

**DELIBERATION: INTEGRATING STAKEHOLDER VALUES AND RISK  
ASSESSMENTS IN ENVIRONMENTAL DECISION MAKING**

by  
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Susan E. Pickett

Submitted to the Department of Nuclear Engineering on August 8, 1997  
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Nuclear Engineering and Master of Science in Technology and Policy.

## ABSTRACT

Risk management has gained a significant amount of attention from both policy makers and the public over the past thirty years, as the interaction of technology and policy choices become more predominant in the evaluation of trade-offs in a democratic society. This is particularly so in decisions regarding the management, disposal and clean up of hazardous wastes throughout the United States. The responsible agency must balance the multiple elements of risk, multiple and conflicting objectives, and stakeholder values and perceptions inherent in environmental decisions in order to meet social needs, while maintaining the integrity of both the technical and social aspects of that decision.

The National Research Council (1996) has recommended that the responsible agency incorporate all relevant stakeholders in the decision making process from the start, specifying an analytical-deliberative process for dealing with decisions that involve substantial risk analysis and assessment. The basic premise of this recommendation is that by involving the stakeholders in the process from the beginning and simultaneously performing the necessary risk assessments, taking into account the stakeholder values in an analytic-deliberative method, the decision making process can be enhanced.

The concept of bringing together multiple stakeholders in environmental decision making attempts to address the fact that past decisions have neglected stakeholder values, however, by bringing together the multiple stakeholders, the agency is faced with numerous other challenges. These challenges include: communicating and characterizing risk, unreasonable expectations, selecting of stakeholders, utilizing of time and resources efficiently, providing access to resources, addressing stakeholder concerns, and defining consensus.

In order to aid in this process, this work investigates the integration of risk assessment and stakeholder involvement in reaching a fair, wise, efficient and stable decision concerning environmental remediation. We propose an integration of stakeholder values and risk assessments using a combination of mathematical and decision analysis tools which culminate in a ranking of the remediation alternatives. From this integration, we devise strategies for a consensual deliberation that focus on the interests of the stakeholders while simultaneously account for the technical issues. This work presents the results of such an integration and details the formulation of strategies.

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Lastly, I am forever grateful to my family, Brian, for his insights and philosophies; Julie for calling things as they are; Mom, for reminding me that I am “just a grain of sand” ; and Dad, for the belief that anything is possible.

*Things derive their being and nature by mutual dependence and are nothing in themselves.*

- S. Aurobindo, The Synthesis of Yoga

*The world thus appears as a complicated tissue of events in which connections of different kinds alternate or overlap or combine and thereby determine the texture of the whole - W. Heisenberg Physics and Philosophy*



# TABLE OF CONTENTS

<b>CHAPTER 1:INTRODUCTION.....</b>	<b>11</b>
INTRODUCTION .....	11
1.1 THE DEPARTMENT OF ENERGY .....	11
1.2 RISK ANALYSIS AND STAKEHOLDER VALUES .....	12
1.3 THESIS OUTLINE .....	15
<b>CHAPTER 2: PROJECT OVERVIEW .....</b>	<b>17</b>
2.1 THE SITE .....	17
2.2 THE RISK ASSESSMENT.....	19
<i>Table 2.1: Objective Categories and Performance Measures .....</i>	<i>20</i>
2.3 THE STAKEHOLDERS.....	20
<i>Table 2.2: Representation of the initial stakeholders .....</i>	<i>21</i>
<i>Table 2.3: The Six Stakeholders who completed the process through to deliberation .....</i>	<i>22</i>
2.4 THE DECISION.....	22
2.5 THE ALTERNATIVES.....	24
<i>Table 2.4 : The Remedial Action Alternatives .....</i>	<i>24</i>
2.6 THE OBJECTIVE CATEGORIES .....	25
2.7 INTEGRATION AND DELIBERATION .....	28
2.8 FINAL PRODUCT.....	30
<b>CHAPTER 3: ELEMENTS OF RISK .....</b>	<b>31</b>
3.1 A DEFINITION OF RISK.....	31
3.2 RISK ASSESSMENT .....	33
3.3 RISK MANAGEMENT .....	36
<i>Table 3. 1: Annual Cost of Risk.....</i>	<i>39</i>
3.4 RISK COMMUNICATION AND PERCEPTION.....	40
<i>Table 3. 2: Risk Perception: A question of framing.....</i>	<i>42</i>
<i>Table 3.3: Factors that contribute to risk perceptions .....</i>	<i>44</i>
3.5 AN INTEGRATED APPROACH TO RISK .....	47
3.6 CHAPTER SUMMARY .....	48
<b>CHAPTER 4: INTEGRATION OF VALUES AND RISK ASSESSMENTS.....</b>	<b>49</b>
4.0 INTRODUCTION .....	49
4.1 WHAT IS INTEGRATION? .....	50

