○ normal [○] emergency						
Dunnage Incinerator & Pollution Abatement System	[●]	[●]	○ normal [○] emergency						
Metal Parts Furnace and Pollution Abatement System	[●]	[●]	○ normal [○] emergency						
Deactivation Furnace and Pollution Abatement System	[●]	[●]	○ normal [○] emergency						
Defuse. Punch. and Drain	[○]	[○]	•						
Unpack in MDB	[○]	[○]	•						
Store in Container Handling Building	[○]	[○]	•						
Munitions Transport	[○]	[○]	[○]						
Store in Igloos and Warehouses	[○]	[○]	[○]						
Cross-Pathway Transfer		[●] →	[○]						

	Interface III - Reception - Exposure						
	Plants	Animals	Employees/Visitors		Residents		
			Visual/ Aural	Inhalation/ Dermal/ Ingestion	Visual/ Aural	Inhalation/ Dermal	Ingestion
Vectors - humans							
- animal							
- vehicle							
Soil							
Ground water							
Surface water							
Air - light/noise				normal	○	•	•
				emergency	●	•	•
- particles				normal	•	○	△
				emergency	•	[●]	[△]
- gases				normal	•	△	•
				emergency	•	[●]	•
Cross-Pathway Reception							

	Interface IV - Impacts		
	Health Effects		Nuisances
Background Levels	●		●
Residents - Ingestion	△ [△]	normal emergency	△ [△]
- Inhalation/Dermal	△ [●]	normal emergency	△ [●]
- Visual/Aural	○ ◬	normal emergency	○ ●
Employees - Inhalation Dermal/Ingestion			
- Visual/Aural			
Animals			
Plants			

	Interface V - Nonphysical Impacts			
	Stress - Psychological	Political - Trust - Equity	Economic - Property Values - Infrastructure	Community Status/Image
Background Levels			•	•
Health Effects			△ *normal* ◎ *emergency*	△ ●
Nuisances			△ *normal* ◎ *emergency.*	△ ●

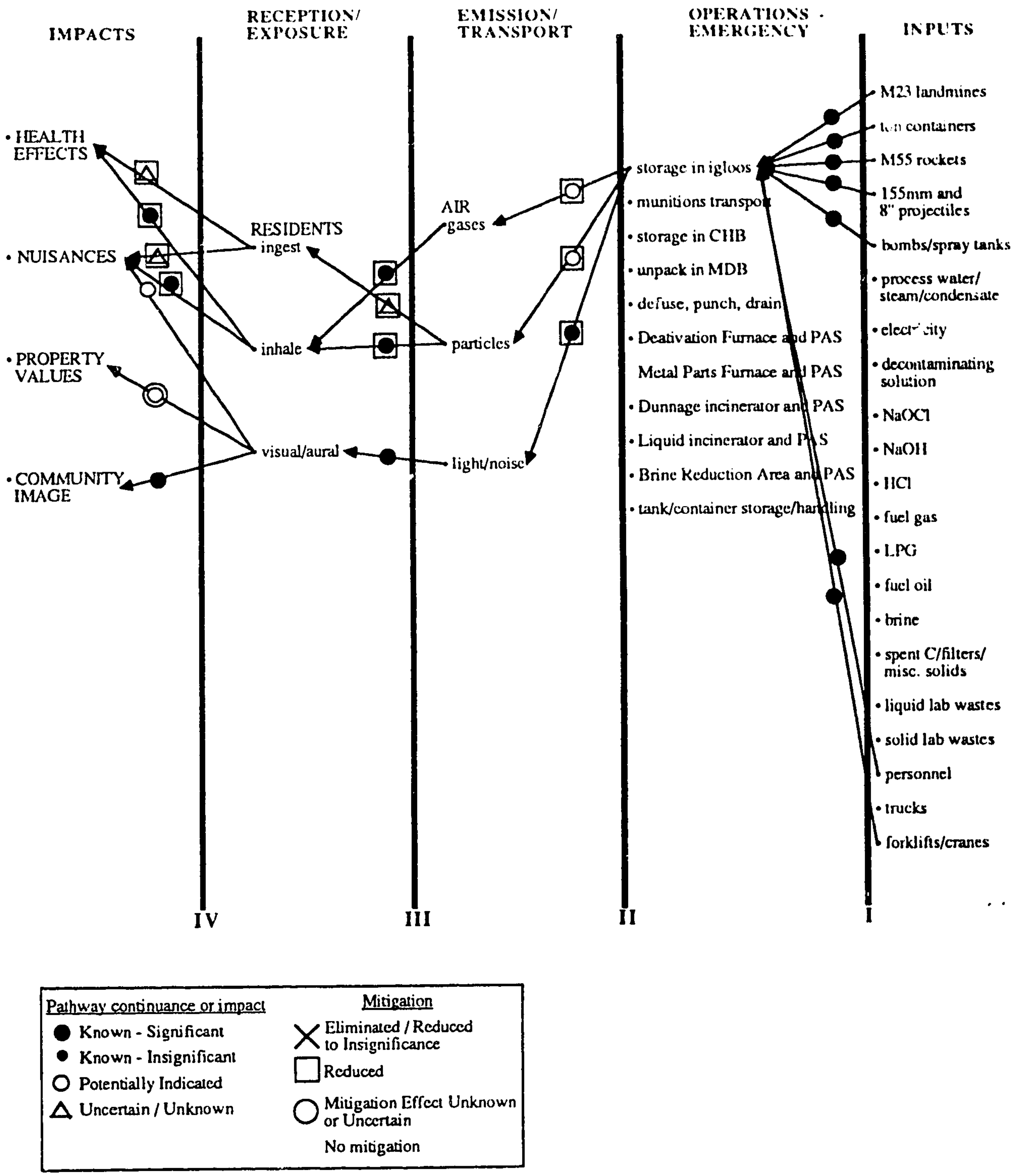

Figure - Reverse network for emergency storage of munitions in igloos

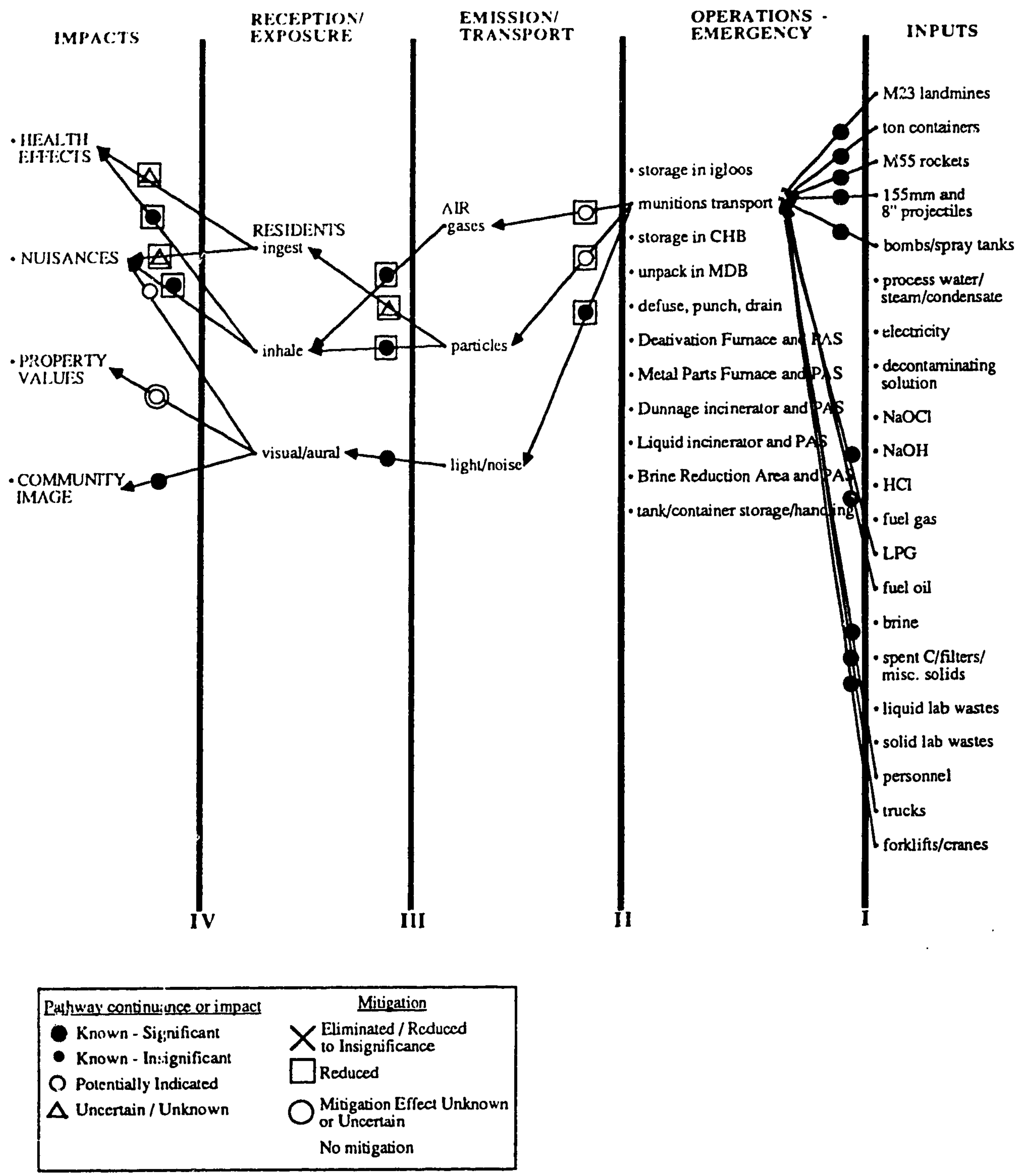

Figure - Reverse network for emergency transport of munitions

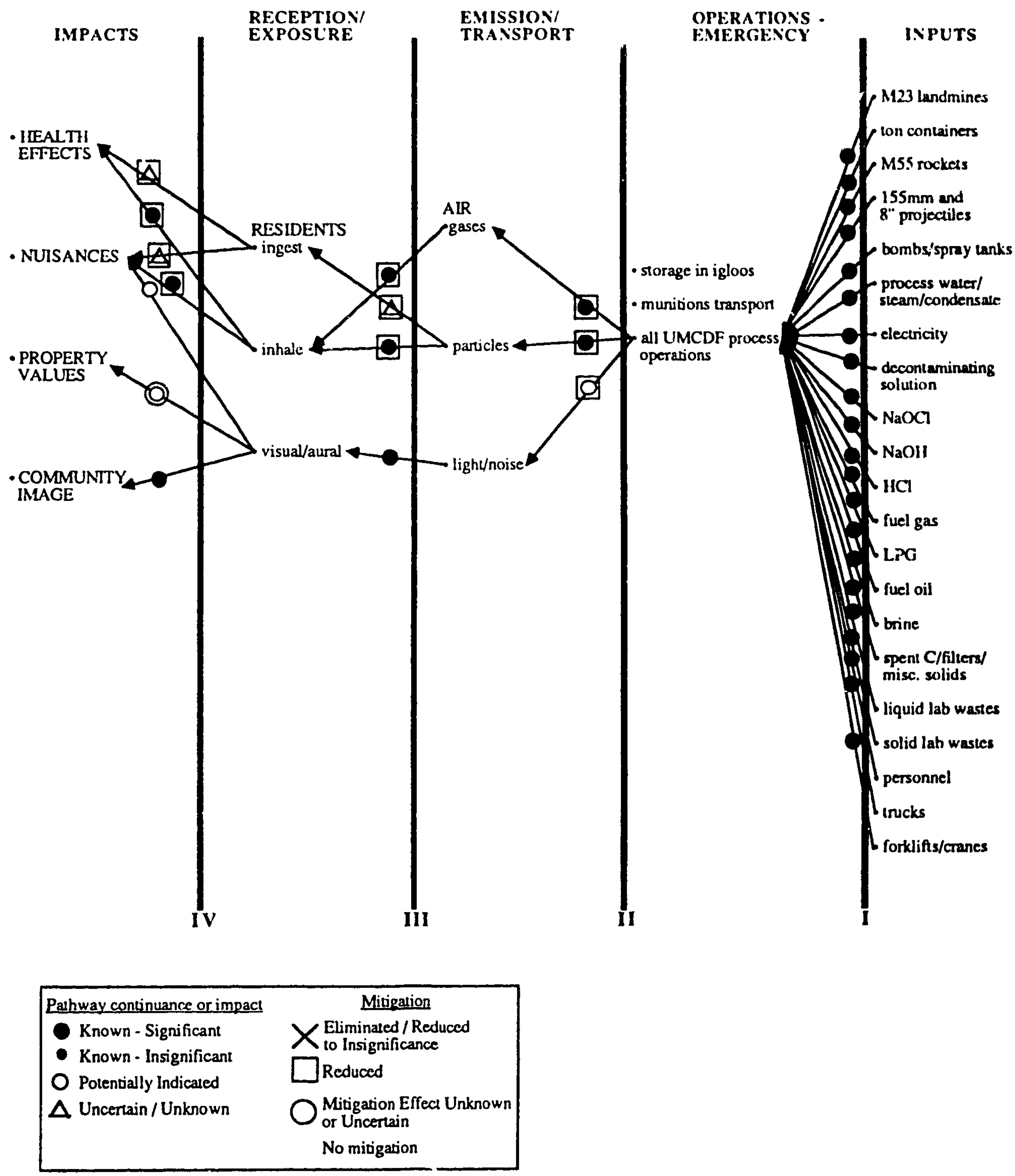

Figure - Reverse network for emergency operations from within UMCDF

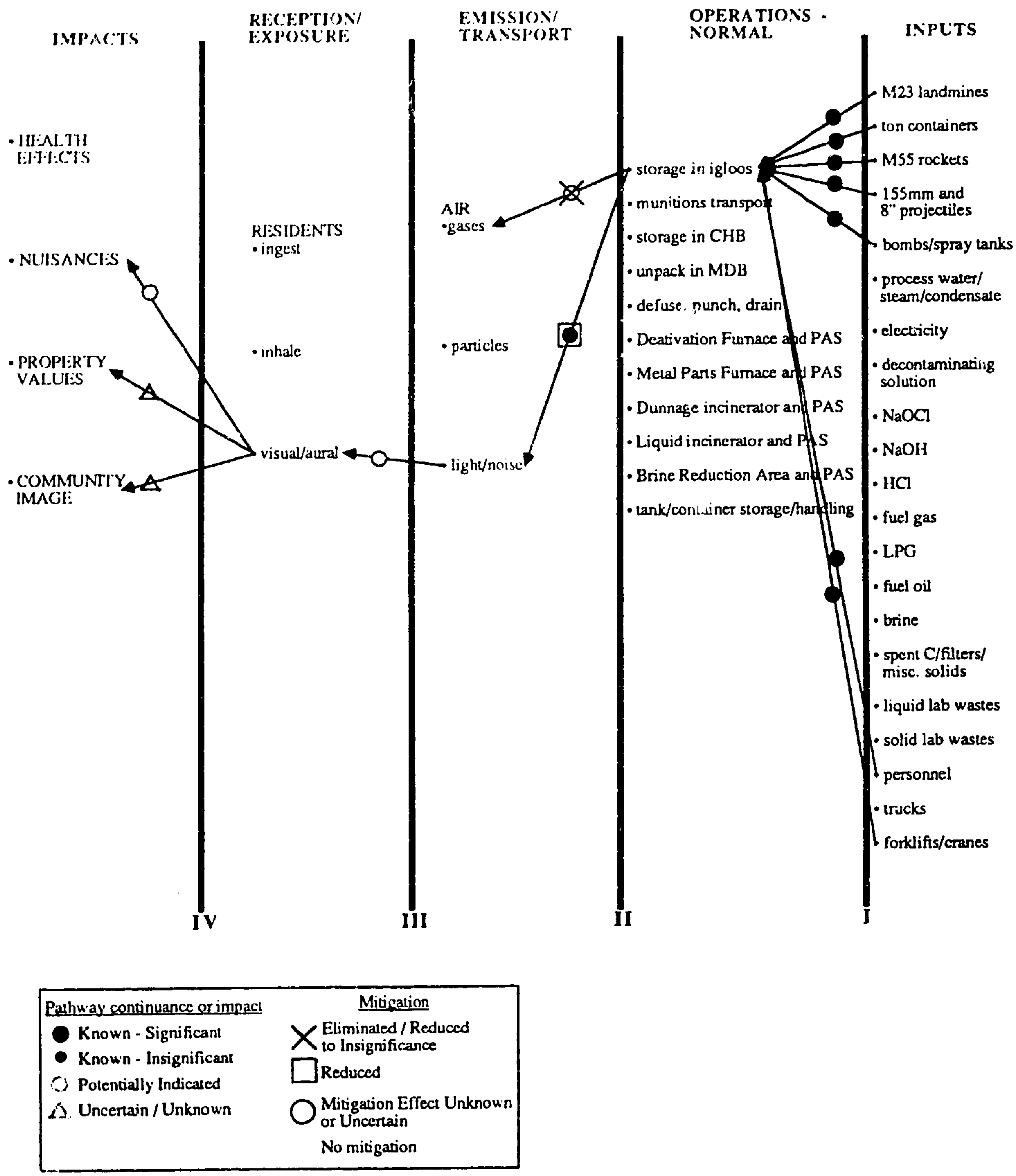

Figure - Reverse network for incident-free storage of munitions in igloos

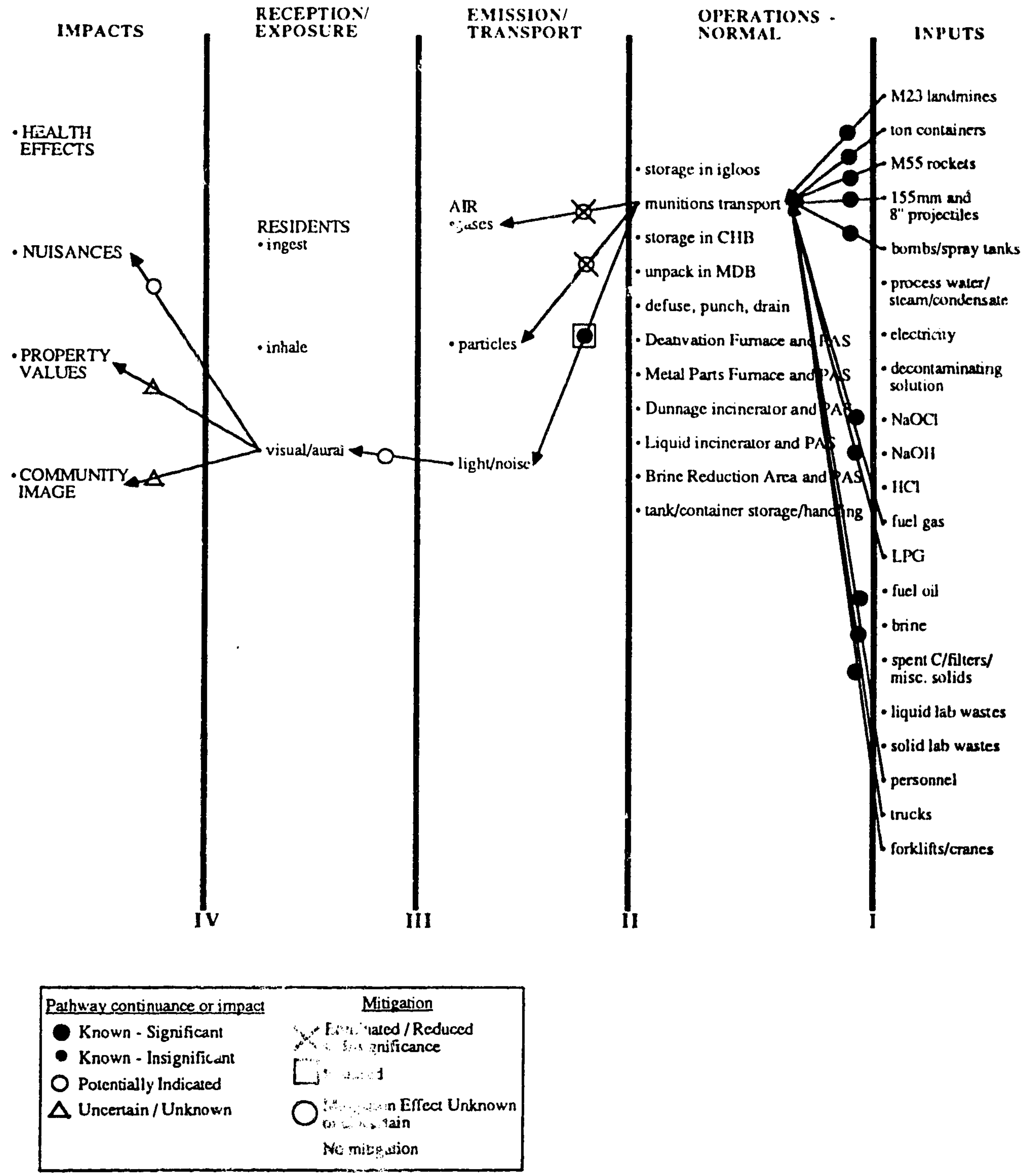

Figure - Reverse network for incident-free transport

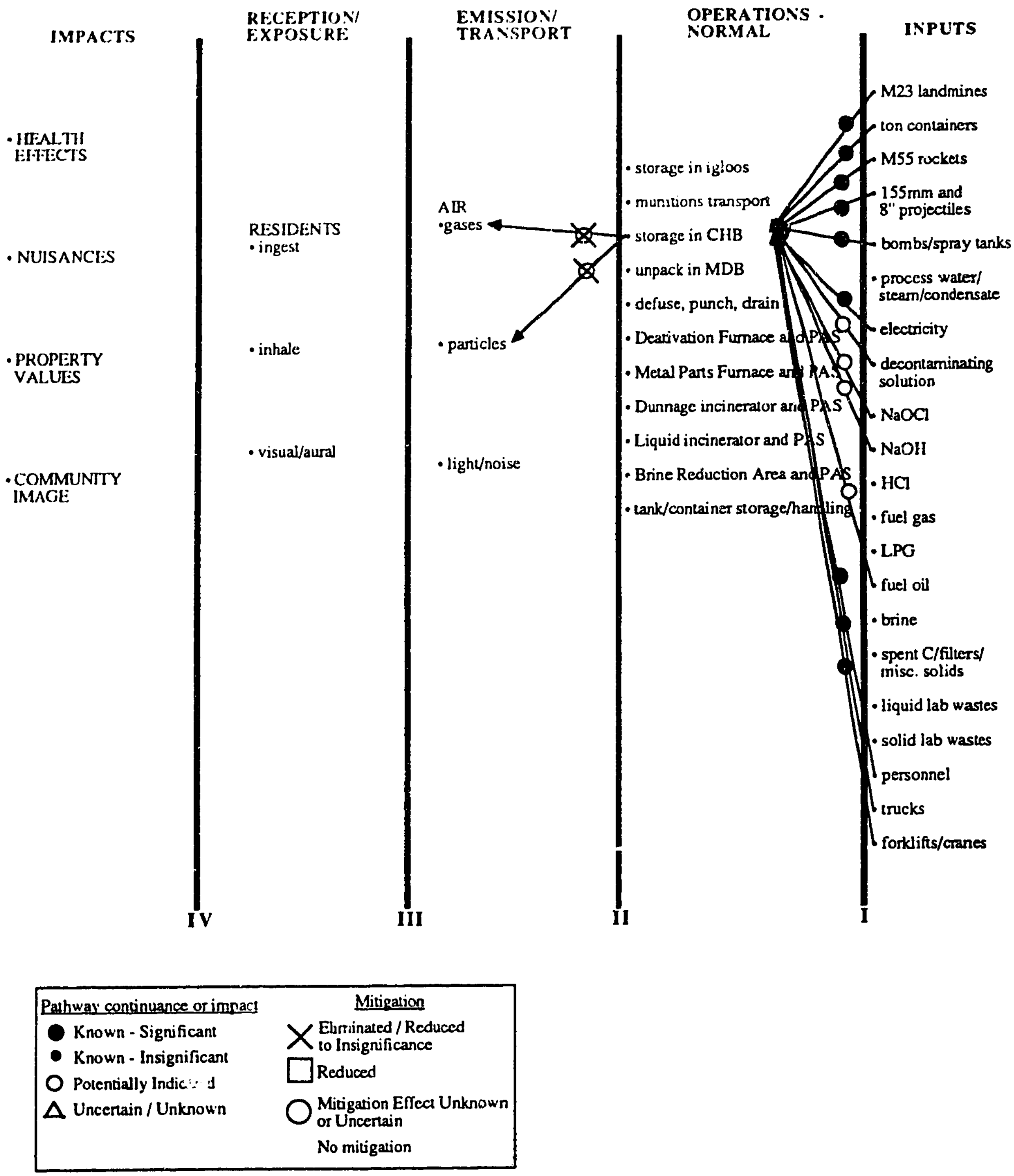

Figure - Reverse network for incident-free storage of munitions in CHB

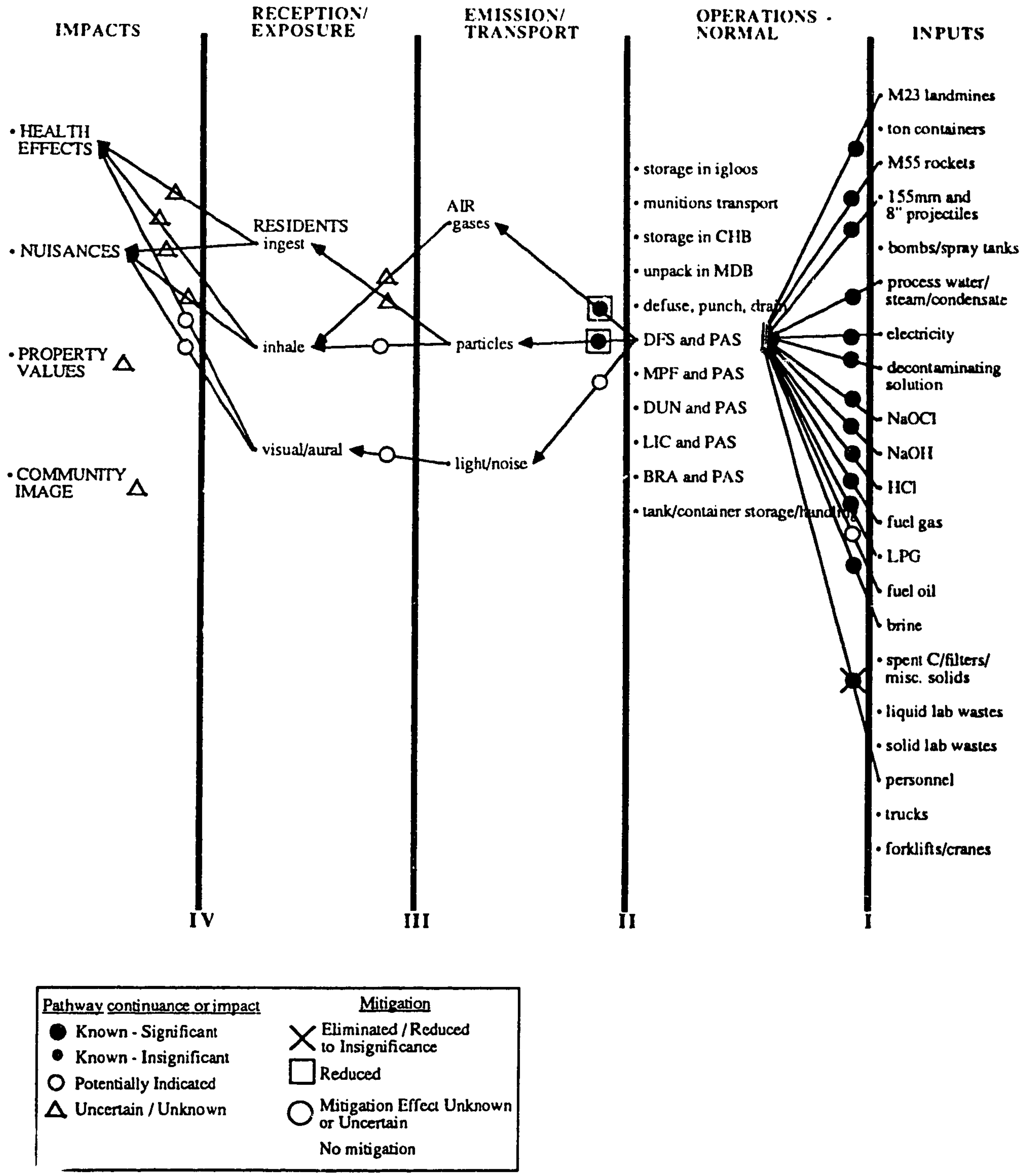

Figure - Reverse network for incident-free operation of Deactivation Furnace System and Pollution Abatement Syst

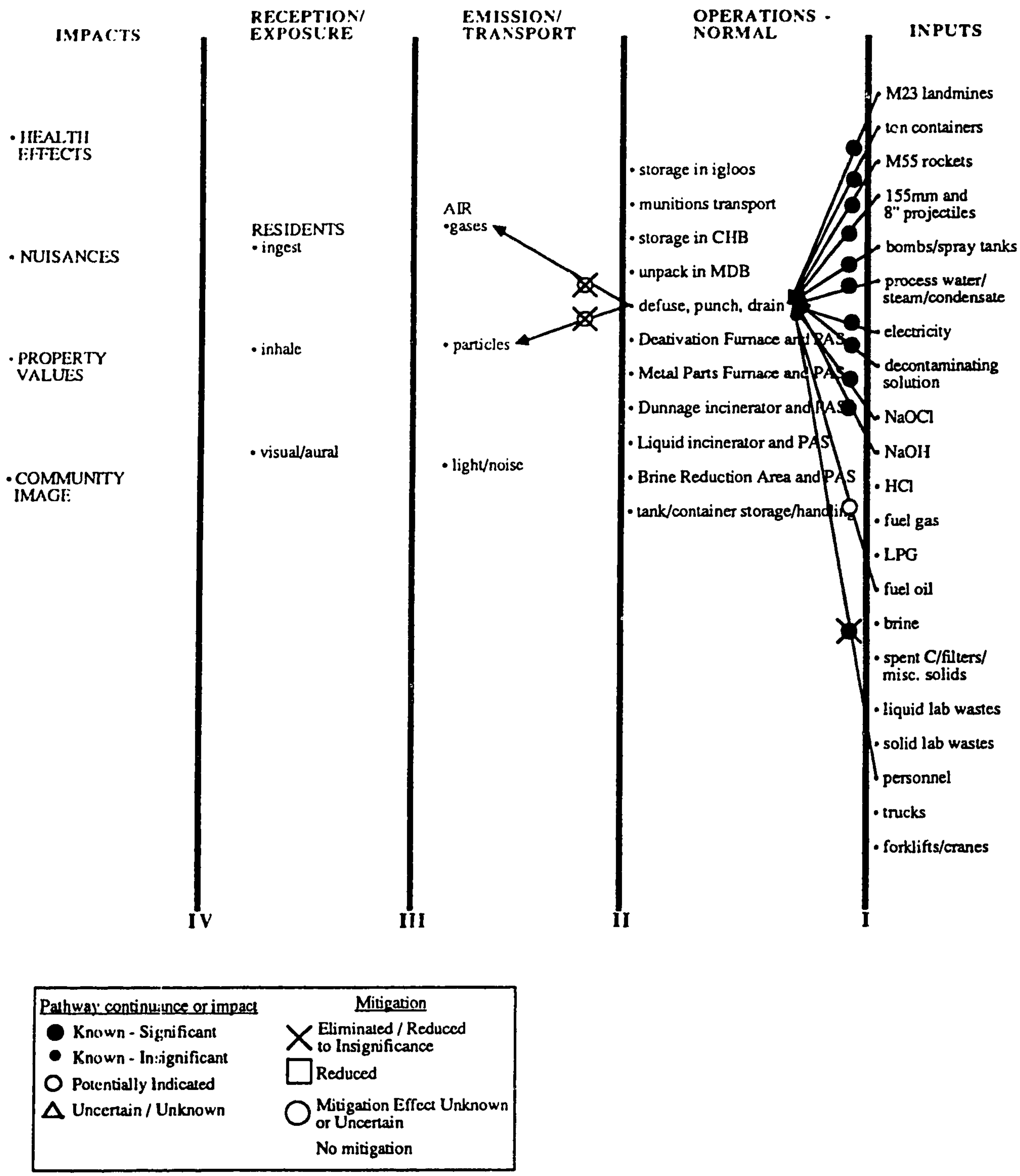

Figure - Reverse network for incident-free defusing, punching, and draining of munitions in MDB

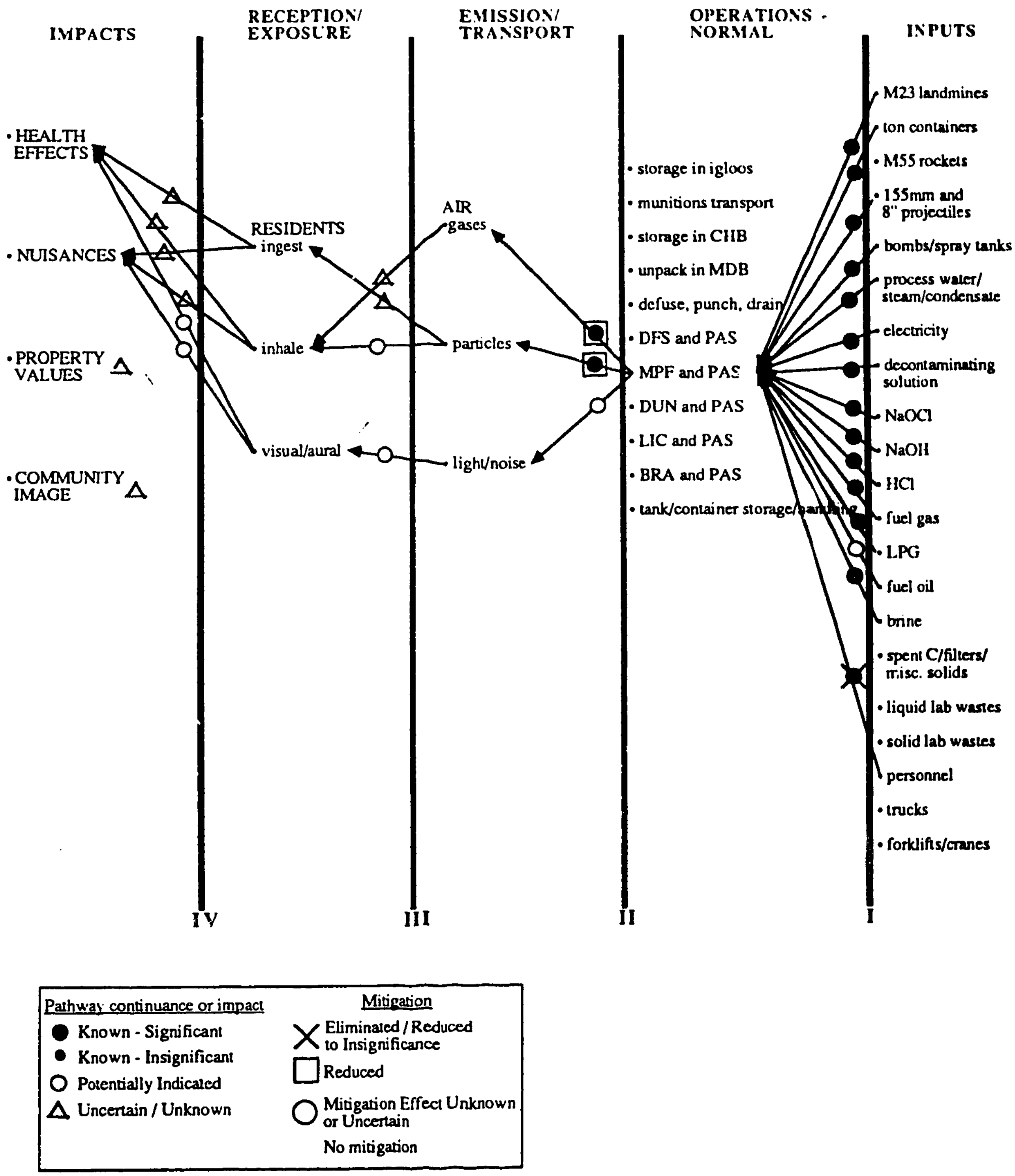

Figure - Reverse network for incident-free operation of Metal Parts Furnace and Pollution Abatement System