4.2 SELECTING A DECISION TOOL .....	50
4.3 BENEFITS OF MAUA .....	55
4.4 CHALLENGES WITH MAUA .....	57
4.5 UTILIZING MAUA .....	59
<i>Table 4.1a: Performance Measure Weights, after stakeholder confirmation</i> .....	64
<i>Table 4.1b: ID A: Stakeholder Weights After confirmation</i> .....	65
<i>Table 4.2: Overall Rankings for all stakeholders</i> .....	66
<i>Table 4.3: Stakeholder #3: Performance Measure and Overall Utilities as determined by integration</i> .....	67
4.6 ANALYSIS OF THE RESULTS OF THE INTEGRATION .....	69
4.7 CHAPTER SUMMARY .....	70
<b>CHAPTER 5: DELIBERATION</b> .....	<b>73</b>
5.1 RATIONALE FOR DELIBERATION .....	73
5.2 GOALS OF DELIBERATION: FAIRNESS AND EFFICIENCY .....	76
5.3 CHALLENGES IN MULTI-STAKEHOLDER DELIBERATION .....	79
5.4 DELIBERATION DESIGN .....	82
<i>Table 5.4.2: Tentative Conclusions for Deliberation</i> .....	92
<i>Table 5.4.3a: Stakeholder Specific Conclusions</i> .....	95
<i>Table 5.4.3b: Stakeholder Specific Conclusions</i> .....	96
5.5 CHAPTER SUMMARY .....	97
<b>CHAPTER 6: DELIBERATION CONDUCT AND RESULTS</b> .....	<b>99</b>
6.1 INTRODUCTION INTO DELIBERATION .....	100
6.2 PRE-DELIBERATION RESULTS .....	100
6.3 DELIBERATION CONDUCT .....	103
<i>Table 6.1a Stakeholder #4</i> .....	109
<i>Table 6.1b Stakeholder #1</i> .....	110
<i>Table 6.1c Stakeholder #2</i> .....	111
<i>Table 6.1d Stakeholder #6</i> .....	113
<i>Table 6.1e Stakeholder #5</i> .....	114
<i>Table 6.2: Hybrid RAAs</i> .....	116
6.4 DELIBERATION INTERACTIONS ANALYSIS .....	118
6.5 DISCUSSION OF DELIBERATION GOALS .....	120
6.6 CHAPTER SUMMARY .....	125
<b>CHAPTER 7: RISK COMMUNICATION INSIGHTS</b> .....	<b>127</b>
7.1 INFLUENCE DIAGRAMS .....	127

7.2 TIMELINESS OF PRE-DELIBERATION MATERIAL .....	127
7.3 GRAPHS AND DIAGRAMS .....	128
7.4 ELICITATION .....	129
7.5 PRE-DELIBERATION COMMUNICATION.....	129
7.6 RISK COMMUNICATION SUMMARY .....	130
<b>CHAPTER 8.....</b>	<b>133</b>
<b>CHAPTER 9: FUTURE APPLICATIONS .....</b>	<b>143</b>
<b>APPENDIX 1.....</b>	<b>147</b>
<b>APPENDIX 2.....</b>	<b>155</b>







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## CHAPTER 1: INTRODUCTION

“It is not enough that you should understand about applied science in order that your work may increase man’s blessing. Concern for the man himself and his fate must always form the chief interest of all technical endeavors...never forget this in the midst of your diagrams and equations.”  
Albert Einstein, 1931.

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### Introduction

Risk management has gained a significant amount of attention from both policy makers and the public over the past thirty years, as the interaction of technology and policy choices become more predominant in the evaluation of trade-offs in a democratic society. This is particularly so in environmental decisions regarding the management, disposal and clean up of hazardous wastes throughout the country. Environmental decisions are laden with a myriad of risks and values which possess different connotations for individuals. While balancing the multitude of objectives in order to meet social needs, policy makers and the responsible parties are faced difficult choices which must maintain the integrity of both the substance, technical integrity, and process, social fairness, of that decision. Trade-offs amongst incompatible measures such as environmental resources, technologies, health impacts, cultural resources and lands, religion and costs must be made.

### 1.1 The Department of Energy

The Department of Energy (DOE) currently has over 2000 contaminated facilities that will require clean up and decommissioning. In facing these challenges, it has realized that decisions must be made in collaboration with the public. For the last 50 years, DOE has invested \$300 billion in developing a nuclear weapons complex that it is now faced with the clean up and remediation of both radiological and hazardous waste sites (DOE, 1995). By 1995, approximately \$23 billion was spent on the identification and characterization of its wastes and, it is estimated that over the next 75 years, an additional \$250-300 billion will

be required for the remediation of such sites (DOE, 1997). The Environmental Management Program has defined six goals in regards to the clean up process, as stated by former Assistant secretary Thomas P. Grumbly, they are:

- Eliminate and manage urgent risks in the system
- Emphasize health and safety for workers and the public
- Establish a system that is managerially and financially in control
- Demonstrate tangible results
- Focus technology development on identifying and overcoming obstacles to progress
- Establish a stronger partnership between DOE and its stakeholders (DOE, 1995)

Furthermore environmental restoration decisions at DOE facilities are subject to federal and state laws which mandate specific remediation procedures; specifically, there are two main federal statutes which require public participation in the decision making process: CERCLA: the Comprehensive Response and Compensation And Liability Act, passed in 1980, which ensures the location and remediation of hazardous waste sites throughout the country, and the Resources Conservation and Recovery Act, which requires all facilities which generate, treat, store, or dispose of hazardous wastes to obtain permits. Ideally, these laws permit the public to document and discuss its concerns about the range of activities at the DOE facilities, however, often participation comes too late in the decision making process and leads to opposition from the affected parties. Although the Department of Energy has full legal responsibility for the decisions made at its hazardous waste site, the Agency must however take into account public comment and recommendations when implementing an alternative for remediation thus, the more substantiated the public or stakeholder recommendation, the more likely DOE is to implement it.