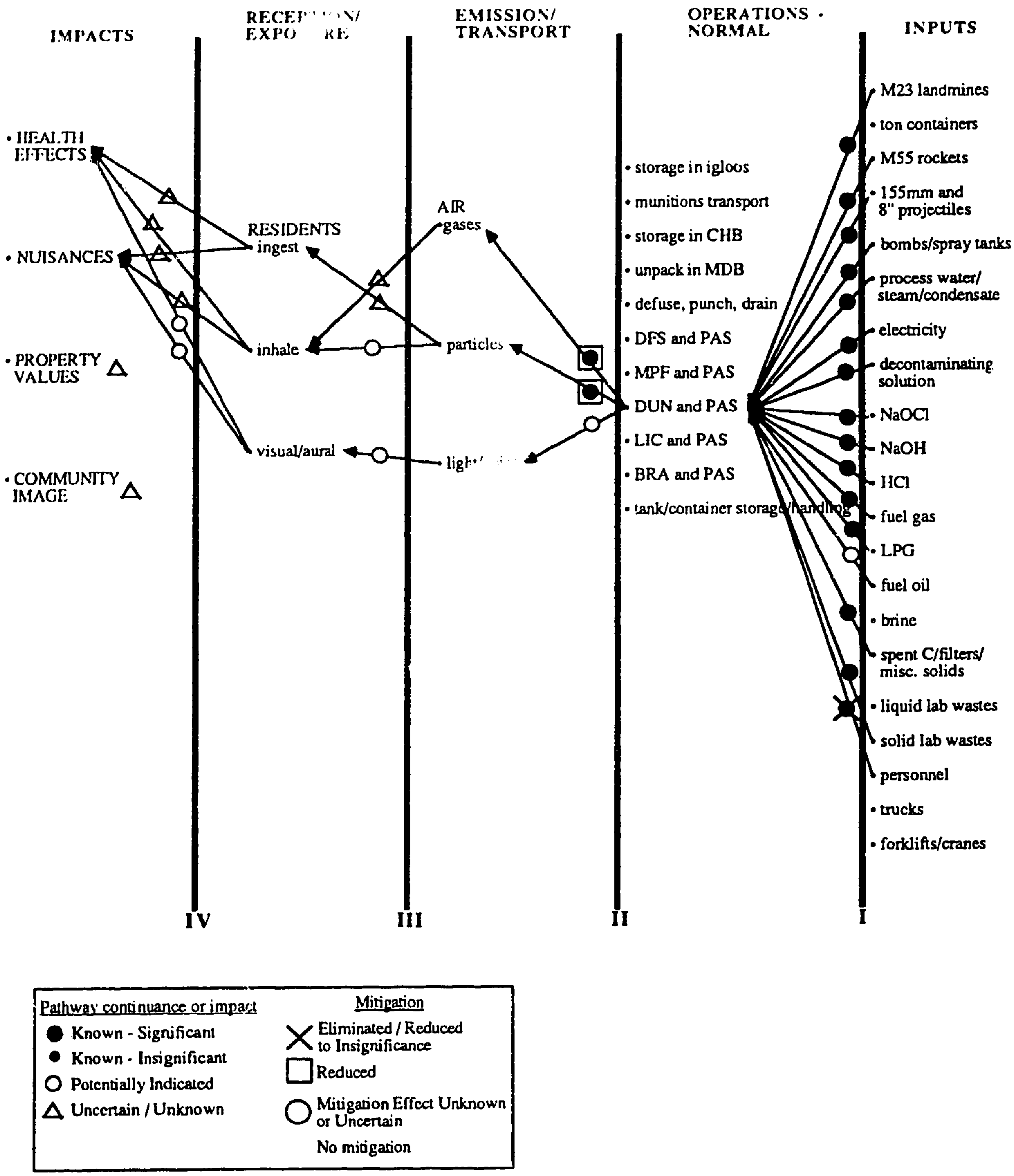

Figure - Reverse network for incident-free operation of Dunnage Incinerator and Pollution Abatement System

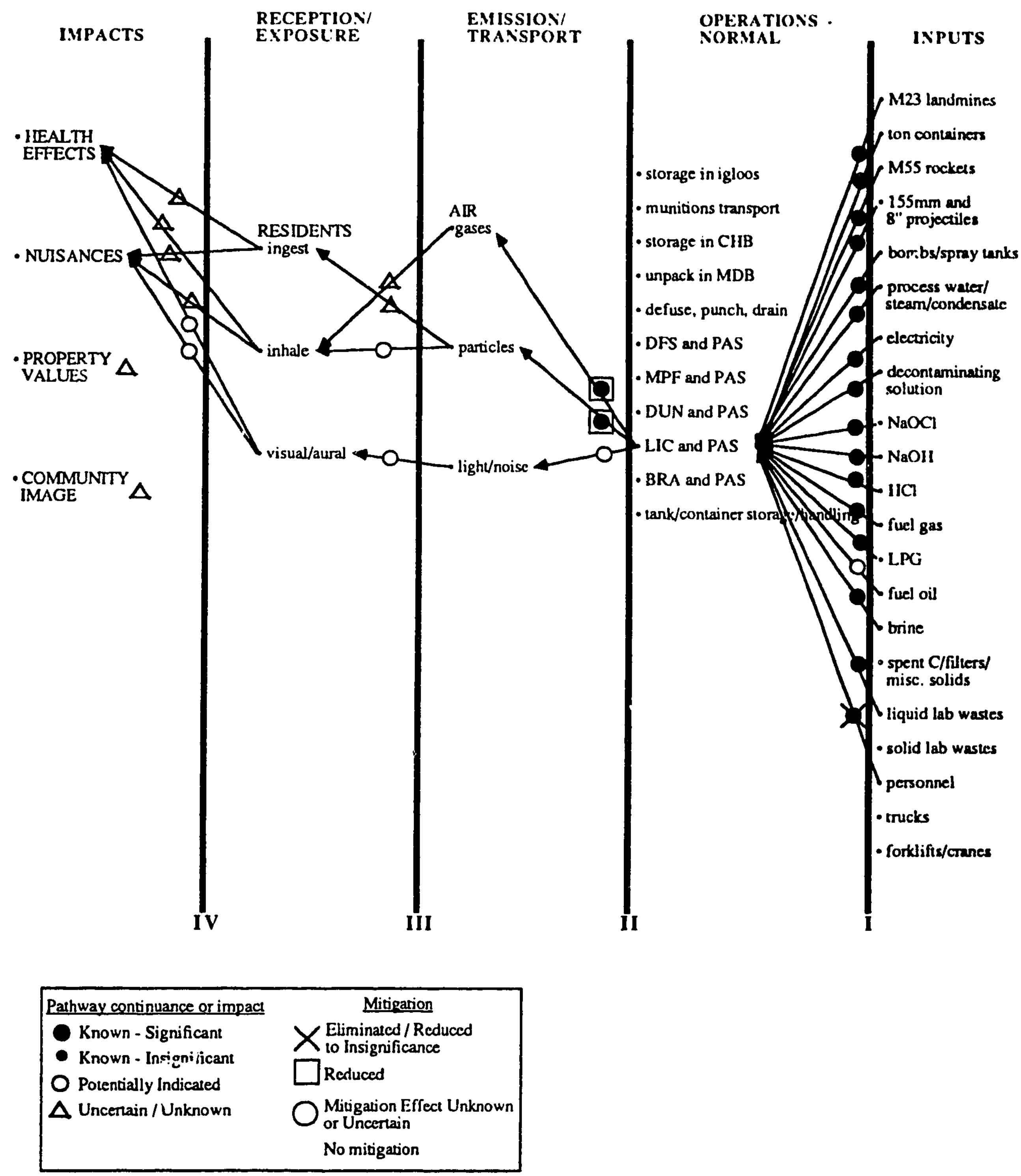

Figure - Reverse network for incident-free operation of Liquid Incinerator and Pollution Abatement System

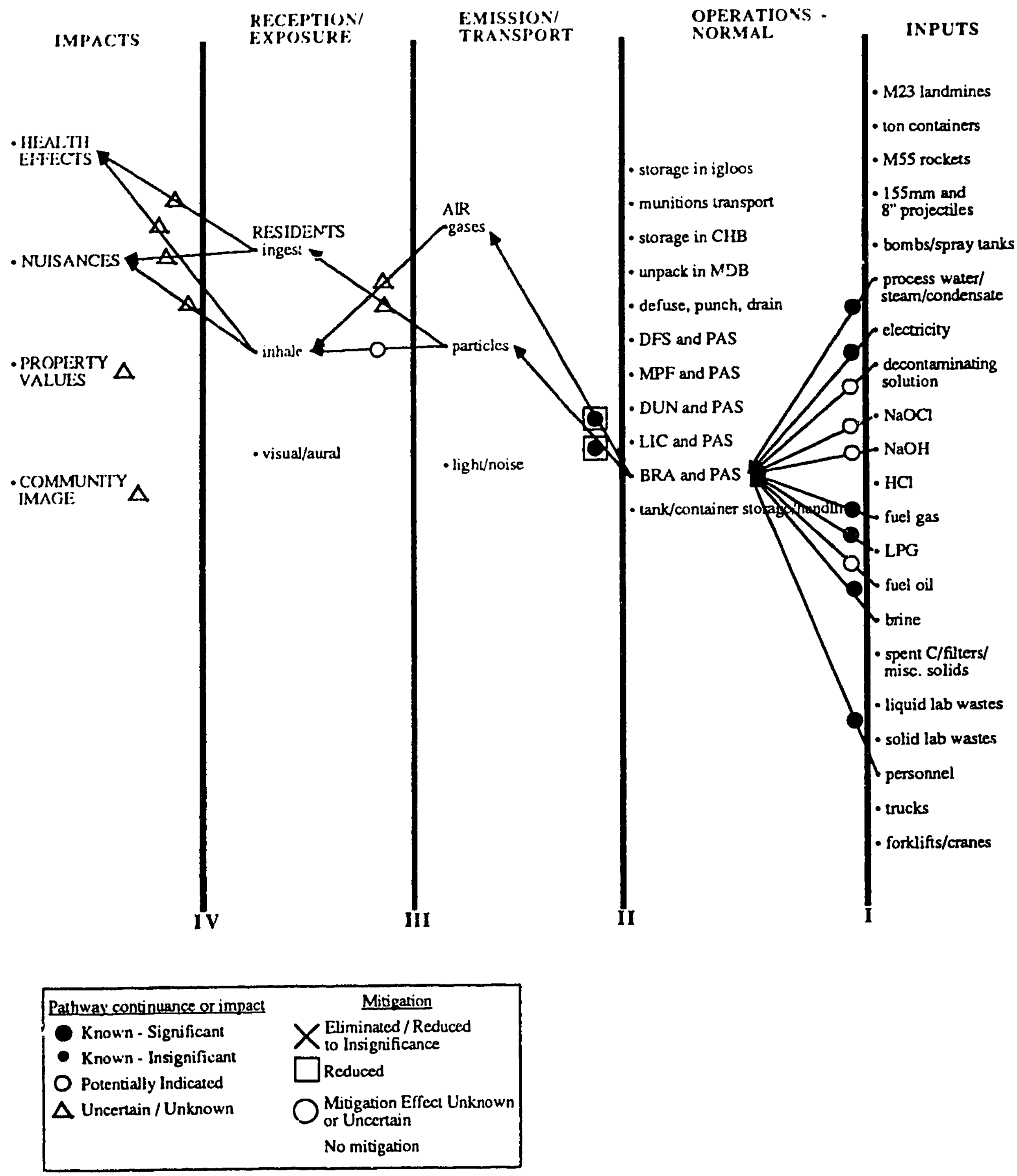

Figure - Reverse network for incident-free operation of Brine Reduction Area and Pollution Abatement System

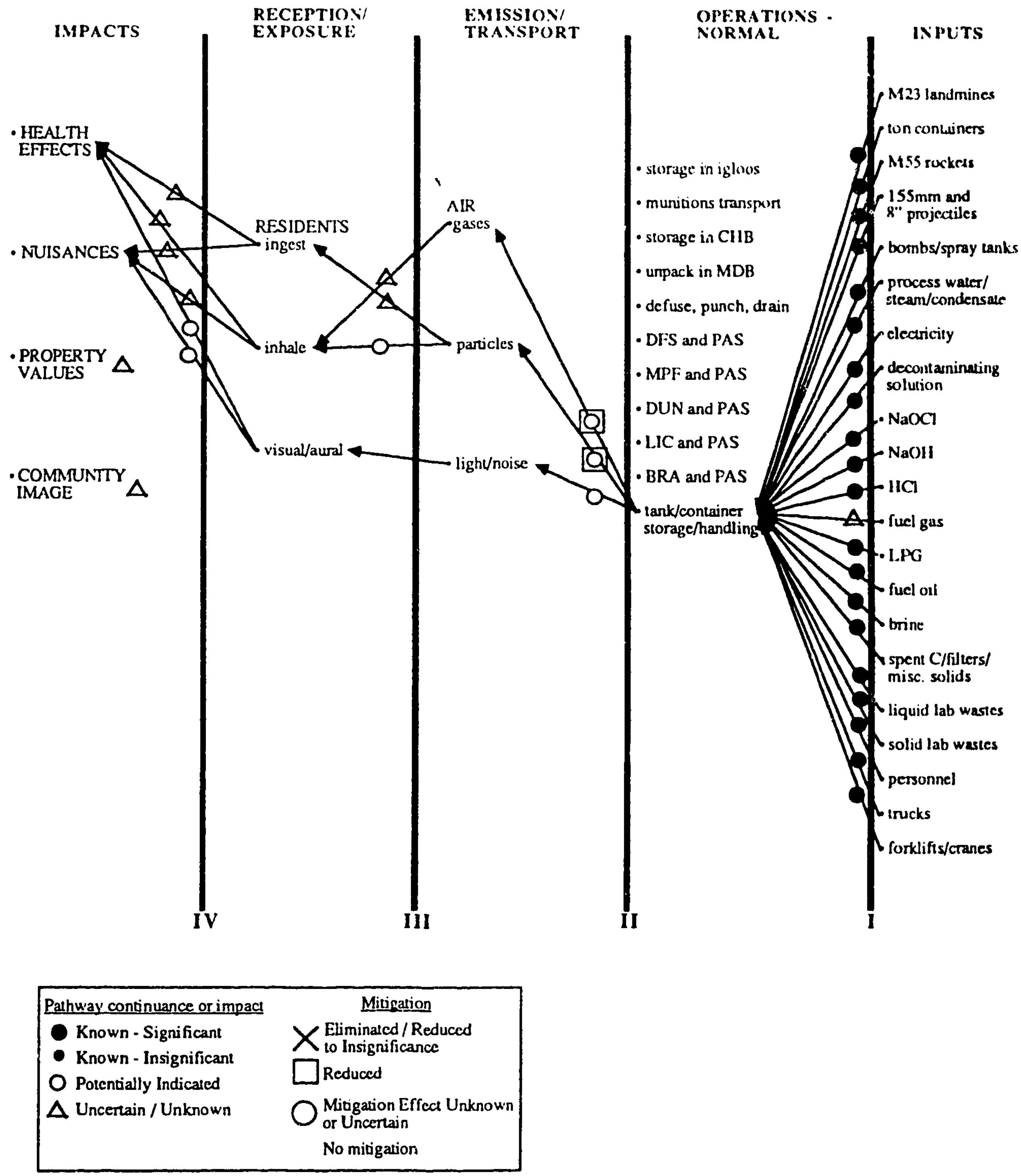

Figure - Reverse network for incident-free operation of tank and container storage/handling

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of Storage in Igloos **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
M23 Landmines	• all munitions presently being stored in igloos in K-block at UMDA	known significant	pg. 2-3, UMDA EIS, 1992
Ton Containers			
M55 Rockets			
Projectiles			
Bombs/Spraytanks			
Process Water	• no interaction, storage area in K-block is separate and removed from treatment facility	known insignificant	pg. 2-6, UMDA EIS, 1992
Electricity			
Decontaminating Solution			
Hydrochloric Acid			
Fuel Gas/Oil/LPG			
Brine			
Spent Carbon, Filters, Solid Waste			
Liquid Lab Wastes			
Personnel	• ongoing surveillance, maintenance, and treatment of leaking munitions by UMDA personnel	known significant	pg. 2-5 to 2-6, UMDA EIS, 1992
Trucks	• trucks do not enter igloos	known insignificant	personal tour
Forklifts	• forklifts required for handling of munitions inside igloos	known significant	personal tour

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of Munitions Transport with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines	• all munitions must be transported from storage in igloos to UMCDF	known significant	Fig. 21 UMDA EIS, 1992
Ton Containers			
M55 Rockets			
Projectiles			
Bombs/Spraytanks			
Process Water	• no interaction, munitions transport is along separate roads and removed from other treatment buildings	known insignificant	Fig. B-4-4 to Fig B-4-11 RCRA Application, 1995
Electricity			
Decontaminating Solution			
Hydrochloric Acid			
Fuel Gas/Oil/LPG	• used to power vehicles for transport	known significant	
Brine	• no interaction, munitions transport is along separate roads and removed from other treatment buildings	known insignificant	Fig. B-4-4 to Fig B-4-11 RCRA Application, 1995
Spent Carbon, Filters, Solid Waste			
Liquid Lab Wastes			
Personnel	• required to handle and maneuver munitions for transport	known significant	pg. 2-18 to 2-19 UMDA EIS, 1992 pg. D-3-2, RCRA Application, 1995
Trucks	•		
Forklifts	•		

FACILITY: Umatilla Chemical Demilitarization Incineration Facility — **INTERFACE:** I - Normal Operations

Interactions of Storage in CHB with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines Ton Containers M55 Rockets Projectiles Bombs/Spraytanks	• all munitions are stored in CHB, stockpiles to allow 24 hr/day operation of UMCDF	known significant	pg. D-3-2 RCRA Application, 1996 pg. 2-18, UMDA EIS, 1992
Process Water	• no interaction, CHB is used for storage. treatment occurs in MDB	known insignificant	pg. D-3-6, RCRA Application, 1995
Electricity	• required for lights, HVAC, monitoring, blowers, fans	known significant	pg. D-2-24, RCRA Application, 1995
Decontaminating Solution	• used to decontaminate outside of ONCs and any surfaces contaminated by agent	known significant	pg. D-1-26, RCRA Application, 1995
Hydrochloric Acid Fuel Gas/Oil/LPG Brine Spent Carbon, Filters, Solid Waste Liquid Lab Wastes	• no interaction, CHB is used for storage, treatment occurs in MDB	known insignificant	pg. D-3-6, RCRA Application, 1995
Personnel Trucks Forklifts	• involved in unloading and handling in building	known significant	pg. D-3-4 to D-3-7, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		INTERFACE: I - Normal Operations	
Interactions of Unpacking - MDB with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
M23 Landmines Ton Containers M55 Rockets Projectiles Bombs/Spraytanks	• all munitions are conveyed from storage in CHB in ONCs to unpack area of MDB, air inside ONC sampled for agent, if no agent is detected, ONCs are unpacked and munitions are placed on trays for processing • leaking munitions are unpacked by personnel in protective suits in Toxic Maintenance area and placed on trays • trays are placed on conveyors to Explosive Containment Room (ECR)	known significant	pg. D-2-3 to D-2-14 RCRA Application. 1996
Process Water	• no interaction, unpacking area is separate from processing	known insignificant	pg. D-1-9, RCRA Application, 1995
Electricity	• required for lights, HVAC, monitoring, blowers, fans	known significant	pg. D-2-24, RCRA Application, 1995
Decontaminating Solution	• used to decontaminate outside of ONCs and any surfaces contaminated by agent	known significant	pg. D-2-5, RCRA Application, 1995
Hydrochloric Acid Fuel Gas/Oil/LPG Brine Spent Carbon, Filters, Solid Waste Liquid Lab Wastes	• no interaction, unpacking area is separate from processing	known insignificant	pg. D-2-1 to D-2-15, RCRA Application, 1995
Personnel	• involved in unloading and handling in building	known significant	pg. D-1-9, RCRA Application, 1995
Trucks	• not involved in unloading and handling in building	known insignificant	pg. D-1-9, RCRA Application, 1995
Forklifts	• involved in unloading and handling in building	known significant	pg. D-1-9, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		**INTERFACE:** I - Normal Operations	
Interactions of Defuse and Drain **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
M23 Landmines	• in glove box, drums opened, plug removed and placed on conveyor, fuzes and activators removed to ECR, dunnage and arming plug on DUN conveyor, drums to MPF, mines to ECR and Mine Orientation Station to orient mine, punch and drain agent, then burster, agent pumped to Toxic Cubicle	known significant	pg. D-2-6 to D-2-8 RCRA Application. 1996
Ton Containers	• containers go to munitions processing bay, bulk drain station, container is punched, tube inserted and agent pumped to tank in Toxic Cubicle, a second hole is punched after draining, trays of drained munitions taken to buffer storage conveyors to MPF	known significant	pg. D-2-12 to D-2-14 RCRA Application. 1996
M55 Rockets	• inside ECR, rockets are punched and agent drained, rockets are sheared into sections, agent is pumped into holding tank in Toxic Cubicle	known significant	pg. D-2-3 to D-2-5 RCRA Application. 1996
Projectiles	• processed by projectile/mortar disassembly machine to remove fuze, supplementary charge, and burster • projectile bodies taken out of ECR to tilting conveyer, placed into unit pallet assemblies to verify burster removal, taken to munitions corridor and loaded on charge car then to Munitions Processing Bay to Multipurpose Demil Machines to remove top of welded/stuck burster wells, agent is drained, burster wells are crimped then replaced • projectile returned to charge car, agent is pumped to tank in Toxic Cubicle	known significant	pg. D-2-9 to D-2-12 RCRA Application. 1996
Bombs/Spraytanks	• same as for ton containers	known significant	pg. D-2-12 to D-2-14 RCRA Application. 1996
Process Water	• rocket shearing blades sprayed with process water or decontaminating solution to prevent ignition of explosives or propellants	known insignificant	pg. D-2-4. RCRA Application. 1995
Electricity	• required for lights, HVAC, monitoring, blowers, fans, process	known significant	pg. D-2-3 to D-2-15. RCRA Application. 1995
Decontaminating Solution	• same as for process water	known significant	pg. D-2-4. RCRA Application. 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		**INTERFACE:** I - Normal Operations	
Interactions of Defuse and Drain **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Hydrochloric Acid	• no interaction - not mentioned in process description	known insignificant	pg. D-2-1 to D-2-15, RCRA Application, 1995
Fuel Gas/Oil/LPG			
Brine			
Spent Carbon, Filters, Solid Waste			
Liquid Lab Wastes			
Personnel	• Control room operator oversees are defuse/punch/drain operations remotely • process is automated, no personnel directly involved	known significant - reduced to insignificance	pg. D-2-3 to D-2-15, RCRA Application, 1995
Trucks	• no interaction, not mentioned in process description	known insignificant	pg. D-2-3 to D-2-15, RCRA Application, 1995
Forklifts	•		

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of DFS and PAS with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines	• booster is pushed out of mine and into Deactivation feed chute, processed mines also go into feed chute; fuzes and activators placed on mine conveyor through ECR and to DFS feed chute • enter rotary retort in DFS, thermally deactivate and incinerate explosives and propellant components and destroy residual agent on hardware; flue gas maintained at 1000 to 1800F, rotary retort rotated at 05. to 2 rpm depending on munitions processed • heated discharge conveyor removes ash and scrap, holding for 15 min. at 1000F for 5X destruction of residual agent • flue gas passes through blast attenuation duct, then cyclone (solids to exit cyclone via slide gate to sealed container), then through to DFS PAS - quench tower, venturi scrubber, packed bed scrubber tower, demister vessel, gas/gas heat exchanger, gas chiller exchanger, carbon filter units, and exhaust blower	known significant	pg. D-2-7 to D-2-8, pg. D-7-16 to D-7-18, pg. D-7-28 to D-7-30 RCRA Application, 1996
Ton Containers	• no fuzes, boosters, or propellants which require deactivation	known insignificant	pg. D-2-14 RCRA Application, 1996
M55 Rockets	• sheared rocket pieces containing fuzes enter feed chute for DFS • rest of process same as for landmines	known significant	pg. D-2-4 RCRA Application, 1996
Projectiles	• nose plugs enter feed chute for DFS • rest of process same as for landmines	known significant	pg. D-2-10 RCRA Application, 1996
Bombs/Spraytanks	• same as for ton containers	known insignificant	pg. D-2-14 RCRA Application, 1996
Process Water	• water inputted in feed chute to prevent explosions • constituent in brine/separator condensate to saturate and cool gas in quench tower and venturi scrubber; separated in packed bed tower • process water used in demister	known significant	pg. D-7-28 fig D-7-2, RCRA Application, 1995
Electricity	• required for control and monitoring, lighting, HVAC, pumps and blowers	known significant	pg. D-2-24, D-7-55-61, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		**INTERFACE:** I - Normal Operations	
Interactions of DFS and PAS with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Decontaminating Solution	• may be used in startup/shutdown to decontaminate surfaces • used in feed chute	known significant	pg. D-7-1 to D-7-62, RCRA Application, 1995
Hydrochloric Acid	• acid wash solution to wash down demister vessel when pressure drop indicates plugging	known significant	pg. D-7-29, fig D-7-1 and D-7-2, RCRA Application, 1995
Fuel Gas/Oil/LPG	• used to run rotary retort and burner block, heated discharge conveyor, afterburner - pilot and primary fuel • LPG is backup for fuel gas and for controlled cool-downs	known significant	pg. D-2-25, fig D-7-1, D-7-16, and D-7-18, RCRA Application, 1995
Brine	• added to Venturi scrubber and removed from scrubber tower, stored in brine surge tanks and recycled back to Venturi	known significant	pg. D-7-28 to D-7-29, fig D-7-1 and D-7-2, RCRA Application, 1995
Spent Carbon, Filters, Solid Wastes	• spent Carbon removed from Carbon filter units, none inputted	known insignificant	pg. D-7-28 to D-7-29, fig D-7-1 and D-7-2, RCRA Application, 1995
Liquid Lab Wastes	• not inputted into DFS. no interaction	known insignificant	pg. D-7-1 to D-7-62, fig D-7-1 and D-7-2, RCRA Application, 1995
Personnel	• Control room operator oversees are defuse/punch/drain operations remotely • process is automated, no personnel directly involved • interaction during shutdown maintenance only	known significant - reduced to insignificance	pg. D-7-1 to D-7-62, RCRA Application, 1995
Trucks	• no interaction, not mentioned in process description	known insignificant	pg. D-7-1 to D-7-62, RCRA Application, 1995
Forklifts	•		

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of MPF and PAS with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines	• empty mine drums conveyed to MPF on trays on power driven rollers into MPF entry airlock, then tray is fed into burnout chamber at >1000F for 20-85 min. for 5X decontamination; trays of decontaminated parts are conveyed to discharge airlock, then to cooling area and finally scrap metal bins • MPF is a direct-fired, roller hearth incinerator • flue gas is vented to afterburner, PAS same as for DFS	known significant	pg. D-2-6, D-6-15 to D-6-18, D-6-27 to D-6-29; fig. D-6-1, D-6-2 and D-6-3, RCRA Application, 1995
Ton Containers	• drained containers are conveyed on trays to buffer storage conveyers then to MPF • process similar to that for landmines	known significant	pg. D-2-14, RCRA Application, 1995
M55 Rockets	• entire rocket is conveyed to DFS, no interaction	known insignificant	pg. D-2-4 and D-6-5, RCRA Application, 1995
Projectiles	• processed projectiles conveyed on trays to buffer storage containers, then conveyed into MPF • process similar to that for landmines	known significant	pg. D-2-12 and D-6-15, RCRA Application, 1995
Bombs/Spraytanks	• process similar to that for landmines	known significant	pg. D-2-14 and D-6-15, RCRA Application, 1995
Process Water	• inputted into zone 1 and zone 2 of MPF; required for secondary cooling; inputted into PAS as for DFS PAS	known significant	pg. D-6-15 to D-6-18; fig D-6-1, RCRA Application, 1995
Electricity	• required for process control and monitoring	known significant	pg. D-6-1 to D-6-60; RCRA Application, 1995
Decontaminating Solution	• may be used in startup/shutdowns	known significant	pg. D-6-1 to D-6-60; RCRA Application, 1995
Hydrochloric Acid	• same as for DFS	known significant	pg. D-6-1 to D-6-60; RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		**INTERFACE:** I - Normal Operations	
Interactions of MPF and PAS with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Fuel Gas/Oil/LPG	• used to fuel burners in MPF and afterburners	known significant	pg. D-6-25 to D-6-29; fig. D-6-1, RCRA Application, 1995
Brine	• same as for DFS	known significant	pg. D-6-1 to D-6-60; RCRA Application, 1995
Spent Carbon, Filters, Solid Waste		known significant	
Liquid Lab Wastes		known insignificant	
Personnel		known significant - mitigated to insignificance	
Trucks		known insignificant	
Forklifts		known insignificant	

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of DUN and PAS with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines	• wood and polystyrene packing from M23 mine packs is charged into primary chamber through an airlock and DUN lift system and feed ram which pushes charged wastes along chamber at 1500-1800F until all waste ash falls into collection bin below • flue gas flows into afterburner at 2000F for 2 s then enters quench tower to be quenched with sodium hydroxide to bring temperature to 350F to remove acidic gases and chlorides; then flue gas enters the baghouse for particulate removal and collection in hoppers below; then enters the plate and frame gas/gas heat exchanger and passes through separator 1; then through a gas chiller exchanger and separator 2; then flue gas is sent back to gas/gas exchanger for reheating then through the carbon filter unit, blower, and out the stack	known significant	pg. D-8-13 to D-8-14, D-8-23; fig. D-8-1, D-8-2, D-8-3, RCRA Application, 1995
Ton Containers	• no interaction - there is no dunnage associated with ton containers, all are fed through MPF	known insignificant	pg. D-8-13 to D-8-15, RCRA Application, 1995
M55 Rockets	• some dunnage associated with used pallets and packing cases, dunnage also removed from overpacking of leaking munitions	known significant	pg. D-8-13, D-7-16, D-2-5, RCRA Application, 1995
Projectiles	• some dunnage associated with used pallets and packing cases	known significant	pg. D-2-9 ;to D-2-12, D-8-13, RCRA Application, 1995
Bombs/Spraytanks	• same as for projectiles	known significant	pg. D-2-12 ;to D-2-14, D-8-13, RCRA Application, 1995
Process Water	• inputted and recirculated from quench tower; condensate removed from separator 1 and 2	known significant	pg. D-8-2, D-8-3, D-8-13, D-8-14, D-8-23, D-8-24 RCRA Application, 1995
Electricity	• required for process control and monitoring	known significant	pg. D-8-1 to D-8-52, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		INTERFACE: I - Normal Operations	
Interactions of DUN and PAS with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Decontaminating Solution	• used to decontaminate lab wastes prior to incineration; may be used to decontaminate system during shutdowns	known significant	pg. D-8-14, RCRA Application, 1995
Hydrochloric Acid	• not used in process, no de[illegible]rs in DUN PAS	known insignificant	pg. D-8-23 to D-8-25, fig D-8-2 and D-8-3, RCRA Application, 1995
Fuel Gas/Oil/LPG	• used to fire burners in primary chamber and afterburner	known significant	pg. D-8-15, fig. D-8-1, RCRA Application, 1995
Brine	• not used in process, no Venturi scrubber, acid gases removed instead with a quench tower, baghouse, heat exchangers and separators	known insignificant	pg. D-8-23 to D-8-25, fig D-8-2 and D-8-3, RCRA Application, 1995
Spent Carbon, Filters, Solid Waste	• all miscellaneous solid wastes, spent Carbon and filters are incinerated in DUN for volume reduction prior to final disposal	known significant	pg. D-8-13 to D-8-14, RCRA Application, 1995
Liquid Lab Wastes	• no interaction, not inputted into DUN	known insignificant	pg. D-8-13 to D-8-14, RCRA Application, 1995
Personnel	• no interaction during operation, system is completely automated with personnel in control room, maintenance during shutdown only	known significant - mitigated to insignificance	pg. D-8-1 to D-8-52, RCRA Application, 1995
Trucks	• no interaction during operation	known insignificant	pg. D-8-1 to D-8-52, RCRA Application, 1995
Forklifts		known insignificant	

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of LIC and PAS with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
M23 Landmines	• all liquid agent drained from munitions is pumped into agent collection tank system in Toxic Cubicle, pumped through duplex strainer to remove large particles; agent is dispersed into burner block with atomizing nozzle and mixed rapidly with combustion air and/or fuel gas at 2500 to 3500F • flue gas then passes into secondary chamber and spent decontaminating solution is atomized at top of chamber at 200F for 2 s, maintained with separate burner block • flue gas then goes through PAS similar to PAS for DFS and DUN	known significant	pg. D-5-16 to D-5-17, D-5-26 to D-5-27, fig. D-5-2, D-5-3, D-5-4 RCRA Application, 1995
Ton Containers		known significant	
M55 Rockets		known significant	
Projectiles		known significant	
Bombs/Spraytanks		known significant	
Process Water	• inputted into secondary chamber with spent decontaminating solution • inputted into PAS as for DFS PAS	known significant	pg. D-5-16 to D-5-17, D-5-26 to D-5-28, fig. D-5-2, D-5-3, D-5-4, RCRA Application, 1995
Electricity	• required for process control and monitoring	known significant	pg. D-5-1 to D-5-60, RCRA Application, 1995
Decontaminating Solution	• inputted into secondary chamber of LIC for incineration	known significant	pg. D-5-16 to D-5-17, fig. D-5-2, RCRA Application, 1995
Hydrochloric Acid	• inputted into PAS as for DFS PAS	known significant	pg. D-5-26 to D-5-28, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization [illegible]ation Facility		**INTERFACE:** I - Normal Operations	
Interactions of LIC and PAS with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Fuel Gas/Oil/LPG	• used to fire blocks in primary [illegible]ondary chambers	known significant	pg. D-5-16 to D-5-17, fig. D-5-2, RCRA Application, 1995
Brine	• same as for DFS PAS	known significant	pg. D-5-1 to D-5-60, fig. D-5-2 to D-5-4, RCRA Application, 1995
Spent Carbon, Filters, Solid Waste	•	known insignificant	
Liquid Lab Wastes	• will be incinerated in LIC, inputted into secondary chamber with spent decontaminating solution	known significant	pg. D-5-16 to D-5-17, RCRA Application, 1995
Personnel	• same as for DFS PAS	known significant - mitigated to insignificance	pg. D-5-1 to D-5-60, fig. D-5-2 to D-5-4, RCRA Application, 1995
Trucks	•	known insignificant	
Forklifts		known insignificant	

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of BRA and PAS with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
M23 Landmines	• no interaction; components handled by other processes; BRA only handles brine which contains combustion products from MPF, DFS, and LIC	known insignificant	pg. D-9-1 to D-9-36, fig. D-9-1 to D-9-5, RCRA Application, 1995
Ton Containers		known insignificant	
M55 Rockets		known insignificant	
Projectiles		known insignificant	
Bombs/Spraytanks		known insignificant	
Process Water	• steam is used to heat drum dryers and heat exchangers, the condensate is recirculated to the boilers • process waters is flushed through system to prevent brine spillage during shutdown	known significant	pg. D-9-9 to D-9-10, D-9-30, fig. D-9-1, RCRA Application, 1995
Electricity	• used for process control, monitoring and to power systems	known significant	pg. D-9-13 to D-9-14, RCRA Application, 1995
Decontaminating Solution	• no interaction; brines will have been tested previously for the absence of agent, therefore no decontamination is required • only required in emergencies	potentially significant	pg. D-9-1 to D-9-36, RCRA Application, 1995
Hydrochloric Acid	• not required; steam heated process water is sufficient to dissolve accumulated salts	known insignificant	pg. D-9-20 to D-9-23, RCRA Application, 1995
Fuel Gas/Oil/LPG	• used for process steam boilers	known significant	pg. D-2-25, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of BRA and PAS with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
Brine	• BRA and PAS are the process for handling brines to reduce brines by 80% of weight and produce brine salts; brine surge tank is filled and batch is tested, preheated thoroughly heat exchangers then recirculated through flash evaporator until specific gravity ≥ 1.08, then fed through evaporator once more; then fed to drum dryers with steam on the inside of the rotating drum for heat, knife blades continuously scrap the salts from the drums and the salts drop through to collection guides onto a conveyor then to a collection container which is moved to Residue Handling Area (RHA) when full and then sampled, then sent to final disposal • water vapor and air from process is sent to a PAS - a dryer knockout box to remove particles and heat to prevent condensation, then through baghouses for more particle remove then out the stack	known significant	pg. D-9-40 to D-9-42, fig. D-9-1, RCRA Application, 1995
Spent Carbon, Filters, Solid Waste	• no interaction, misc. wastes are produced from this process but none are inputted	known insignificant	pg. D-9-1 to D-9-42, fig. D-9-1, RCRA Application, 1995
Liquid Lab Wastes	• same as for DFS	known insignificant	pg. D-9-1 to D-9-36, RCRA Application, 1995
Personnel	• daily surveillance of BRA and PAS by personnel	known significant	pg. D-9-42, RCRA Application, 1995
Trucks	• same as for DFS	known insignificant	pg. D-9-1 to D-9-36, RCRA Application, 1995
Forklifts		known insignificant	