## **1.2 Risk Analysis and Stakeholder Values**

Risk analysis methods for identifying the impact and consequences of an activity in order to help the decision maker assess the situation and choices to reach a substantiated conclusion, have fallen to criticism for their inability to address the often non quantifiable

concerns of the stakeholders: cultural, ethical and moral values. Decision making methods have separated risk management and assessment, focusing either too much on one aspect or the other thereby contributing to a disconnect between the decision maker (agency) and the public. The affected and interested parties, the stakeholders, feel that their values and objectives have been neglected; they feel that the decision has not been arrived at in a fair process. Their opposition may rest on misperceptions of the risks involved, the omission of necessary input, be it science or values, or a lack of trust in the agency. Stakeholders may take issue with the type of analyses conducted, the subject of the analyses, the definition of the problem or the methodology used. Although the responsible agency has made many decisions for the social “good” claiming “objectivity “ based in risk assessment, the resolution has often been contested by the affected parties. Neglecting stakeholder values, oversimplifying assumptions and obscuring key contributors leads to an inaccurate analysis and resolution which perpetuates poor risk characterization and the lack of trust in the agencies. In the end, the decision itself is questioned either through the media, public opposition, or litigation.

In order to fill this void, the National Research Council (1994) has recommended that the respective decision maker (governmental agency), incorporate all relevant stakeholders in the decision making process from the start. The National Research Council recommends an analytical-deliberative process for dealing with decisions that involve substantial risk analysis and assessment. In making decisions concerning the environment, the objectives, trade-offs, uncertainties, risks and nonobjective judgments must be made explicit. Hiding these elements behind science or the guise of national security only results in unwise and inefficient decisions that lack support of the affected community. Risk analyses, analytic techniques used to understand risk, need to be utilized in conjunction with input from the affected parties so that assumptions underlying the evaluation are clarified, understood and validated.

The basic premise of this recommendation and the goal of the DOE is that by involving the stakeholders in the process from the beginning and simultaneously performing the necessary risk assessments, taking into account the stakeholder values, the decision

making process can be enhanced and the previous failings and causes for mistrust overcome.

The concept of bringing together multiple stakeholders in environmental decision making seems to address the fact that past decisions have neglected stakeholder values, however, by bringing together the multiple stakeholders interested in or affected by the decision, the agency is faced with numerous other challenges, including: communicating and characterizing risk, unreasonable expectations (on the part of all or some parties), selecting of stakeholders, utilizing of time and resources efficiently, providing access to resources, addressing stakeholder concerns, and defining consensus.

In order to aid in this process, this work investigates the integration of risk assessment and stakeholder involvement in reaching a fair, wise, efficient and stable decision concerning the remediation of hazardous waste sites. We propose an integration of stakeholder values and risk assessments using a combination of mathematical and decision analysis tools which culminate in a ranking of the remediation alternatives. From this integration, we devise strategies for a consensual deliberation that focus on the interests of the stakeholders while simultaneously account for the technical issues. This work presents the results of such an integration and details the formulation of strategies.

With regards to this investigation, the purpose of this work is to :

- i. Develop and test an integration methodology through a deliberation
- ii. Examine the role of deliberation in addressing the risk laden issues in environmental decision making

### *1.2.1 The Methodology*

This project is a multifaceted approach to stakeholder involvement and risk analysis in environmental restoration decisions. It aims to develop a formal risk management methodology for decision making regarding the clean up of the Hazardous Waste Site that will successfully integrate the stakeholders' concerns and the technical analyses of the site,

with explicit consideration of the uncertainties. Ultimately, the methodology will produce a systematic, traceable, defensible and acceptable approach for use by the Department of Energy. This work reports on the structure and results of such a deliberation. Six Remedial Action Alternatives (RAAs) were considered by six stakeholders representing the public, the site owner, and regulatory agencies (state and city). The fundamental objectives defined by the stakeholders are grouped into six categories: Programmatic Risks, Life Cycle Costs, Socioeconomic Impacts, Cultural Impacts, Environment, and Human Health and Safety. Fourteen Performance Measures (PM) were defined to represent these objectives. Risk Assessments were conducted to evaluate the numerical impact of each RAA on each PM. Using relative importance weights that were derived for each PM from stakeholder input (via the Analytic Hierarchy Process), the RAAs were ranked in order of preference for each stakeholder. Furthermore, the principal contributors to each stakeholder's ranking were determined from the analysis. From this point the deliberation began - from pre-deliberation and planning through the interaction between the stakeholders.

### **1.3 Thesis Outline**

Chapter Two provides a description of the site and the stakeholders involved in the process. Chapter Three discusses the multiple dimensions of risk which contribute to the complexity of environmental decision making. It also explores the need for a deliberative process when dealing with issues of risk. Chapter Four describes the Integration Methodology used, and the results that are the foundation of the deliberation proposals. Chapter Five discusses the issues of fairness and efficiency in a social decision making process, elaborating on the challenges of achieving both elements. Chapter Six describes deliberation in the context of environmental decision making, involving multiple stakeholders and risk. It presents the preparation and design of deliberation from the integration results discussed in Chapter Four. The goals, interactions of participants and risk communication issues are discussed here as well.

Then in Chapter Seven, conclusions concerning the integration methodology as an aid to deliberation, as a method for communication and characterization of risks and as a mode to involve stakeholders. Furthermore, the deliberation in terms of its usefulness in risk

characterization and stakeholder involvement is examined. Lastly, we present a summary of the lessons learned and how agency decision makers may use this method in the future.



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## CHAPTER 2: PROJECT OVERVIEW

“There is no such thing as objective risk.” Paul Slovic, 1994

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This Chapter presents an overview of the project, detailing each component integrated into the framework for a consensual deliberation. The purpose of this overview is to provide the reader with a general sense and background of the project to establish a decision making method for DOE and the role of deliberation in this decision making process. Although it is not necessary to understand each component in depth, a context is needed in which to place the deliberation.