FACILITY: Umatilla Chemical Demilitarization Incineration Facility		**INTERFACE:** I - Normal Operations	
Interactions of Tank/Container Storage/Handling **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
M23 Landmines	• stored in CHB in ONCs prior to processing for 1 to 5 days • agent drained from munitions is stored in agent holding tank and surge tank (1960 gal combined volume); agent holding tank size = 4 hr operation of 1 LIC and 2.5X size of tom container; surge tank volume = 1300 gal. used only for emergencies; agent stored in Toxic Cubicle prior to incineration, through a duplex strainer to remove particles then to LIC	known significant	pg. D-3-1, D-4-6 to D-4-9, RCRA Application, 1995
Ton Containers			
M55 Rockets			
Projectiles			
Bombs/Spraytanks			
Process Water	• condensate stored in condensate surge tank, liquid wastes in sumps	known significant	pg. D-4-3, RCRA Application, 1995
Electricity	• used for process control, monitoring, HVAC	known significant	pg. D-2-24, RCRA Application, 1995
Decontaminating Solution	• 3-2300 gal. storage tanks hold spent decontaminating solution prior to treatment in secondary LIC chamber; solution flows into sumps and trenches on first and second floors of MDB and pumped into storage tanks, filling switches tanks when first tank is full	known significant	pg. D-4-19 to D-4-20, RCRA Application, 1995
Hydrochloric Acid	• stored in tanks onsite	known significant	RCRA Application, 1995
Fuel Gas/Oil/LPG	• stored onsite in main fuel oil storage area as backup for natural gas; one underground tank in diked storage area with 8 hour supply day tank	known significant	pg. D-2-25, RCRA Application, 1995
Brine	• 4 brine surge tanks with inlets from PAS of DFS, MPF, and 2 LICs, inlet from acid wash solution and one pump recycle feed line; inlet valves switch tanks when preset level has been reached • brine salts are transferred from BRA line collection containers to lines, covered transportation containers for storage in RHA while awaiting shipment to approved hazardous waste treatment, storage, or disposal facility	known significant	pg. D-4-21 to D-4-22, D-3-11, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** I - Normal Operations

Interactions of Tank/Container Storage/Handling **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Spent Carbon, Filters, Solid Waste	• spent filter media is removed from filter media and placed in plastic bags then into lined collection containers for transport to Toxic Maintenance Area of MDB, there the Carbon is removed from the reusable frames and placed in combustible dunnage feed boxes for transfer to DUN to be incinerated on weekends when no contaminated dunnage will be incinerated; solid lab wastes contained then disposed in DUN	known significant	pg. D-3-13 to D-3-14, RCRA Application, 1995
Liquid Lab Wastes	• input from lab sinks, emergency showers and eyewash stations by gravity feed, wastes in tank are pumps into spent decontaminating solution holding tanks	known significant	pg. D-4-4 to D-4-5. RCRA Application, 1995
Personnel	• regularly inspect tanks, strainers in agent holding tanks; handle containers in RHA; transfer LPG and fuel oil to tanks; transfer wastes to containers for transport or disposal; repair any leaks	known significant	pg. D-4-1 to D-4-42, RCRA Application, 1995
Trucks	• transport containers of incinerator ash, baghouse residue, cyclone residue from DUN, slag, brine salts, and scrap metal to proper facility for storage, treatment, and/or disposal	known significant	pg. D-3-11 to D-3-12. RCRA Application, 1995
Forklifts	• used to handle containers in CHB and RHA	known significant	pg. D-3-11 to D-3-12. D-3-5 to D-3-7. RCRA Application. 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal/Emergency Operations

Interactions of Background Levels with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
Air - Gaseous Air - Particulate	See pollutant table below	known insignificant known significant	Table 3.2, UMDA EIS, 1992
Air - Light/Noise	• conventional ammunition disposal/detonation conducted on west side of UMDA; two major highways near UMDA; food processing plant southeast of UMDA; agricultural fields with farm equipment operating surrounding UMDA	unknown significance	pg. 3-17, UMDA EIS, 1992

Pollutant	Monitor location	Year	Actual max. ($\mu g/m^3$)	Actual annual mean ($\mu g/m^3$)	# State primary standard violations
total suspended particulate matter (TSP) (24 hr ave.)	Ordnance	1980	204	36	1
	Pendleton	1983	191	75	2
		1984	247	83	4
		1985	270	93	8
		1986	327	85	8
PM_{10} (24 hr ave.)	Pendleton	1986	133	40	0
		1987	136	46	0
		1988	119	41	0
		1989	101	37	0
SO_2 (24 hr ave.)	Pendleton	1975	15	13	0
		1976	16	13	0
		1977	13	13	0
lead	Pendleton	1978		0.32	0
		1979		0.43	0
		1980		0.36	0
		1981		0.40	0
		1982		0.27	0
		1983		0.27	0
NO_2	Ordnance	1980		23	0
		1981		23	0
O_3	no representative monitoring data available				
CO	no representative monitoring data available				

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Tank/Container Storage/Handling	• salts are placed in 3'X3'X3' lined collection containers then into 8'X20'X5' containers for transport to treatment/storage/disposal facility; residue (ash and particulate matter) placed separately in collection containers 5'X5'X4' then into line and covered collection containers 8'X20'X5' for transport to treatment/storage/disposal facility; cyclone residue from DFS and slag is collected in 55 gal. containers for transport to treatment/storage/disposal facility; spent filter media is placed in 3'X3'X3' lined containers for transport to Toxic Maintenance Are for transferal to DUN; storage and handling in CHB and RHA only, continuous emissions monitoring of agent in CHB, wastes in containers do not contain free liquids, negative pressure in CHB and RHA, doors closed during handling; floors in RHA coated with epoxy resin compatible with wastes stored which prevents reactions which may form vapors; containers stored for <90 days; stored in rows to allow inspection and forklift movement, forklift speed <5 mph, trucks <25 mph; all containers meet Department of Transportation Codes including manifesting; trucks routed through UMCDF to avoid collisions; agent collection system has working capacity 78% of total capacity + surge tank for overflows; design, material, construction in accordance with ASME boiler and pressure vessel codes for possibility for overpressuring, meet seismic zone 3 design requirements • no sumps or trenches for agent, agent in air-tight tanks only with rupture disks and sight gauges for manual observation, level varies little, therefore small amounts of air vented in and out, interlock system to prevent munitions draining if tank is full, vacuum relief valve, strainers on agent feed lines with pressure alarms to indicate clogging of strainer baskets, strainer baskets are manually removed, placed in plastic container and sealed in secondary container and sent to DUN, new/clean unit is installed, agent tank is airlocked in Toxic Cubicle with carbon filter on tank, negative pressure in cubicle, remotely monitored	potentially significant mitigation reduced	pg. D-3-10 to D-3-11, D-3-14 to D-3-15, D-3-5, fig. B-4-3 to D-4-11, RCRA Application, 1995 pg. D-4-6 to D-4-9, D-4-18, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
Tank/Container Storage/Handling	• spent decontaminating solution holding tank size equal to one day's normal operation + one week's washdown + one emergency washdown, designed and constructed with ASME codes for potential of overpressuring; sump and sloped foundation provide secondary containment - 97 sumps in MDB and PUB; level sensor in concrete liner will detect leakage from sump; sumps pumped to storage tank; receive liquid lab wastes; daily visual inspections • 4 brine surge tanks with size of each equal to one day's max. brine production; designed and constructed with American Petroleum Institute Standard 650, equipped with agitators to prevent solids buildup, cathodic protection, tanks in diked area • all tanks have continuous level transmitter with low/high level alarms, process data and recording system, valve position switches, liquid flow control, pressure indicator and transmitter, mass flow measurement and transmitter, venting through MDB ventilation/filtration system for brine	potentially significant mitigation reduced	pg. D-4-9 to D-4-13. pg. D-4-14 to D-4-15. pg. D-4-15 to D-4-16, RCRA Application, 1995
BRA and PAS	• liquids collected in sumps to brine surge tanks; catch pans under drum dryers to catch solids and liquids, conveyors are enclosed; valves to isolate strainers during change-out; periodically monitoring of key process parameters; testing of feed brine for metals to evaluate if process interiors are being eroded, hydrostatic testing of pipe lines for leaks; all processes enclosed in PUB for secondary containment, all equipment designed to be compatible with brine; visual check for leaks, spills, damage during scheduled or emergency shutdowns, and daily; analysis of brine prior to processing confirms absence of agent • exhaust air routed through PAS and out stack, continuous monitoring of process parameters of PAS shutdown initiated if system parameters are exceeded, automatic continuous air monitoring system on exhaust stack of PAS using gas chromatography for agent GB, VX, and HD; gaseous emissions from BRA PAS are: SO_2=0.01 lb/hr =0.03 tons/yr; NOx=0.3 lb/hr=0.90 tons/yr; CO =0.6 lb/hr =1.80 tons/yr; VOC=0.03 lb/hr=0.44 tons/yr	known significant mitigation reduced	pg. D-9-14 to D-9-31, table D-9-5 and D-9-6, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
LIC and PAS	• emissions from LIC, MPF, and DFS combined stack are: pollutant / (lb/hr) / (tons/yr) / standby (tons/yr) SO_2 3.5 4.63 0.004 NOx 26.0 28.69 0.10 CO 98.7 103.66 16.97 VOC 0.1 0.05 0.41 • exceeds emission rates for NOx by 2.5X Oregon Major Source Threshold Emission Rate, therefore, the emissions are significant, but are reduced by PAS • what about other gaseous emissions such as PICs, dioxins/furan/heavy metals?	known significant mitigation reduced	table D-9-5 and D-9-6, RCRA Application. 1995
	• PICs are not determined but CO (the most fundamental PIC) can be used as an indicator for the destruction of higher order PICs - CO levels representing 99.99% carbon burnout indicate 99.9999% destruction of other organic compounds; CO annual max. potential emissions are 41.59 tons/yr < 100 tons/yr = Oregon Major Source Threshold Emission Rate; CO is monitored between primary and secondary chambers, ductwork between secondary chamber and ductwork, and ductwork between exhaust blower and combined stack; if [CO]>100 ppm then chemical agent feed is shut-off, thereby reducing emissions of PICs	potentially significant mitigation reduced	Makansi, 1987 pg. D-9-79, RCRA Application, 1995
	• dioxins and furans adsorb onto particulate matter, therefore, reduce particulate matter and reduce those emission rates; dioxins and furans not detected in JACADS stack with DRE > 99.9999% as required by RCRA due to high burn temperatures, afterburners, and small amounts of chlorinated organics in wastefeed	potentially significant mitigation reduced	personal judgment pg. 4-18 to 4-19 UMDA EIS, 1992
	• emissions of lead and other carcinogenic metals are expected to be well below any quantifiable standard, lowering temp. before baghouse condenses metals onto particles which are then removed	potentially significant mitigation reduced	Makansi, 1987 pg. 4-14 UMDA EIS, 1992

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous with	Cause-Effect Rationale • **Significance** • **Mitigation**	Judgment	References
DUN and PAS	• startup/shutdown of facility, trial burn of surrogate then agent to detect and correct problems and demonstrate compliance; permit limits set for operation parameters; solid wastes charged through airlock, conservative temp. and residence times for 5X decontamination conditions; continuous local and remote monitoring for process parameters and or PAS; automatic shutoff systems triggers if process parameters are not met • emissions from DUN PAS are lower than Oregon standards: pollutant (lb/hr) (tons/yr) SO_2 0.7 2.10 NOx 9.2 27.60 CO 1.5 4.50 VOC - -	known significant mitigation reduced	pg. D-8-1 to D-8-51, D-9-6, RCRA Application. 1995
MPF and PAS	• startup/shutdown period and trial burns of surrogate and agent to ensure safe operation and compliance, review operations; establish operational parameters for permit; no explosives fed into system; charge and discharge airlocks, vapors generated in airlocks are vented to burnout chamber to assure 5X decontamination criteria (1000F for > 15 min.) then to afterburner and PAS; local and remote continuous monitoring for process parameters with automatic shutdown, enclosed by building with negative pressure; see LIC and PAS for combined gaseous emissions	known significant mitigation reduced	pg. D-6-1 to D-6-60, RCRA Application, 1995
DFS and PAS	• startup/shutdown pretrial and trial burns of surrogate and agent to ensure safe operation and compliance, review operations, establish operational parameters for permit; only process single munitions and agent type to optimize process for then type and maximize destruction; feed on feed chutes passes through blast gates to isolate rotary retort and Explosives Containment Room; rotary retort to thermally deactivate and incinerate enclosed by shroud and negative pressurized; flue gases goes through blast attenuation duct to withstand explosions and prevent damage and leakage, then through cyclone, and afterburner, then DFS PAS; local and remote continuous monitoring for process parameters with automatic cutoff of auxiliary fuel; see LIC and PAS for combined gaseous emissions	known significant mitigation reduced	pg. D-7-1 to D-7-43, RCRA Application. 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
Defuse, Punch, Drain	• rockets transferred to Drain Station, blast gates closed, then rocked sheared (shear blades sprayed with decontaminating solution or water to prevent ignition, then next munitions enters; only one blast gate (feed and DFS chute feed) is open at one time; DFS and PAS interlocked with rocket processing rate to prevent extra rockets being stored in feed chutes • mines received by mine orientation station in Explosive Containment Room through double blast gates; mines are oriented, punched, and drained (sucked by pump); there are 3 tries to orient mine properly then shutdown of system requiring entry by personnel; all gates times with process steps, each mine forwarding a position; in areas where agent may be released, the area is enclosed with negative pressure; same as for projectiles and bulk containers; bursters, propellant, explosives are removed in Explosive Containment Room only, proper removal is checked, the ECR is isolated by airlocks and blast gates, conveyors are enclosed; flow switches, level indicators and load cells on drain lines ensure munitions are drained to maximum extent (>95% removal); if munitions cannot be drained (i.e. bulk items) >95% ODEQ will be notified and item will be processed individually; automatic continuous air monitoring inside MDB	potentially significant mitigation reduced	pg. D-2-1 to D-2-20 RCRA Application, 1995
Unpack in MDB	• sample air in ONCs for agent prior to opening, if air is agent free, munitions are unloaded in unload area of MDB; ONCs containing agent and overpacked munitions are unloaded in Toxic Maintenance Area, overpacked and transferred to ECR; ONCs are decontaminated to 3X with solution, decontamination is confirmed with monitoring • dry-pipe preaction sprinkler system installed in unpack area; automatic continuous air monitoring system in MDB handling area, exhaust air from MDB, MDB is enclosed with carbon filters and negative pressures	potentially significant mitigation reduced	pg. D-2-3 to D-2-20 RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Gaseous with	Cause-Effect Rationale • Significance • Mitigation	Judgment	References
Storage in CHB	• munitions stored in airtight ONCs for 1 to 5 days; ONCs/overpack are vapor tight, seals are impervious to chemical agent and able to withstand decontamination solution, all engulfing fire of 1500F; ONCs compatible with door sizes, clearances, and material handling system • ONCs handled, moved by pneumatic roller track to unpack area of MDB with loading factor of safety of 1.25 • automatic continuous air monitoring for agent in CHB; CHB is steel frame building with insulated metal roofing and side panels; unloading area are covered, conveyor corridor is enclosed, building is enclosed with air exhaust and carbon filters, no incompatible waste present, only one agent processed at a time	potentially significant mitigation reduced	pg. D-2-1 to D-2-14, D-3-1 to D-3-6, RCRA Application, 1995
Munitions Transport	• # convoys/day differs with type of munitions, agent, and processing rate, munitions are in ONCs/overpacking which are vapor tight, able to withstand 1500F all engulfing fire; transport during daylight hours only; traffic patterns set up to minimize interaction of transport vehicles with other vehicles	potentially significant mitigation reduced	pg. D-3-6, RCRA Application, 1995
Storage in Igloos	• munitions stored in igloos and warehouses in UMDA Chemical Limited Area; munitions inspected for leakage before removed from storage; if munitions are leaking then: ton containers are surface decontaminated and reconditions (plugs and valves replaced), bombs are overpacked, spray tanks are stored in overpack containers, rockets are overpacked • before opening igloos, igloos air is sampled for presence of agent, then igloos is opened, periodic surveillance and inventorying of containers, tanks, and munitions with air monitoring for agent and visual examination including condition of igloos	potentially significant mitigation reduced	pg. D-2-3 to D-2-12, RCRA Application, 1995 pg. 2-5 to 2-6, table 4.9, UMDA EIS, 1992

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Emergency Operations

Interactions of Air - Particulate with	Cause-Effect Rationale • Significance • Mitigation	Judgment	Reference
Tank/Container Storage/Handling BRA and PAS LIC and PAS DUN and PAS MPF and PAS DFS and PAS Defuse, Punch, Drain Unpack in MDB Storage in CHB	• emergency releases of agent due to plant accidents - largest credible accident scenarios with probability $>10^{-8}$ <u>munitions</u> — <u>accident scenario</u> GB-rockets — crash of large aircraft without fire VX-mines — earthquake with fire GB-rockets — earthquake with fire GB-rockets — crash of large aircraft with fire VX-rockets — earthquake with fire VX-8" projectilesearthquake with fire VX-spraytanks — earthquake with fire GB-155 mm projectiles — earthquake with fire • UMCDF designed for seismic zone 2 by Uniform Building Code, seismic actuated cutoff valves on main gas supply for incinerators • UMDA not designated at restricted airspace, designation under review; Boardman bombing range is 16 km southwest of UMDA • internally initiated accidents include: dropping of munitions pallet, dropping of single bare munitions with detonation, forklift collision with short fire, munitions detonation in ECR causing structural/ventilation system failure and fire, MPF explosion due to failure to stop fuel flow after shutdown, burstered munitions is fed into DUN • add chemical relief valves to agent storage tanks, buildings are enclosed, accidents are avoided with QC to prevent feed of burstered munitions into DUN, dampers fail in fail safe position, redundant induced draft fans, battery powered forklift, extend backup power supply for critical systems from 15 min. to 45 min. • further mitigation measures include security: double fencing around UMCDF perimeter with warning signs, entry limited to one gate staffed by armed security, access limited to persons/vehicles displaying appropriate ID badges, continuous surveillance by roving/armed patrols, 2-way radio communication for personnel, security lighting at key locations; inspections schedule to detect equipment deterioration	potentially significant mitigation reduced	pg. D-2-3 to D-2-12. RCRA Application. 1995 pg. G-9, F-3 table 4-9 UMDA EIS, 1992 personal communication Maj. Moralis; Hermiston area landuse map pg. I-8, table 4-9 UMDA EIS, 1992 pg. F-1-1 to F-1-4, RCRA Application, 1995 pg. F-2-1 to F-2-95, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	INTERFACE: II -Emission - Transport Emergency Operations		
Interactions of Air - Particulate with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Tank/Container Storage/Handling BRA and PAS LIC and PAS DUN and PAS MPF and PAS DFS and PAS Defuse, Punch, Drain Unpack in MDB Storage in CHB	• further mitigation included waiver and documentation of emergency preparedness and prevention with internal/external communications, emergency equipment requirements, water supply to National Fire Protection Association Standards, aisle space requirements • also preventative procedures, structures, and equipment for: unloading and handling, equipment failure control, incinerator upset control, emergency power, spend decontaminating solution collection system, chemical agent monitoring system, personnel protection equipment • precautions are taken to prevent the reaction of ignitable or reactive wastes: no ignitable wastes onsite, buildings are designed to prevent accidental ignition or reaction, cutting/welding in process areas is not allowed while wastes are present, all buildings are nonsmoking and signed, all equipment is grounded, handling/processing done to minimize accidents, fire protection system - automatic smoke, thermal, photoelectric detectors, manual alarm pulls, fire protection water, automatic sprinkler system in unpack area, automatic fire extinguishers in control room and power room, dry chemical fire protection in Toxic Cubicle, portable fire extinguishers, water deluge system in Explosive Containment Room	potentially significant mitigation reduced	pg. F-3-1 to F-3-6, F-4-1 to F-4-165, F-5-1 to F-5-18, RCRA Application, 1995
Munitions Transport	• largest credible accident scenarios releasing chemical agent with probability > 10^{-8}: munitions — accident scenario VX-rockets — vehicle accident with detonation and fire GB-rockets — earthquake/accident with detonation and fire GB-rockets — vehicle accident with detonation and fire GB-8" projectiles — vehicle accident with detonation and fire • internally initiated accidents releasing agent during loading/transporting munitions: dropping of bare pallet/ONC with/without fire, forklift tine puncturing bare munitions, forklift collision with/without fire, vehicle collision/overturn crushing/puncturing ONC and munitions, vehicle accident with fire	potentially significant mitigation reduced	pg. G-9, I-9 and I-10, table 4-9, UMDA EIS, 1992

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Emergency Operations

Interactions of Air - Particulate with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Munitions Transport (continued)	• mitigated by using qualified forklift operators only, blunt bumpers on forklift tines, transport only during daylight hours, upgrade roads, speed limit = 20 mph, limit truck fuel so fire <10 min., ONCs can withstand 1500F all engulfing fire, traffic routed to minimize interaction with transport flatbed trucks	potentially significant mitigation reduced	pg. G-9, I-9 and I-10, table 4-9, UMDA EIS, 1992
Storage in Igloos	• releases of chemical agent due to storage accidents - largest credible accident scenarios with probability > 10^{-8}: munitions — accident scenario HD-ton container — earthquake with fire in 2 igloos HD-ton container — aircraft crash with fire HD-ton container — earthquake with fire in 1 igloo GB-rockets — aircraft crash with fire GB-rockets — aircraft crash without fire VX-spraytanks — aircraft crash with fire • not restricted airspace, designation under review; facility designed for zone 2 Uniform Building Code	potentially significant mitigation reduced	pg. F-3, G 10, table 4-9, UMDA EIS, 1992

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal/Emergency Operations

Interactions of Air - Particulate with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Tank/Container Storage/Handling	• same as for tank/container storage and handling - gaseous emissions	potentially significant mitigation reduced	pg. D-3-10 to D-3-11, D-3-14 to D-3-15, RCRA Application, 1995
BRA and PAS	• operations and mitigation measures same as for BRA and PAS - gaseous emissions • particulate emission rates for PM_{10}/TSP =0.5 lb/hr=1.5 tons/yr	known significant mitigation reduced	pg. D-9-14 to D-9-31, table D-9-5 and D-9-6 RCRA Application, 1995
LIC and PAS	• operations and mitigation measures same as for LIC and PAS - gaseous emissions • combined particulate emission rates for LIC, MPF and DFS stack: PM_{10}/TSP =3.5 lb/hr=4.63 tons/yr and 0.004 tons/yr on standby	known significant mitigation reduced	pg. D-5-1 to D-5-60, table D-9-5 and D-9-6 RCRA Application, 1995
DUN and PAS	• operations and mitigation measures same as for DUN and PAS - gaseous emissions • particulate emission rates for PM_{10}/TSP =0.5 lb/hr=1.5 tons/yr	known significant mitigation reduced	pg. D-8-1 to D-8-51, table D-9-5 and D-9-6 RCRA Application, 1995
MPF and PAS	• operations and mitigation measures same as for MPF and PAS - gaseous emissions • combined particulate emission rates for LIC, MPF and DFS stack: PM_{10}/TSP =3.5 lb/hr=4.63 tons/yr and 0.004 tons/yr on standby	known significant mitigation reduced	pg. D-6-1 to D-6-60, table D-9-5 and D-9-6 RCRA Application, 1995
DFS and PAS	• operations and mitigation measures same as for DFS and PAS - gaseous emissions • combined particulate emission rates for LIC, MPF and DFS stack: PM_{10}/TSP =3.5 lb/hr=4.63 tons/yr and 0.004 tons/yr on standby	known significant mitigation reduced	pg. D-7-1 to D-7-43, table D-9-5 and D-9-6 RCRA Application, 1995
Defuse, Punch, Drain	• operations and mitigation measures same as for Defuse, Punch, Drain - gaseous emissions	known significant mitigation reduced	pg. D-2-1 to D-2-20, RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal/Emergency Operations

Interactions of Air - Particulate with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Unpack in MDB	• operations and mitigation measures same as for Unpack in MDB - gaseous emissions	potentially significant mitigation reduced	pg. D-2-3 to D-2-20. RCRA Application. 1995
Storage in CHB	• operations and mitigation measures same as for Storage in CHB - gaseous emissions	potentially significant mitigation reduced	pg. D-2-3 to D-2-20. RCRA Application. 1995
Munitions Transport	• operations and mitigation measures same as for Munitions Transport - gaseous emissions	potentially significant mitigation reduced	pg. D-3-6. RCRA Application. 1995 pg. G-9. I-9. I-10. table 4.9. UMDA EIS. 1992
Storage in Igloos	• operations and mitigation measures same as for Storage in Igloos - gaseous emissions	potentially significant mitigation reduced	pg. D-2-3 to D-2-12, RCRA Application. 1995 pg. G-10. F-3. 2-5 to 2-6. Table 4.9. UMDA EIS. 1992

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Normal Operations

Interactions of Air - Light/Noise with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Tank/Container Storage/Handling	• all tanks are inside or underground, all containers are stored inside • containers of residual material are transported to appropriate treatment. storage, or disposal facility, containers are labeled as hazardous; transportation of containers will be seen and heard along transportation routes	potentially significant	pg. D-3-1 to D-3-23, D-4-1 to D-4-60, D-3-14 to D-3-24, RCRA Application, 1995
BRA and PAS LIC and PAS DUN and PAS MPF and PAS DFS and PAS Defuse, Punch, Drain Unpack in MDB Storage in CHB	• all operations occur inside UMCDF which mitigates view and sound from operations; however, stacks and blowers will emit light and sound comparable with other industrial facilities - 60 dBA at 76 m from source	potentially significant	pg. D-9-1 to D-9-31, RCRA Application, 1995 pg. 4-19, UMDA EIS, 1992
Munitions Transport Storage in Igloos	• occur onsite but outdoors; limited view of operations, little or no noise during normal operations	potentially significant	RCRA Application, 1995

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** II -Emission - Transport Emergency Operations

Interactions of Air - Light/Noise **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Tank/Container Storage/Handling	• most accident scenarios occur indoors except: crash of large aircraft with/without fire, earthquake with/without fire, vehicle accident with/without fire and detonation, forklift collision with/without fire, pallet dropping with detonation/fire • these scenarios would release smoke/fire which would be seen; noise? • mitigation same as fore gaseous emissions	potentially significant mitigation reduced	RCRA Application, 1995 UMDA EIS. 1992
BRA and PAS			
LIC and PAS			
DUN and PAS			
MPF and PAS			
DFS and PAS			
Defuse, Punch, Drain			
Unpack in MDB			
Storage in CHB			
Munitions Transport			
Storage in Igloos			

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure

Interactions of Background Levels **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Residents - Visual/Aural	• residents see and hear particles/dust from current agriculture and wind erosion, background traffic from 2 major highways, background detonation activities at UMDA, other local industries; ambient noise levels and significance of view and sound are unknown	unknown significance	personal judgment
Residents - Inhalation/Dermal	• inhalation/ingestion of background airborne particulates is unknown; agricultural area - background inhalation/ingestion of pesticides and herbicides is unknown; percentage of population that smokes is unknown	unknown significance	personal judgment
Residents - Ingestion	•		

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Normal Operations

Interactions of Residents - Visual/Aural **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Light/Noise	• view of facility, stacks, plumes - height of stacks and plumes and radius of view is unknown • view of off site transport of residuals along highways is unknown, 11 to 15 off site trips/day are expected • no measures noise levels, if noise emissions are comparable to other industrial operations - 60 dBA at 76 m = 30 dBA at nearest residents (4 km) < 40 dBA will not disturb sleep of light sleepers	potentially significant	pg. 4-21. UMDA EIS, 1992 pg. 4-19. UMDA EIS, 1992 Bugliarello et al., 1976
Air - Particles	• view/sound of particles and gases addresses by cross-pathway transfer to air - light/noise		
Air - Gases			

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Emergency Operations

Interactions of Residents - Visual/Aural **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Light/Noise	• view of smoke from fire - radius?, view of highway reader boards, view/participation in evacuation procedures • hear emergency siren and notices on t.v. and radio, hear emergency evacuation procedures	known significant	personal judgment
Air - Particles	• view/sound of particles and gases addresses by cross-pathway transfer to air - light/noise		
Air - Gases			

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Normal Operations

<table>
<tr><th>Interactions of Residents - Inhalation/Dermal with</th><th>Cause-Effect Rationale
• Significance
• Mitigation</th><th>Judgment</th><th>References</th></tr>
<tr><td>Air - Light/Noise</td><td>• no significant interaction</td><td>known insignificant</td><td>personal judgment</td></tr>
<tr><td>Air - Particles

Air - Gases</td><td>
<table>
<tr><th>Pollutant</th><th>averaging time</th><th>max. predicted conc. (μg/m³)</th><th>background value (μg/m³)</th><th>applicable standard (μg/m³)</th></tr>
<tr><td>TSP</td><td>annual</td><td>0.59</td><td>36</td><td>60</td></tr>
<tr><td></td><td>24-hr</td><td>4.64</td><td>138</td><td>150</td></tr>
<tr><td>PM10</td><td>annual</td><td>0.59</td><td>36</td><td>50</td></tr>
<tr><td></td><td>24-hr</td><td>4.64</td><td>138</td><td>150</td></tr>
<tr><td>SO2</td><td>annual</td><td>1.21</td><td>13</td><td>52</td></tr>
<tr><td></td><td>24-hr</td><td>8.99</td><td>16</td><td>262</td></tr>
<tr><td></td><td>3-hr</td><td>57.55</td><td>N/A</td><td>1300</td></tr>
<tr><td>NO2</td><td>annual</td><td>3.45</td><td>23</td><td>100</td></tr>
<tr><td>CO</td><td>8-hr</td><td>22.45</td><td>N/A</td><td>10,000</td></tr>
<tr><td></td><td>1-hr</td><td>62.87</td><td>N/A</td><td>40,000</td></tr>
<tr><td>GB</td><td>72-hr</td><td>0.00004</td><td>0</td><td>0.003</td></tr>
<tr><td></td><td>8-hr</td><td>0.00009</td><td>0</td><td>0.10</td></tr>
<tr><td>VX</td><td>72-hr</td><td>0.00004</td><td>0</td><td>0.003</td></tr>
<tr><td></td><td>8-hr</td><td>0.00009</td><td>0</td><td>0.10</td></tr>
<tr><td>HD</td><td>72-hr</td><td>0.004</td><td>0</td><td>0.10</td></tr>
<tr><td></td><td>8-hr</td><td>0.010</td><td>0</td><td>3.0</td></tr>
</table>
• potentially significant for particulate matter
• known insignificant for SO2, NO2, CO, GB, VX, and HD; emissions/receptions of PICs, metals, dioxins and furans are unknown; not modeled no National Ambient Air Quality Standards set</td><td>potentially significant

known insignificant

unknown significance</td><td>table 4.5, pg., 4-16, UMDA EIS, 1992</td></tr>
</table>

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Emergency Operations

Interactions of Residents - Inhalation/Dermal with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Light/Noise	• no significant interaction	known insignificant	personal judgment
Air - Particles Air - Gases	(see table below)	known significant	pg. G-9 to G-10, table G-2, UMDA EIS, 1992

accident scenario	agent-munitions	worst case: computed no deaths distance km(MI)	worst case: potential maximum deaths	most likely: computed no deaths distance km(MI)	most likely: potential maximum deaths
Plant accidents					
- crash of large aircraft w/o fire	GB-rockets	28(17)	3,170	7(4)	77
- earthquake w/ fire	VX-mines	28(17)	3,170	7(4)	77
- earthquake w/ fire	GB-rockets	18(11)	875	5(3)	1
- crash of large aircraft w/fire	GB-rockets	18(11)	875	5(3)	1
- earthquake w/ fire	VX-rockets	17(10)	940	5(3)	1
- earthquake w/ fire	VX-8" projectiles	12(8)	940	4(2)	1
- earthquake w/ fire	VX-spraytanks	12(7)	940	2(1)	0
- earthquake w/ fire	GB-155 mm projectiles	9(6)	41	3(2)	1

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Emergency Operations

Interactions of Residents - Inhalation/Dermal with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Particles Air - Gases (continued)	(see table below)	known significant	pg. G-9 to G-10, table G-2, UMDA EIS, 1992

accident scenario	agent-munitions	worst case: computed no deaths distance km(MI)	worst case: potential maximum deaths	most likely: computed no deaths distance km(MI)	most likely: potential maximum deaths
Onsite Transport Accidents					
- vehicle accident w/ fire/detonation	VX-rockets	14(9)	940	4(2)	1
- earthquake accident w/ fire/detonation	GB-rockets	14(9)	940	4(2)	1
- vehicle accident w/ fire/detonation	GB-rockets	12(8)	940	3(2)	1
- vehicle accident w/ fire/detonation	GB-8" projectiles	10(6)	41	3(2)	1
- vehicle accident w/ fire/detonation	VX-8" projectiles	10(6)	41	3(2)	1

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Emergency Operations

Interactions of Residents - Inhalation/Dermal with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Particles Air - Gases (continued)	(see accident table below)	known significant	pg. G-9 to G-10. table G-2. UMDA EIS. 1992
	• emergency release of chemical agent resulting from largest probable accident scenarios would result in significant inhalation/dermal exposure of residents • Chemical Stockpile Emergency Preparedness Program (CSEPP) has developed protective strategies depending on size and type of release. meteorology	mitigation reduced	UMDA/CSEPP Emergency Planning Zone Map. Protective Action Sectors and Evacuation Routs and Strategies, Nov. 18, 1994

accident scenario	agent-munitions	worst case: computed no deaths distance km(MI)	worst case: potential maximum deaths	most likely: computed no deaths distance km(MI)	most likely: potential maximum deaths
Storage Accidents					
- earthquake w/ warehouse fires	HD-ton containers	314(195)	10,300	31(19)	6,610
- crash of large aircraft w/ fire	HD-ton containers	202(125)	10,300	23(14)	6,610
- earthquake w/ warehouse fire	HD-ton containers	202(125)	10,300	23(14)	6,610
- crash of large aircraft w/ fire	GB-rockets	125(77)	10,300	23(14)	6,610
- crash of large aircraft w/o fire	GB-rockets	48(30	3,740	20(12)	1,920
- crash of large aircraft w/ fire	VX-spraytanks	19(12)	940	5(3)	1

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Normal Operations

Interactions of Residents - Ingestion **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Light/Noise	• no significant interaction	known insignificant	personal judgment
Air - Particles	• PICs unknown, dispersion/settling on produce which is then ingested, no plans to monitor	unknown significance	personal judgment
Air - Gases	• no significant interaction, inhalation is primary exposure route	known insignificant	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** III - Reception-Exposure Emergency Operations

Interactions of Residents - Ingestion **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Air - Light/Noise	• no significant interaction	known insignificant	personal judgment
Air - Particles	• response and recovery plan included monitoring and decontamination to check food safety - sampling and testing by USDA, inventorying and identification, access control, and embargoes and quarantine	unknown significance mitigation reduced	Food Safety and Agricultural Recovery at CSEPP Symposium.. 1995
Air - Gases	• no significant interaction, inhalation is primary exposure route	known insignificant	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** IV - Impacts

Interactions of Background Levels with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Health Effects	• downwind from Hanford's radiation experiments which released radioactive iodine clouds to trace dispersions, radioactive iodine, plutonium and xenon into the groundwater and Columbia River; radioactive releases correlated with higher rates of thyroid cancer in the area • there is a higher rate of cancer among Hanford workers - occupational radiation exposure accounts for 3-7% of workers' cancer	potentially significant known significant	Kimball and Glass, 1991 Kneale and Stewart, 1993; Ackland, 1993
Nuisances	• Hanford radiation experiments, Vietnam agent orange - incidents are salient to residents and quoted incidents as reasons for not trusting the Army and fearing further contamination	known significant	responses to questionnaires

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** IV - Impacts
Normal Operations

Interactions of Health Effects with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Residents - Ingest	• settling of HCl, metals, particles on plants, uptake and ingestion, effective dose is unknown	unknown significance	personal judgment
Residents - Inhale/Dermal	• exposure insignificant for SO_2, NO_3, CO, GB, VX, HD; potentially significant for TSP and PM_{10}, unknown significance for PICs, metals, and dioxins and furans - dispersions unknown, effective dose unknown	unknown significance	personal judgment
Residents - Visual/Aural	• received noise levels likely will not exceed background level at most receptors during normal operations; too low to create health problems or likely even nuisance problems	potentially significant	see Interface III

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** IV - Impacts Emergency Operations

Interactions of Health Effects with	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Residents - Ingest	• GB: oral human T[illegible] = [illegible]g/kg TFX:BLO: oral rat TD_{Lo} = 4 μ/kg • VX: oral human [illegible]D_{Lo} = [illegible]g/kg RFX:RBC • settling of Hcl, me[illegible] [illegible]ucles on plants. uptake and ingestion, effective dose is unknown • mitigation same as for inhalation-health effects during emergency operations	unknown significance mitigation reduced	pg. C-1-46 to C-1-54. RCRA Application. 1996 personal judgment
Residents - Inhale/Dermal	• see Air-Particles/Gases-Residents Inhalation/Dermal for effects health during emergency operations • HD: inhalation significance criteria = 0.1 μg/m³; inhalation produces pulmonary edema, potential carcinogen causing lung tumors • GB(Sarin): inhalation significance criteria = 0.1 μg/m³ (single 1-hr exposure); 72-hr time weighted average = 0.003 μg/m³; inhalation produces meiosis, diarrhea, convulsions, respiratory collapse and death; may cause delayed neuropath syndrome like degeneration of peripheral nerves and permanent paralysis and abnormal fetal development • mitigation of Sarin exposure by treatment with oxime derivatives which can accelerate the regeneration of chlolinersterase • VX: inhalation significance criteria = 0.01 μg/m³ (single 1-hr exposure); 72-hr time weighted average = 0.003 μg/m³; similar reactions as those produced for GB, unlikely to cause delayed neuropathy syndrome • CSEPP evacuation, response, and recovery plan reduces exposure	known significant mitigation reduced	pg. G-4-3 to G-4-6. RCRA Application. 1995 CSEPP Symposium, 1995
Residents - Visual/Aural	• evacuation of shelter in place may cause stress, psychological grief and psychosomatic effects by just thinking about possible exposure of self, friends, and relatives • mitigate by having organized evacuation, response and recovery - effectiveness unknown	known significant mitigation unknown	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	**INTERFACE:** IV - Impacts Normal Operations		
Interactions of Nuisances **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Residents - Ingest	• settling of Hcl, metals, particles on plants, uptake and ingestion, effective dose is unknown; significance level for nuisance is unknown •	unknown significance	personal judgment
Residents - Inhale/Dermal	• exposure insignificant for SO_2, NO_2, CO, GB, VX, HD; potentially significant for TSP and PM_{10}, unknown significance for PICs, metals, and dioxins and furans - dispersions unknown, effective dose unknown, significance criteria unknown	unknown significance	personal judgment
Residents - Visual/Aural	• *same as for health* • *presence of facility can cause nuisance and psychological stress and* psychosomatic syndromes independent from distance which implies that "knowing" that the facility is there may be sufficient to cause nuisance	*potentially significant*	*Dunn et al., 1992; Roht* et al., 1985; Ozonoff et al, 1987