### 2.1 The Site

The site chosen for the development of this methodology is the Chemical Waste Landfill(CWL) which is located at Sandia National Laboratories in Albuquerque, New Mexico. It was selected by the Team 1 in consultation with the Department of Energy and chosen to be the testbed for methodology development. Since the decision situation is a prototypical situation, the problem definition is simplified. This infers that while the final recommendation reached by the stakeholders may not be applicable or used by DOE, the integration methodology and use in deliberation can provide interesting insight into the communication and characterization of risk in decision making.

The site is a 1.9 acre site where disposal of waste persisted from 1962 until 1985, when waste management activities were initiated. The Chemical Waste Landfill is located 4 miles from the nearest drinking well and 3 miles from the nearest spring. The sediment make up of the CWL is primarily a mixture of limestone, quartz, granite and metamorphic

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<sup>1</sup> The “Team” consists of the sub contract groups to whom the project was granted, i.e., the risk analysts, stakeholder involvement specialists and the decision integration ...

clast sands and gravel. The base sediments were deposited by alluvial (earthen) and fluvial action. The water table at the site is located 490 feet below the surface. The underlying media is heterogeneous sequence of unconsolidated to semi-consolidated lenses and sheets of cobbles, gravels, sands, silts and clays. The waste consisted of PCB's, chlorinated organics, cyanide, acetone, hydrocarbons, aluminum, ammonia oxides, beryllium and other miscellaneous debris. The wastes were separated and buried according to their physical and chemical properties, following which they were buried in pits ranging from 8 to 12 feet deep and at minimum 2 feet wide. One unlined and one lined chromic acid pit are located on the site. The former is a 23 ft by 66 ft by 7 ft deep pit situated in the southwest quadrant of the CWL, used for the disposal of chromic acid waste from the early 1970's to 1978. The latter, is a 15ft by 15ft by 5ft deep pit near the south of the CWL and was used between 1979 and 1982 for disposing of liquid chromic acid and ferric chloride wastes. Once capacity of a given waste pit was reached, a new pit was dug and given the same identification number of the previous pit. Subsequently, accurate specifications concerning the location of each type of waste do not exist.

In 1992, the site was investigated as a potential RCRA (Resource Conservation and Recovery Act) site. Prior to this investigation, site characterization activities had begun in 1985 and from 1985 -1992, twelve monitoring wells were installed. The Voluntary corrective measures (VCM) ensued in order to reduce sources driving ground water contamination and to eliminate health and environmental risk pathways. The three VCM's are vapor extraction, focused excavation and landfill wide excavation. They intend to reduce the uncertainties associated with the final site remediation. Upon the completion of the VCM's, site characterization has shown the two primary pollutants of concern to be trichloroethylene and chromium, both of which have been characterized as toxic by the Environmental Protection Agency (EPA). For the purposes of this prototype project, these two elements have been selected as the subject of evaluation in the risk assessment and characterization phase of the project.

## 2.2 The Risk Assessment

The risk assessment component will be conducted in consultation with the stakeholders. First, the stakeholders define the primary objective categories, then a method of actually measuring how a given alternative (remedial action alternative (RAA)) performs in that objective category is determined by the analysts.<sup>2</sup> This measure is referred to as a performance measure (PM); they have been agreed upon by the stakeholders. An influence diagram, devised by both the analysts and stakeholders helps to guide the evaluation process and tries to ensure that all parties are aware of the inputs and analyses. The PMs, listed in Table 2.1, consist of such things as: Contaminated Media Quantity, Disposal, Transportation. For each PM, the alternatives are evaluated for the corresponding risk. Thus for each performance measure, the risk analysis shows the way in which a given alternative performs. This outcome is a probabilistic outcome and accordingly, there are different levels of uncertainty regarding the assessment.<sup>3</sup>

Objective Category	Objective	Performance Measure
Programmatic Assumptions	Minimize Waste	Quantity of Waste transported Quantity of Process Waste Generated Quantity of ER Waste Generated
Life Cycle Cost	Minimize Direct Costs	Implementation Costs Completion Costs
Socio-economic Issues	Promote Community Quality of Life	Changes in Ambient Conditions Impact on Local Economy
	Promote Environmental Justice	Compare Total Population Health Effects
Cultural, Archeological and Historic (CAH) Resources	Protect CAH Resources	Number Impacted/Severity of Impacts
Environment	Protect Environmental Resources	Contaminant Concentration

<sup>2</sup> The process of risk assessment has numerous technical aspects. It is the opinion of the author that the technical components should be rephrased in common language and not withheld from the stakeholders, but provided in an overview format, with details available if desired.

<sup>3</sup> This uncertainty is the parameter uncertainty commonly used in risk assessment techniques. For more information, please consult Apostolakis, 1991.

Objective Category	Objective	Performance Measure
		Changes in Resources
	Minimize Risk to Public Health and Safety	Individual Health Risk
Worker Health and Safety	Minimize Risk to Worker Health and Safety	Individual Worker Health Risk

*Table 2.1: Objective Categories and Performance Measures*

Prior to the risk analyses, the stakeholders were shown an approximation of how the risk assessment occurs and the assumptions made. Their input was noted and considered by the analysts.

### **2.3 The Stakeholders**

The stakeholders were selected for participation based on the broad definition that a stakeholder is any person or organization that may have a stake in the consequences of a particular decision. At the CWL, based on input from sponsors and review of site relevant information, the project facilitator team compiled a preliminary list of stakeholders who might participate in the project. From an initial interview base of 48 participants representing x organizations, 12 stakeholders were selected to participate in the project.<sup>4</sup> The following organizations were represented:

- DOE and Sandia National Labs
- Citizens Advisory Board Members
- Corrective Action Management Unit Working Group members<sup>5</sup>
- Local, state and federal officials
- Regulatory organizations
- Native American Nations
- Business and Community Leaders

---

<sup>4</sup> The issue of stakeholder selection is complex. This methodology focuses primarily on the decision making method and not stakeholder selection.