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** IV - Impacts Emergency Operations

Interactions of Nuisances **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Residents - Ingest	• settling of Hcl, metals, particles on plants, uptake and ingestion. effective dose is unknown • mitigation same as for inhalation-nuisance effects during emergency operations	unknown significance mitigation reduced	pg. C-1-52. RCRA Application. 1996 personal judgment
Residents - Inhale/Dermal	• subtoxic effects of exposure to agent would be an annoyance • HD (mustard) causes intense inflammation of skin, eyes, and mucous membranes delayed from 2 to 24 hours after exposure • GB (Sarin) causes dilated pupils-meiosis, frontal headache, eye pain, dimness of vision, nausea and vomiting, tightness in chest, wheezing, coughing, giddiness, tension, anxiety, restlessness, slowness of recall, confusion, slowness of speech, generalized weakness, drooling, and runny nose • VX causes effects similar to GB • mitigation same as for inhale/dermal-health effects for emergency operations	known significant mitigation reduced	pg. C-1-52. RCRA Application. 1995
Residents - Visual/Aural	• evacuation or shelter in place would totally disrupt current activity, preventing residents from leaving from or returning to home until "all clear" is given	known significant	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	**INTERFACE:** V - Nonphysical Impacts		
Interactions of Background Levels **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Property Values Community Status/Image	• the economics of the area are improving, increasing development and property value - there are no existing significant impacts to property value • increasing development is leading to greater image/status for this area	known insignificant	personal communication, Lee Butler, analyst with Umatilla County Tax Assessors' Office

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	**INTERFACE:** V - Nonphysical Impacts Normal Operations		
Interactions of Property Values **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Health Effects	• health effects from normal operations are unknown but possible, overall impact of health effects on property value is unknown	unknown significance	personal judgment
Nuisances	• same as for property value-health for normal operations	unknown significance	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility **INTERFACE:** V - Nonphysical Impacts Emergency Operations

Interactions of Property Values **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Health Effects	• health effects during emergency are known to be significant and widespread • there is evidence that negative externalities (i.e. health effects) may be translated into lower property values - likely in the short term, possibly into the longterm • compensation may be sought under: 1) CERCLA - Army may be held liable, however, all of the largest credible accident scenarios are not compensatible, only internally initiated accidents, and CERCLA will only compensate for costs of removal, remediation, or response such as evacuation or cleanup and not compensate directly for economic impacts such as property value 2) Stafford Act - declaration of emergency to provide assistance to states, local governments, and individuals when state and local resources are overwhelmed for removal, remediation, and response - there is no property value compensation 3) Federal Tort Claims Act - claims death, personal injury, and damage/loss of property, property value claims are only payable is damage/loss of property can be proved and Army is held liable 4) Military Claims Act - claims death, personal injury, and damage/loss of property involving fault of Army • mitigation is possible but uncertain, depending on type of accident, liability, etc.	potentially significant mitigation uncertain	Zeiss and Lefsrud, 1995; Sorenson et al., 1987 CSEPP Symposium, 1995
Nuisances	• same as for property values-health effects for emergency operations	potentially significant mitigation uncertain	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	**INTERFACE:** V - Nonphysical Impacts Normal Operations		
Interactions of Community Status/Image **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Health Effects	• same as for property value-health effects for normal operations, overall impact of health effects on community status/image is unknown	unknown significance	personal judgment
Nuisances	• same as for community status/image-health effects for normal operations	unknown significance	personal judgment

FACILITY: Umatilla Chemical Demilitarization Incineration Facility	**INTERFACE:** V - Nonphysical Impacts Emergency Operations		
Interactions of Community Status/Image **with**	**Cause-Effect Rationale** • **Significance** • **Mitigation**	**Judgment**	**References**
Health Effects	• widespread concerns and anxieties, family tension and conflict, decline in community will being, economic disruption, possible decline in population	known significant	Sorenson et al., 1987
Nuisances	• same as for community status/image-health effects for emergency operations	known significant	personal judgment

APPENDIX B - QUESTIONNAIRE A

University of Alberta
Edmonton, Canada

Survey of Opinions and Behaviors

regarding the planned

Chemical Demilitarization Incinerator
at the Umatilla Depot Activity

September 1995

If you cannot answer this questionnaire, please check (√) the reasons why:
____ no one in this household is over 18 years of age
____ no one in this household is a permanent resident
____ no one in this household is comfortable answering a questionnaire in English

Upon completion of the questionnaire (or checking your reasons for not completing it), please put it in the enclosed postage-paid envelope and mail it.

Questionnaire #___

This questionnaire asks about your views about the Chemical Demilitarization Incinerator planned for the Umatilla Army Depot. It should take about 30 minutes to fill out. **To complete this questionnaire, you must be over 18 years of age and a permanent resident of the household.** Your responses will be held strictly confidential. You may refuse to answer any question. There is an identification number on this questionnaire for record keeping purposes only.

TO ANSWER EACH QUESTION, PLEASE CIRCLE THE NUMBER WHICH CORRESPONDS TO YOUR RESPONSE OR WRITE YOUR ANSWER IN THE GIVEN SPACE.

1) Do you support or oppose the Chemical Demilitarization Incinerator being built at the Umatilla Army Depot?

Strongly Oppose 1
Oppose 2
Neither Support nor Oppose 3
Support 4
Strongly Support 5

2) What do you consider to be the most important reasons for your favorable or unfavorable attitude towards the incinerator being built at the Depot?

____
____
____
____
____
____
____
____
____
____

3) Have you taken action of any kind in the past (including talking to friends or neighbors) or do you plan to take any actions in the future to support or oppose the incinerator?

Have not taken any action and do not plan to take any action.................... **1**

PLEASE GO TO QUESTION 6

Have taken action in the past or might take action in the future.................**2**

4) Which of the following actions have you taken in the past to support or oppose the incinerator? Which actions do you think you might take in the future?

		Action Taken		Might Take Action		
		YES	NO	YES	NO	DON'T KNOW
a)	Talk to friends or neighbors about the incinerator.	1	2	3	4	9
b)	Write a letter or telephone an editor, public official, or company.	1	2	3	4	9
c)	Sign or circulate a petition about the incinerator.	1	2	3	4	9
d)	Vote for or against a candidate for public office considering his or her position on this issue.	1	2	3	4	9
e)	Attend open houses or public hearings about the incinerator.	1	2	3	4	9
f)	Speak at open houses or public hearings about the incinerator.	1	2	3	4	9
g)	Join or contribute money to an organization supporting or opposing the incinerator.	1	2	3	4	9
h)	Read and review technical information about the incinerator.	1	2	3	4	9
i)	Attend a public demonstration in support or opposition to the incinerator.	1	2	3	4	9
j)	Participate in a lawsuit about the incinerator.	1	2	3	4	9
k)	Have you done or intend to do anything else? If yes, what else? *Please Explain*	1	2	3	4	9

5) How important are the following reasons in determining what actions you have taken or might take in the future towards the incinerator?

		Not Important (no effect)	Slightly Important	Very Important (strong effect)
a)	The importance to you of the incinerator's effects.	**0**	**1**	**2**
b)	The importance to your community of the incinerator's effects.	**0**		**2**
c)	Feeling of personal responsibility - if anyone is going to do anything, it has to be you.	**0**	**1**	**2**
d)	Your personal resources such as time, money, or energy.	**0**	**1**	**2**
e)	Your personal knowledge and expertise about the facility, technology, or the political process.	**0**	**1**	**2**
f)	The need (or lack of need) for the incinerator as a means of managing waste.	**0**	**1**	**2**
g)	The expectation that your actions will have some effect on the design and planning of the incinerator.	**0**	**1**	**2**
h)	Other reasons for your actions. *Please Explain*	**0**	**1**	**2**

____

____

PLEASE GO TO QUESTION 7 ⟶

6) How important are the following reasons in determining why you didn't take any action in the past and don't plan to take any action towards the incinerator in the future?

		Not Important (no effect)	Slightly Important	Very Important (strong effect)
a)	The unimportance to you of the incinerator's effects.	**0**	**1**	**2**
b)	The unimportance to your community of the incinerator's effects.	**0**	**1**	**2**
c)	The feeling that you are not personally responsible to take action. You can leave it to others to do something about the incinerator.	**0**	**1**	**2**
d)	Your lack of personal resources such as time, money, or energy.	**0**	**1**	**2**
e)	Your lack of knowledge about the facility, technology, or the political process.	**0**	**1**	**2**
f)	The need (or lack of need) for the incinerator as a means of managing waste.	**0**	**1**	**2**
g)	The feeling that any action wouldn't affect the design or planning of the incinerator anyway.	**0**	**1**	**2**
h)	Other reasons for not taking action. *Please Explain*	**0**	**1**	**2**

____

____

7a) How strict do you think the restrictions and standards are NOW for the incineration of chemical munitions?

Not very Strict				Extremely Strict
1	2	3	4	5

b) How strict do you think the restrictions and standards SHOULD BE for incineration of chemical munitions?

Not very Strict				Extremely Strict
1	2	3	4	5

8) The incinerator may affect the surrounding site, communities, and residents. Next is a list of factors that may be affected by the facility. In your opinion, will the incinerator have a positive effect or a negative effect on <u>each</u> of these factors? IF POSSIBLE, PLEASE STATE WHY YOU THINK THE INCINERATOR WILL CAUSE EACH EFFECT.

	Very Negative Effect	Somewhat Negative Effect	No Effect at All	Somewhat Positive Effect	Very Positive Effect
a) noise *Why? Noise levels without the facility being changed by noise emissions from construction, regular operations, or emergency?* ________________	**-2**	**-1**	**0**	**1**	**2**
b) air quality *Why? Air quality without the facility being changed by facility emissions to air during construction, regular operations, or emergency? Dispersion with different wind speeds and directions?* ________	**-2**	**-1**	**0**	**1**	**2**

	Very Negative Effect	Somewhat Negative Effect	No Effect at All	Somewhat Positive Effect	Very Positive Effect
c) environmental quality (e.g. vegetation. soil) *Why? Environmental quality without th[illegible]cility being changed [illegible]cility emissions to air, water, and soil during construction, regular operations, or emergency? Sensitivity of local environment?* ________________	**-2**	**-1**	**0**	**1**	**2**
d) quality of surface wate rivers, ponds) *Why? Surfa[illegible] water nea[illegible] Surface water quality without the facility being changed by facility emissions to water or to air (settling on water) during construction, regular operations, or emergency?*_____	**-2**	**-1**	**0**	**1**	**2**
e) quality of ground water (springs, wells) *Why? Ground water quality without the facility being changed by facility emissions to groundwater and soil (leaching into groundwater) during construction, regular operations, or emergency?*_____	**-2**	**-1**	**0**	**1**	**2**
f) availability (quantity) of ground and surface water *Why? Facility using water during construction, regular operations, or emergency changing the availability of water?*________________	**-2**	**-1**	**[illegible]**	**1**	**2**

		Very Negative Effect	Somewhat Negative Effect	No Effect at All	Somewhat Positive Effect	Very Positive Effect
g)	common and endangered wildlife populations *Why? Wildlife populations nearby? Sensitivity of wildlife? Affected by facility emissions to air, water, soil, or plants or disturbance during construction, regular operations, or emergency?*____ ______________________	**-2**	**-1**	**0**	**1**	**2**
h)	health of local residents *Why? Residents nearby? Sensitivity of residents? Affected by changes to air, water, soil, animals or plants or disturbance during construction, regular operations, or emergency? Facility preventing emissions?* _ ______________________	**-2**	**-1**	**0**	**1**	**2**
i)	historic, archaeological, and cultural resources *Why? Resources nearby? Resources affected by changes to air, water, soil, animals or plants or disturbance during construction, regular operations, or emergency?*____ ______________________	**-2**	**-1**	**0**	**1**	**2**
j)	local property values Why? *Changing demand due to facility effects during construction, regular operations, or emergency?*____ ______________________	**-2**	**-1**	**0**	**1**	**2**

		Very Negative Effect	Somewhat Negative Effect	No Effect at All	Somewhat Positive Effect	Very Positive Effect
k)	product values (e.g. vegetables, fruit, wheat, beef) *Why? Changing demand due to facility effects during construction, regular operations, or emergency?*____ ______________________	-2	-1	0	1	2
l)	local employment rates *Why? Changing employment needs during facility construction, operation, or emergency?*_______ _________ ______________________	-2	-1	0	1	2
m)	local tax base *Why? Changing tax base during facility construction, operation, or emergency?*_____ ______________________	-2	-1	0	1	2
n)	commercial and industrial development *Why? Changing development during facility construction, operation, or emergency?*_____ ______________________	-2	-1	0	1	2
o)	public services (e.g. roads, schools) *Why? Changing needs during facility construction, operation, or emergency?*______________ ______________________	-2	-1	0	1	2
p)	community image *Why? Reputation of facility? Change in community image due to other facility effects?*____ ______________________	-2	-1	0	1	2

		Very Negative Effect	Somewhat Negative Effect	No Effect at All	Somewhat Positive Effect	Very Positive Effect
q)	local influence in county, state, or federal political decisions *Why? Changing political influence during facility construction, operation, or emergency?* ________________ ________________	-2	-1	0	1	2
r)	other factors that may be affected by the facility *Why?* ________________ ________________	-2	-1	0	1	2

9) Overall, do you consider the positive effects from the facility to be greater than the negative effects, or the negative effects to be greater than the positive effects?

Negative effects much greater than Positive effects ....-2
Negative effects slightly greater than Positive effects..... ....-1
Negative effects equal to Positive effects 0
Positive effects slightly greater than Negative effects 1
Positive effects much greater than Negative effects 2

10a) How much do you agree or disagree that the Chemical Demilitarization Incinerator has been planned and designed in the best way to minimize the negative effects and maximize the positive effects?

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

If possible, please state the reasons why. ________________________________

____

____

____

____

b) How much do you agree or disagree that the Umatilla Depot is the best place to put the incinerator to minimize the negative effects and maximize the positive effects?

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

If possible, please state the reasons why. ____________________

____

11) Next are a few statements about characteristics of the incinerator and its planning. How much do you agree or disagree with <u>each</u> of the following statements? IF POSSIBLE, PLEASE STATE THE REASONS WHY.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) The facility will protect future generations. *Why?* ____________	1	2	3	4	5
b) If there was an accident or problem, it could be easily cleaned up. *Why?* ____________	1	2	3	4	5
c) The facility design and planning is voluntary - I have a choice whether or not an incinerator is built at the Depot. *Why?* ____________	1	2	3	4	5
d) All the risks from the incinerator are known to the facility engineers and planners. *Why?* ____________	1	2	3	4	5
e) The risk from the incinerator will continue to increase with time. *Why?* ____________	1	2	3	4	5

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
f)	The risks from the incinerator are known to the people who may be exposed. *Why?*____________________	1	2	3	4	5
g)	If there was an accident or problem, people have a greater risk of long-term health effects (e.g. cancer). *Why?*____________________	1	2	3	4	5
h)	When I think about the incinerator being built on the Depot, I get a feeling of dread. *Why?*____________________	1	2	3	4	5
i)	The Army is trustworthy. *Why?*____________________	1	2	3	4	5
j)	The incinerator design and planning is fair - the people at the greatest risk from the facility also receive the greatest benefit. *Why?*____________________	1	2	3	4	5
k)	All the affected people can control how the incinerator is designed. *Why?*____________________	1	2	3	4	5
l)	I can trust the regulator, the Oregon Department of Environmental Quality. *Why?*____________________	1	2	3	4	5
m)	If there were an accident or problem, it would be catastrophic - many people would be killed quickly. *Why?*____________________	1	2	3	4	5

This next set of questions are about about your general beliefs and values for decision making and managing risk. For the purpose of this question, "risk" is defined as the possibility that you or someone else may be harmed by something (i.e. getting an x-ray, smoking cigarettes, flying in a plane, exposure to pesticides, etc). **These questions may appear to be unrelated to the Chemical Demilitarization Incinerator. But, previous research suggests that general beliefs and values may be related to how you think about the facility and its effects.** I want to understand what you are concerned about and why.

12) How much do you agree or disagree with the following statements?

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a)	Employees should always accept decisions made by their managers.	1	2	3	4	5
b)	There is no use doing things for other people - it only backfires anyway.	1	2	3	4	5
c)	I don't like having to act the way that other people expect me to act.	1	2	3	4	5
d)	The more risks I take, the more opportunities I have.	1	2	3	4	5
e)	I think that every able-bodied citizen should have to serve some time in the Armed Forces.	1	2	3	4	5
f)	Some one is to blame for everything that goes wrong.	1	2	3	4	5
g)	The world is changing - it cannot be avoided.	1	2	3	4	5
h)	It is possible to have zero pollution.	1	2	3	4	5
i)	I don't like other people to make decisions for me.	1	2	3	4	5
j)	People should be rewarded according to their position in society.	1	2	3	4	5
k)	Risk is a fact of life - I can't do anything about it.	1	2	3	4	5

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
l)	People can do anything that they want, so long as it doesn't affect anyone else.	1	2	3	4	5
m)	I support less government regulation of business.	1	2	3	4	5
n)	I don't trust what the newspapers or other people tell me - I'll do my own investigation of the facts and come to my own conclusions.	1	2	3	4	5
o)	The future is too uncertain for a person to make serious plans.	1	2	3	4	5
p)	People show their preferences by how they spend their money.	1	2	3	4	5
q)	The police should have the right to listen in on private telephone conversations when investigating crime.	1	2	3	4	5
r)	Being on welfare destroys peoples' ambition and personal initiative.	1	2	3	4	5
s)	If people in this country were treated more equally we would have fewer problems	1	2	3	4	5
t)	Experts are best able to manage risk effectively - they know the facts better than anyone.	1	2	3	4	5
u)	Those who earn more should be taxed more to support the less fortunate.	1	2	3	4	5
v)	A person is better off if he or she doesn't trust anyone.	1	2	3	4	5
w)	No one person or agency can make decisions for an entire community.	1	2	3	4	5
x)	Life is like a lottery - sometimes you win, sometimes you lose.	1	2	3	4	5

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
y)	I would rather put up with something than bother with the hassles of politics.	1	2	3	4	5
z)	The best way to manage risk is through government legislation.	1	2	3	4	5
aa)	Cooperating with others rarely works.	1	2	3	4	5
ab)	A community's resources must be managed by the whole community, not just by a few people.	1	2	3	4	5
ac)	I am stricter than most people about what is right and wrong.	1	2	3	4	5
ad)	Economic growth is the best way to improve the quality of life.	1	2	3	4	5

13a) How much do you agree or disagree that the incinerator is needed by the Army?

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

If possible, please state the reasons why: ______________________________

____

b) How much do you agree or disagree that the incinerator is needed by the local residents?

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

If possible, please state the reasons why: ______________________________

____

Now, I am going to ask some questions about your general attitudes towards technology and the environment.

14) How much do you agree or disagree with each of the following statements?

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a)	The federal government will have to introduce harsh measures to halt pollution since few people will regulate themselves.	1	2	3	4	5
b)	We should not worry about killing too many game animals because in the long run things will balance out.	1	2	3	4	5
c)	I'd be willing to make personal sacrifices for the sake of slowing down pollution even though the immediate results may not seem significant.	1	2	3	4	5
d)	Pollution is personally affecting my life.	1	2	3	4	5
e)	The benefits of modern consumer products are more important than the pollution that results from their production and use.	1	2	3	4	5
f)	We must prevent any type of animal from becoming extinct, even if it means sacrificing some things for ourselves.	1	2	3	4	5
g)	Courses focusing on the conservation of natural resources shou' ᵈ be taught in the public schools.	1	2	3	4	5
h)	Although there is continual contamination of our lakes, streams, and air, nature's purifying processes soon return them to normal.	1	2	3	4	5

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
i)	Because the government has such good inspection and control agencies, it's very unlikely that pollution due to energy production will become excessive.	1	2	3	4	5
j)	The government should provide each citizen with a list of agencies and organizations to which citizens could report grievances concerning pollution.	1	2	3	4	5
k)	Scavengers and predators which prey on farmer's crops and animals should be eliminated.	1	2	3	4	5
l)	The currently active anti-pollution organizations are really more interested in disrupting society than they are in fighting pollution.	1	2	3	4	5
m)	Even if public transportation was more efficient than it is, I would prefer to drive my car to work.	1	2	3	4	5
n)	Industry is trying its best to develop effective anti-pollution technology.	1	2	3	4	5
o)	If asked, I would contribute time, money, or both to an organization like the Sierra Club that works to improve the quality of the environment.	1	2	3	4	5
p)	I would be willing to accept an increase in my family's annual expenses of, say, $100 to promote the wise use of natural resources.	1	2	3	4	5

15) I am also interested in how you see yourself and your community in the future. Generally, what could improve your quality of life? How could your community improve so that it would be a better place for you to live?

____

____

To finish up, I would like to get some general information about you. This information will be used only to get a profile of the demographic characteristics of the respondents.

16a) Are you male or female?

MALE **1**
FEMALE **2**

b) What is your age? ________ years

c) What community do you live in? ____________

d) Approximately, how long have you lived in this area? ________ years

e) Do you rent or own your home?

RENT **1**
OWN **2**

f) Do you have any children under 18 years old living at home?

YES **1**
If yes How many?________

NO **2**

g) How would you describe your political preferences?

Conservative				Liberal	Don't Know
1	**2**	**3**	**4**	**5**	**9**

h) Approximately, what was your total household gross (before taxes) income for last year?

$__________

i) What level of education have you received?

grade 9 or less **1**
some high school **2**
graduated from high school... **3**
some college or university **4**
graduated from college or university................................... **5**
completed Masters/Doctorate degree.................................. **6**

j) Are you currently employed?

YES **1**
NO... **2**

k) What is your occupation (or was your occupation when your were employed)? (e.g. teacher, carpenter, student, farm worker)

____

l) In what industry do/did you work? (e.g. construction, government, education, agriculture)

____

m) Have you or anyone else in your household ever been employed by the U.S. Armed Forces?

Yes, I have been employed by the Armed Forces **1**

Yes, someone else in this household
has been employed by the Armed Forces.. **2**

No one in this household has been employed by the Armed Forces **3**

This is the end of the questionnaire. Thank you for your time. I really appreciate you telling me your opinions on the incinerator. Are there any additional comments that you would like to make about the incinerator?

____

____

____

____

____

____

Are there any comments that you would like to make abo. . this questionnaire or my research?

____

____

____

____

____

After I am done analyzing the ' ^esults, a summary of the findings may be sent to you if you wish. Would you like a sumr. ^ry of the results? *Circle Response*

YES..1
NO...2

If yes, please write down your name and address

____

____

____

____

These two back pages will be inmediately removed from the rest of your questionnaire and kept separately, so your name and address will not be attached to your responses.

The second stage of this research will explore the specific negative and positive effects from the incinerator that concern people. This will be done with personal interviews. Each interview will take approximately one hour and all responses again will be confidential. I cannot promise to interview everyone who is interested since I will not have enough time, but if you are interested, I might contact you in October or November. Would you be interested in being involved in the second stage of this research?

YES..**1**
NO...**2**

If yes, write down your name and home and/or work phone number.

Name:________________________________

Phone number:_________________________

Please put the completed questionnaire in the postage-paid envelope provided and mail it as soon as possible. Thanks again.

Sincerely Yours,

Lianne Lefsrud

APPENDIX C - QUESTIONNAIRE B

University of Alberta
Edmonton, Canada

Survey of Attitudes and Preferences of Residents

regarding the planned

Chemical Demilitarization Incineration Facility
at the Umatilla Depot Activity

February 1996

Questionnaire #_____

This interview is the second phase of my Master's research. In this interview I'll ask you some questions about your attitude towards the Chemical Demilitarization Incineration Facility. I'll also ask about your concerns and look at different ways to address your concerns. This interview should take about 30 to 45 minutes. your responses will be held strictly confidential. and you may refuse to answer any question. Some of these questions may be a little confusing and seem to be unrelated to the facility. But. I'll explain the questions and why I'm asking them as we go along. Try to answer all the questions as best as possible. You may comment or ask questions at any time during the interview. However. I would prefer to answer your questions at the end, so that I don't influence your responses in any way.

This research is designed as being hypothetical. But, these results may be considered by the Oregon Department of Environmental Quality as part of their public review.

The first set of questions asks about your attitude towards the facility.

1) Using the numbers on this card, how much do you support or oppose the Incineration Facility being built at the Umatilla Army Depot as it is currently proposed? *circle response on scale*

strongly oppose		oppose		neither support nor oppose		support		strongly support
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

2a) Has your attitude towards the facility changed in the past four months, since filling out the first questionnaire?

No.....1
Yes.....2
Don't Know.....9

if yes **b)** In what way has your attitude changed, is it more negative or more positive?

More negative.....1
Slightly more negative.....2
Slightly more positive.....3
More positive.....4

if yes **c)** Why has your attitude changed?

____

____

3a) Using the numbers on this card, how likely do you think it is that the proposed facility will be built at the Depot?

It will never be built	1
Not very likely it will be built	2
About 50-50 it will be built	3
Quite likely it will be built	4
It will be built for sure	5

The proposed facility may affect the surrounding area. From the first questionnaire, there seems to be three important effects which may be caused by the facility. These effects are: 1) effect on residents' health, 2) effect on property value, and 3) effect on community image. We'll look at each of these effects separately. First, we'll look at effects on residents' health.

I'd like to try some general ideas about whether people prefer to know the outcome or to gamble when making decisions. *pause* To try these ideas, I'm going to use some hypothetical situations for the Incineration Facility.

4a) Suppose that, beyond the planners' control, the facility will cause a more negative effect on residents' health than was originally expected. Suppose, there are two plans to manage this effect on residents' health. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A there will be 3 more deaths in 100 years in Umatilla and Morrow Counties than were expected

Plan B there is a 1/3 chance that there will be 9 more deaths in 100 years and a 2/3 chance that there will be no more deaths than were expected

b) Now, say for some reason, the effect on residents' health is more positive than was originally predicted. There are two plans to manage this effect on residents health. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A will save 3 more lives in 100 years in Umatilla and Morrow Counties than were expected

Plan B will have a 1/3 chance to save 9 more lives in 100 years and a 2/3 chance to save no more lives than were expected

Now, I'd like to ask your opinion about how the facility at the Umatilla Depot will affect residents' health, as it is currently designed.

5) Using the numbers on this card, do you think the facility will have a positive or negative effect on residents' health, as it is currently designed by the Army?

very negative effect		some what negative effect		no effect at all		some what positive effect		very positive effect
-4	-3	-2	-1	0	1	2	3	4

6a) Why do you think that the facility will have a (positive/negative/neutral) effect on residents' health?

____

____

____

____

____

____

____

b) When you say that the facility would have a (positive/neutral/negative) effect on the health of local residents, what did you comparing against? *probe if necessary*

____

____

____

I'm going to give you some suggested changes for dealing with any effects that the proposed facility may have on residents' health. Each card has a different change to deal with residents' health. *lay each card on the table, read each*

Do you have any questions? *write down questions*

____

____

____

7a) Now, I'd like you to rank these changes in the order that you prefer them. When you rank them, please only consider the information that is given on the cards. Assume that all of these changes will be designed as stated on the cards, are 100% reliable, and cost about the same. Also assume that these changes are about equally effective in dealing with health effects - each change will reduce health effects or the cost of health effects by about 50%. Try to ignore everything else. *wait....* Do you want to make any changes to your ranking? *write down ranking of measures*

#1 ______________________

#2 ______________________

#3 ______________________

#4 ______________________

#5 ______________________

b) Can you tell me why you ranked the changes like you did? What makes you prefer #1 over #2? #2 over #3? #3 over #4? #4 over #5?

#1 over #2 ______________________________________

____

____

#2 over #3 ______________________________________

____

____

#3 over #4 ____

____

____

#4 over #5 ____

____

____

Probe when necessary:

- *Do you think that somehow need definition and prevention measures are better?*
  - *Do you prefer #1 over #2 because it is ethically better?*
  - *Do you prefer #1 over #2 because it is not your personal responsibility and you shouldn't have to do anything about it nor be affected by it?*
  - *Do you prefer #1 over #2 because it is more certain to be effective?*
- *Do you prefer #1 over #2 because it is more appropriate for addressing the effect?*
- *Do you prefer #1 over #2 because it is more effective for addressing the effect?*
- *Any other criteria?*

8) At the beginning of the interview, you (supported/neither/opposed) the facility being built. *show attitude card, circle initial attitude.* If (preferred change) was included in the facility design, how much would you support or oppose the facility being built at the Umatilla Army Depot? Would your attitude towards the facility change? *circle response on scale*

strongly oppose		oppose		neither support nor oppose		support		strongly support
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

9) To finish up with residents' health, I have one more general question. Using the numbers on this card, how satisfied are you with your present health?

very dis-satisfied		dis-satisfied		neither satisfied nor dis-satisfied		satisfied		very satisfied
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

Next, we're going to look at any facility effects to property value. I'll start with the question about whether or not people prefer to know the outcome or to gamble.

10a) Suppose that for some reason, the facility will have a more <u>negative</u> effect on property values than was originally expected. There are two plans to manage the effect on property values. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A	will reduce property values 5% from what was expected
Plan B	will have a 1/3 chance for a 15% reduction in property values and a 2/3 chance that there will be no reduction from what was expected

b) Now, say for some reason, the facility will have a more <u>positive</u> effect on property values than was originally expected. There are two plans to manage the effect on property values. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A	will increase property values 5% from what was expected
Plan B	will have a 1/3 chance for a 15% increase in property values and a 2/3 chance for no increase from what was expected

Now, I'd like to ask your opinion about how the facility will affect property values, <u>as it is currently designed</u>.

11) Using the numbers on this card, do you think the facility will have a positive or negative effect on property value, as it is currently designed by the Army?

very negative effect		some what negative effect		no effect at all		some what positive effect		very positive effect
-4	-3	-2	-1	0	1	2	3	4

12a) Why do you think that the facility will have a (positive/negative/neutral) effect on property value?

b) When you say that the facility would have a (positive/neutral/negative) effect on the property values, what are you comparing against? *probe if necessary*

____

____

____

Now I'm going to give you some suggested changes for dealing with any effect that the proposed facility may have on property values. Each card has a different change to deal with property values. *lay each card on the table, read each*

Do you have any questions? *write down questions*

____

____

____

13a) Now, I'd like you to rank these changes in the order that you prefer them. When you rank them, please only consider the information that is given on the cards. Again, assume that all of these changes will be designed as stated on the cards, are 100% reliable, cost about the same. Also assume that these changes are about equally effective in dealing with property value effects - each suggested change will reduce property value impacts by about 50%. *wait....* Do you want to make any changes to your ranking? *write down ranking of measures*

#1 ______________________

#2 ______________________

#3 ______________________

#4 ______________________

#5 ______________________

b) Can you tell me why you ranked the changes like you did? What makes you prefer #1 over #2? #2 over #3? #3 over #4? #4 over #5?

#1 over #2 ______________________________

____

____

____

#2 over #3 ______________________________

____

____

____

#3 over #4 ______________________________

____

____

____

#4 over #5 ______________________________

____

____

____

Probe when necessary:

- *Do you think that somehow need definition and prevention measures are better?*
    - *Do you prefer #1 over #2 because it is ethically better?*
    - *Do you prefer #1 over #2 because it is not your personal responsibility and you shouldn't have to do anything about it nor be affected by it?*
    - *Do you prefer #1 over #2 because it is more certain to be effective?*
- *Do you prefer #1 over #2 because it is more appropriate for addressing the effect?*
- *Do you prefer #1 over #2 because it is more effective for addressing the effect?*
- *Any other criteria?*

14) At the beginning of the interview, you (supported/neither/opposed) the facility being built. *show attitude card, circle initial attitude.* If (preferred measure) was included in the facility design, how much would you support or oppose the facility being built at the Umatilla Army Depot? Would your attitude towards the facility change? *circle response on scale*

strongly oppose		oppose		neither support nor oppose		support		strongly support
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

15) To finish up with property value, I have one more general question. Using the numbers on this card, how satisfied are you with present property values?

very dis-satisfied		dis-satisfied		neither satisfied nor dis-satisfied		satisfied		very satisfied
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

Lastly, we're going to look at facility effects to community image. I'll start with the question about whether or not people prefer a to know the outcome or to gamble.

16a) Suppose that community image could be measured as a percentage of residents who are satisfied with the image of their community. Now, suppose that the facility will cause a more negative effect on community image than was originally expected. There are two plans to manage the effect on community image. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A will reduce community image 5% from what was expected - i.e. 5 out of 100 residents think that the image of their community has been reduced

Plan B will have a 1/4 chance for a 20% reduction in community image and a 3/4 chance for no reduction from what was expected

b) Now, say for some reason, the facility will have a more positive effect on community image than was originally expected. There are two plans to manage the effect on community image. *give card, read each* Which plan do you prefer, A or B? *circle preferred*

Plan A will increase community image 5% from what was expected - i.e. 5 out of 100 residents think that the image of their community has been improved

Plan B will have a 1/4 chance for a 20% increase in community image and a 3/4 chance for no increase from what was expected

Now, I'd like to ask your opinion about how the facility will affect community image, as it is currently designed.

17) Using the numbers on this card, do you think the facility will have a positive or negative effect on community image, as it is currently designed by the Army?

very negative effect		some what negative effect		no effect at all		some what positive effect		very positive effect
-4	-3	-2	-1	0	1	2	3	4

18a) Why do you think that the facility will have a (positive/negative/neutral) effect on community image?

____

____

____

____

____

____

____

b) When you say that the facility would have a (positive/neutral/negative) effect on the community image, what are you comparing against? *probe if necessary*

____

____

____

Now, I'll introduce some suggested changes for dealing with any effect that the facility may have on community image. Each card has a different change to deal with community image. *lay each card on the table, read each*

Do you have any questions? *write down questions*

____

____

____

19a) Now, I'd like you to rank these changes in the order that you prefer them. When you rank them, please only consider the information that is given on the cards. Again, assume that all of these changes will be designed as stated on the cards, are 100% reliable, cost about the same. Also assume that they are about equally effective in dealing with community image effects - each change will reduce community image effects by about 50%. Try to ignore everything else. *wait....* Do you want to make any changes to your ranking? *write down ranking of measures*

#1 ______________________

#2 ______________________

#3 ______________________

#4 ______________________

#5 ______________________

b) Can you tell me why you ranked the measures like you did? What makes you prefer #1 over #2? #2 over #3? #3 over #4? #4 over #5?

#1 over #2 ______________________

____

____

____

#2 over #3 ______________________

____

____

____

#3 over #4 ______________________

____

____

____

#4 over #5 ______________________

____

____

____

Probe when necessary:

- *Do you think that somehow need definition and prevention measures are better?*
    - *Do you prefer #1 over #2 because it is ethically better?*
    - *Do you prefer #1 over #2 because it is not your personal responsibility and you shouldn't have to do anything about it nor be affected by it?*
    - *Do you prefer #1 over #2 because it is more certain to be effective?*
- *Do you prefer #1 over #2 because it is more appropriate for addressing the effect?*
- *Do you prefer #1 over #2 because it is more effective for addressing the effect?*
- *Any other criteria?*

20) At the beginning of the interview, you (supported/neither/opposed) the facility being built. *show attitude card, circle initial attitude.* If (preferred measure) *lay down card* was included in the facility design, how much would you support or oppose the facility being built at the Umatilla Army Depot? Would your attitude towards the facility change? *circle response on scale*

strongly oppose		oppose		neither support nor oppose		support		strongly support
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

21) To finish up with community image, I have one more general question. Using the numbers on this card, how satisfied are you with the present image of your community?

very dis-satisfied		dis-satisfied		neither satisfied nor dis-satisfied		satisfied		very satisfied
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**

22) Finally, of all the suggested changes that I've given to you, or anything else that wasn't given, what would make the facility more acceptable to you? As a minimum, what measures would you like to see included in the facility design?

Thank you for your time and cooperation. A summary of the results from the first questionnaire and from these interviews will be sent to you in May.

Are there any additional comments that you would like to make about my research, this interview, or the facility?