<sup>5</sup> The CAMU working group was formed by Sandia National Labs to assist Sandia in the potential siting of a facility to consolidate and store wastes generated from the clean up of hazardous wastes at Sandia.

- Environmental organizations
- Civic groups and neighborhood organizations
- Educational and religious organizations
- Minority Groups
- Health and safety professionals

The first set of interviews involved only Sandia, DOE and DOE contract representatives. After the first set of interviews, based on a list of potential stakeholders compiled by DOE, Sandia and potential participants, a set of refined questions were asked to 27 potential participants. They identified themselves in as many categories as he or she designated (Jennings, 1996) and no stakeholder who wanted to participate was denied access or involvement. The stakeholders that remained involved in the process represented the public, the site owner, and regulatory agencies (state and city). The six stakeholders who completed the process through to deliberation, attended a series of working group meetings extending over seven months, meeting approximately every other month. Table 2.2 lists the initial participants, however, only six stakeholders remained with the project through the deliberation phase.

Category/organization	Number
Department of Energy	4
Sandia National Labs	9
Citizen Advisory Board Members	6
CAMU Working Group Members	7
Local, state and federal official	4
Regulatory Agency	1
Native American Nations	1
Business and Community leaders	5
Environmental Organizations	4
Civic groups and neighborhood organizations	4
Educational/religious organizations	0
Minority groups	2
Health and safety professionals	1
<b>Total</b>	<b>48</b>

*Table 2.2: Representation of the initial stakeholders*

The resulting stakeholders representing six organizations were asked to respond to the questions and the activities of the process as a member of the organization which they represent, rather than as individuals.

Stakeholder	Organization
1	Community Real Estate Agent
2	
3	Environmental and Health Department for the city
4	Middle Rio Grande Council of Governments
5	National Laboratories Employee
6	Community Advisory Board

*Table 2.3: The Six Stakeholders who completed the process through to deliberation*

**2.4 The Decision**

A decision involves identification of the objectives, attributes of those objectives, a method of measuring the performance each alternative along each attribute (i.e. assessing the consequence or impact of the alternative if chosen), a determination of the relative weights or preferences amongst those attributes and a method for ranking the alternatives in order to make a decision which adequately addresses the necessary trade-offs.

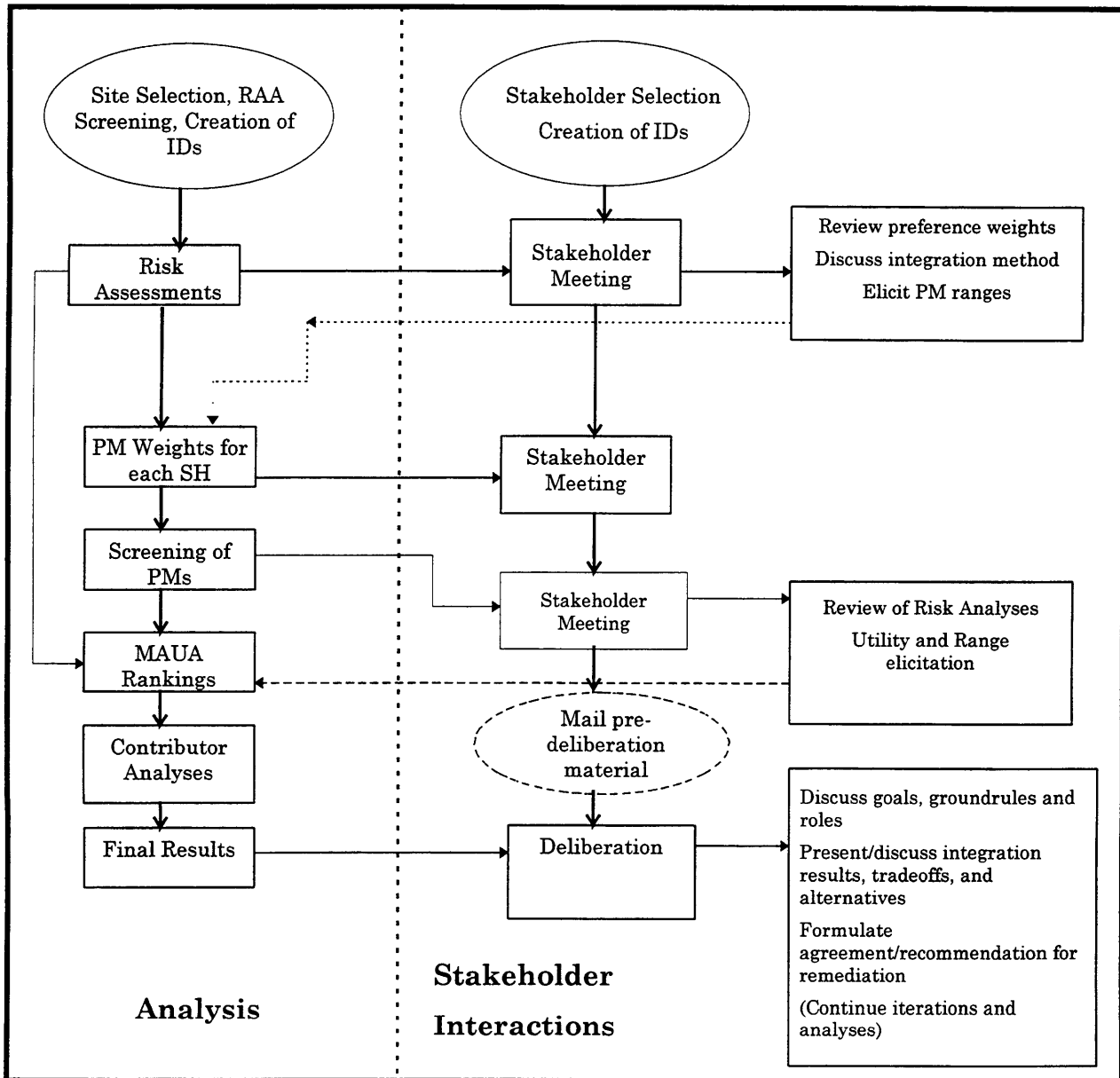


Figure 2.1: Overview of Analytic-Deliberative Process

## 2.5 The Alternatives

The alternatives in this decision are the options for remediation of the site. They are referred to as remedial action alternatives, or RAAs. The remediation alternatives selected for this project were narrowed down from a group of fifteen to a group of seven. The selection of the remediation alternative is one element of the overall methodology development. The seven RAAs chosen by the Team upon consultation with Sandia National Labs and existing documentation on the CWL, all meet a minimum criterion of addressing the action goals of the site, as defined by federal and state regulations. <sup>6</sup> Furthermore, they all must:

- Address the action goals of the site
- Be media specific
- Be contaminant specific and capable of addressing the contaminants in question

The RAAs are as follows(described in detail in Appendix 3):

Remedial Action Alternative	Treatment of Metals	Treatment of Organics
A	in-situ vitrification	soil vapor extraction
B	in-situ stabilization	in-situ bioremediation
C (excavation + on-site disposal)	stabilization/solidification	thermal desorption
D(excavation + off-site disposal)	stabilization/solidification	thermal desorption
E(excavation + off-site disposal)	off-site	off-site
F (No action)	-	-

*Table 2.4: The Remedial Action Alternatives*

It is noted that application of the resulting methodology would include a comprehensive development and screening of alternatives, however, since this is a prototypical decision, those RAAs that would not have survived initial screening on a technical basis were not considered here. Each RAA was evaluated under two scenarios for which risk pathways were identified. The exposure pathways were first identified by the analysts and shared



with the stakeholders. Any additional pathways of stakeholder concern were then discussed whereby the relevant ones were also taken into account in the impact assessment.

Each alternative was evaluated under two different scenarios defined by the Team:

*Scenario Z1: the closest public receptor is fifty feet away, with residential/agricultural development*

*Scenario Z2: the closest receptor is three miles away; federal control, and industrial development (This scenario is used as the "No Action" alternative, RAA F)*

## **2.6 The Objective Categories**

In Section 2.5: Risk Assessment, the objective categories of the project were briefly mentioned. In decision making, the objectives must be made explicit at the early stages of the process. Once the problem or decision context has been identified by the relevant stakeholders, the fundamental objectives are laid out. The higher level objectives, in this project referred to as the Objective Categories, are typically broad based concerns. These objective categories in the case of this project are:

- Environment
- Human Health and Safety
- Socioeconomics
- Cultural Resources
- Life Cycle Costs
- Programmatic Assumptions

These are common objectives when making environmental decisions, however the same objectives are not relevant to every environmental decision situation. The stakeholders and analysts arrived at these after a two day meeting. They are specific to the stakeholders involved as well as the CWL site. Once the categories and their associated objectives are decided, the remaining hierarchy of objectives is defined. For each objective

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<sup>6</sup> Primary sources of data include: Corrective Measures Study Plan for CWL, 2/1/95; CWL Final Closure Plan and Post Closure Permit Application, 12/1992; CAMU Options Analysis, Final Report, 12/8/95; Environmental Assessment of the Environmental Project at SNL/NM, 12/95.

category, attributes, or again in this case Performance Measures, are defined by the stakeholders. Following that, the stakeholders designate the relevant attributes to be used in the risk assessment (in this project we use the term: performance measures to refer to the element of measure for the respective objective).

The diagram below indicates the overall objective. Although additional attributes were identified, the performance measures shown are those that were considered in this project. In a comprehensive evaluation, additional measures may have to be considered as well. The prioritization of these objectives occurs with feedback from the stakeholders. Objective hierarchy model:

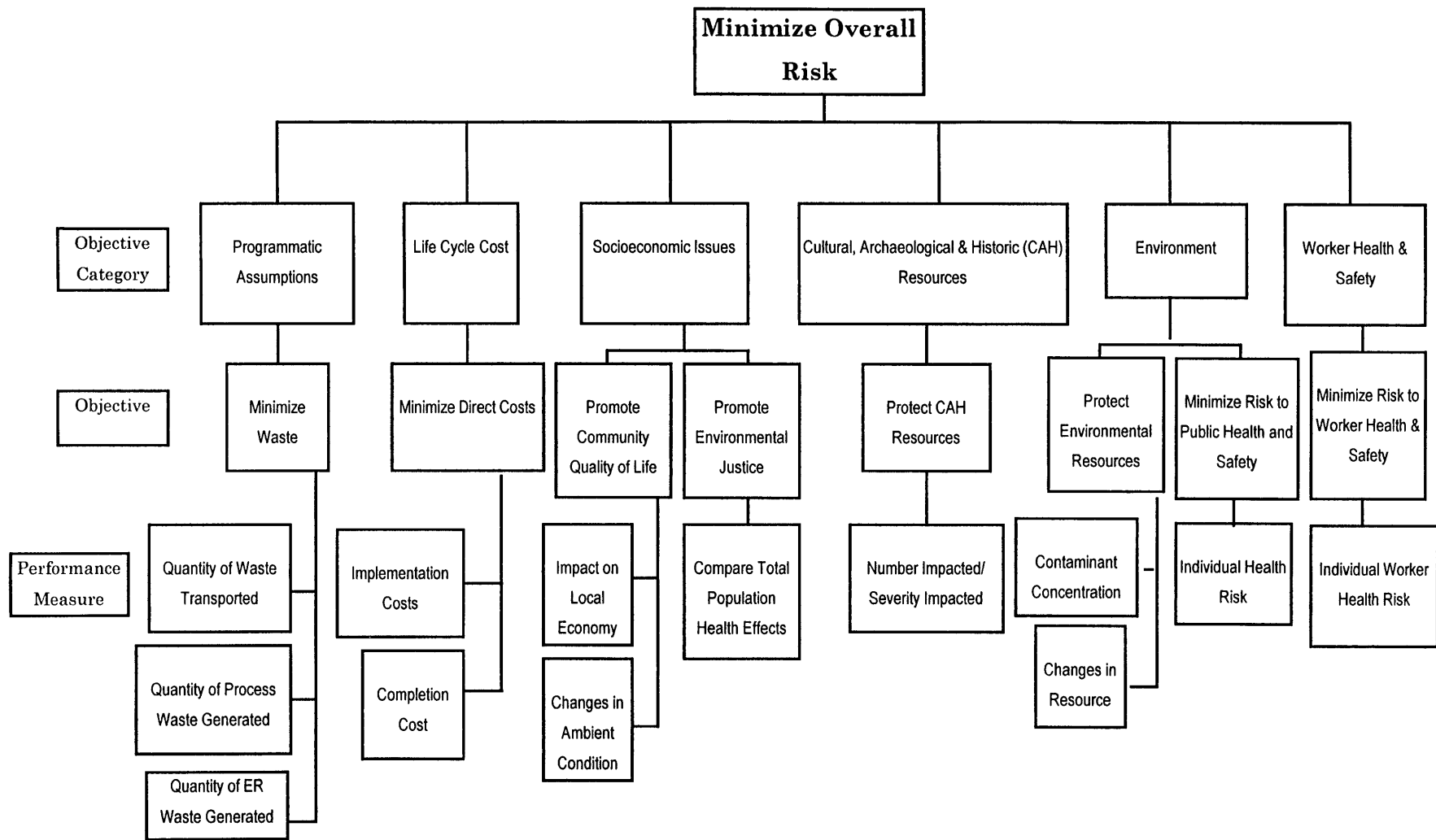
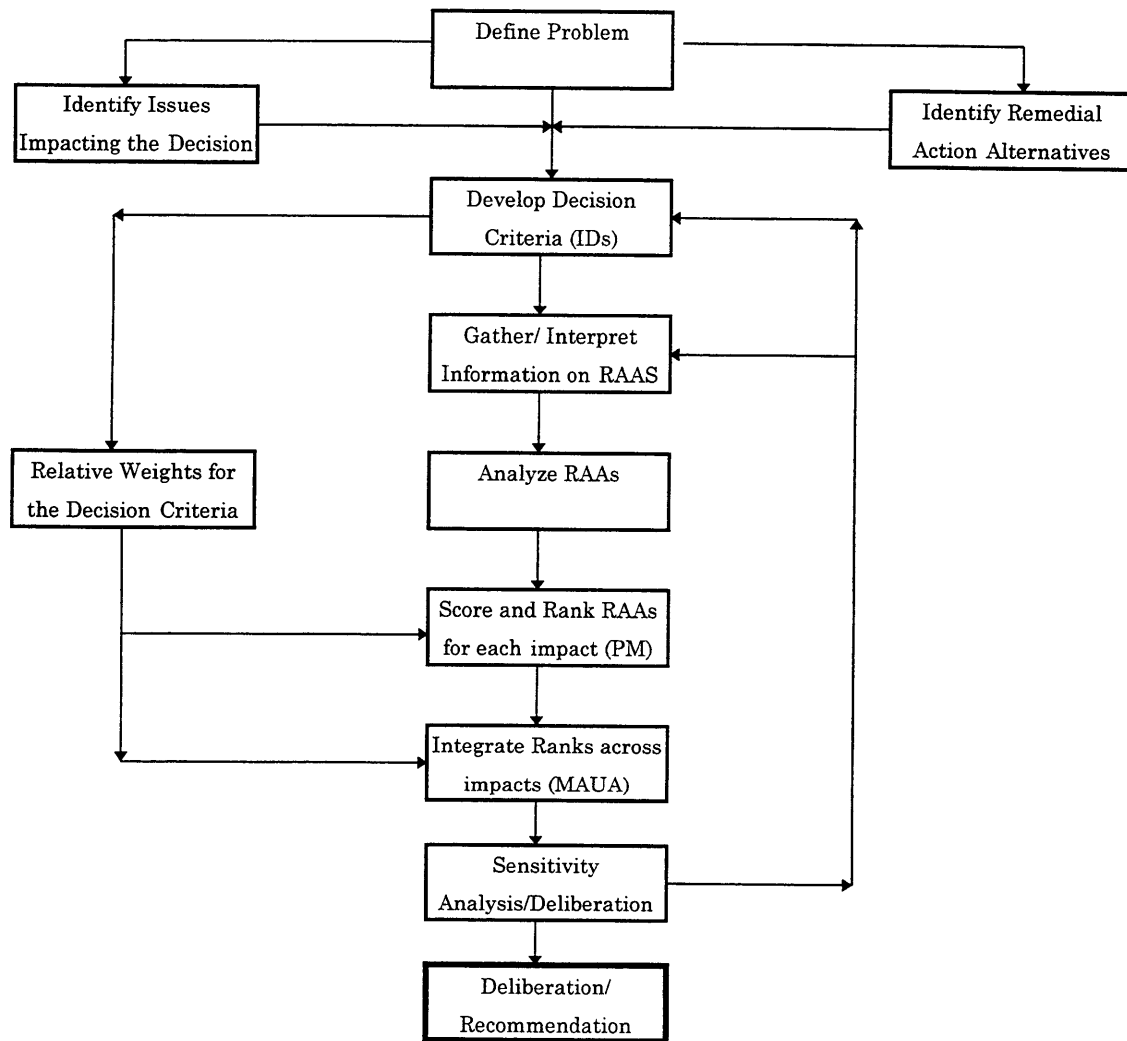


Figure 2.2: The Objective Hierarchy

In order to Integrate the stakeholder preferences with the risk assessments as shown in figure 2.1, the decision process, and alternative selection for each stakeholder is first evaluated in accordance to the following flow diagram.



*Figure 2.3: The Decision Process for a single stakeholder*

## 2.7 Integration and Deliberation

In the next component of the project we integrate the risk assessments with the stakeholders' preferences. First, we rank, using multi-attribute utility theory (MAU) , described in Chapter 4, the six RAAs for each stakeholder in accordance with their

individual utility functions and preference weights. Once the primary contributors for each stakeholder is determined, sensitivity studies were done to test the stability of our results. In integrating risk assessments (twenty realizations for each RAA, for each Performance Measure) with the preference weights, and utilities for nineteen performance measures from each stakeholder, for 6 stakeholders, leads to a complex process with many possible sources of uncertainty.<sup>7</sup> We proceed to test the sensitivity of the weights, the impact results and the utilities. From which, we determine those rankings which may not be stable.

Given that there is no mathematical model which fully captures the complexity of integrating risk assessment and stakeholder values, we draw on the ongoing elicitation of these values and via risk management techniques, examine the key interests and major contributors to the points of disagreement. This focus on the basic elements will - as we will test - allow for a discussion which brings out the major tradeoffs in relation to both the risks and values, necessary In selecting a remedial alternative.

Deliberation, being the cumulative integration of the ongoing deliberative meetings will serve to integrate the technical analyses, the stakeholders values to determine an overall ranking of the alternatives available which is supported by the stakeholders involved. The key questions that must be addressed:

- Did the quantification of the stakeholders' preferences maintain the integrity of those preferences?
- Are the assumptions understood?
- Are the uncertainties explicit?

Preparing the deliberation, we focus on understanding the major drivers of each stakeholder's preferences. Furthermore, this analysis determines the characteristics of the RAAs constitute the strengths and weaknesses of each alternative. The formulation of strategies for deliberation, aimed at resolution of disagreements and attainment of the

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<sup>7</sup> We assume the elicited information, that is, the weights and the ranges, correctly represent what the individual thinks they represent.

deliberation goals is both a qualitative and quantitative process. Each stakeholder is presented with a qualitative as well as quantitative assessment of his or her rankings and primary contributors, as well as apparent reasons, drawn from an analysis of the technologies themselves prior to the deliberation.

## **2.8 Final Product**

Once the deliberation is completed, the product of that deliberation, as far as the stakeholders are concerned is a recommendation to the Department of Energy concerning the remediation of the Chemical Waste Landfill. Our goals for that deliberation keeping in mind that this is a prototype case study and as such the “recommendation” is a experimental recommendation, are to develop a process which has successfully integrated risk assessments and stakeholder values while simultaneously satisfying the process and substantive goals of a deliberation.

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## CHAPTER 3: ELEMENTS OF RISK

Imagination is more powerful than knowledge - Albert Einstein

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Trust and risk are two interlinked elements underlying the environmental decision making process. Agencies, scientists and the public involved in and affected by the environmental decision making process have different perceptions of the risks. These perceptions have limited the past decision making capabilities because of the exclusion of certain parties due to a perceived need for time and financial efficiency on the part of the agencies, or a technical arrogance on the part of scientists. Excluding the affected parties from the decision making, contributes to a feeling of mistrust, thereby perpetuating the controversy between agencies and the public. This is related to a misunderstanding regarding the elements and importance of the risks (Slovic, 1996). In order to attain sustainable long term decisions, agencies must address these issues of risk and trust with the stakeholders. By broadening the risk characterization process, the decision making process is enhanced both in terms of process and substance. Involving the stakeholders not only contributes to a more accurate definition of the problem but also builds trust in the agency so long as the process is “sincere” and not simply following a set of guidelines without a equal level of effort (Laws, 1996). *This chapter discusses the need for improved risk communication and assessment techniques from their root causes to potential solutions. It concludes with a discussion of the interdependent relationship between risk and decision making, illuminating the role of deliberation in this process.*

### 3.1 A Definition of Risk

Risk: the mere mention of word evokes both feelings and images in individuals which centered around fear, uncertainty, peril and insecurity. How individuals categorize the risks differ depending on a variety of factors: psychological, physical, personal. Most scientists, whether in the social, physical or biological sciences, have

come to realize that there are a variety of factors that contribute to an individual's perception of risk, as such, one concrete and absolute definition is not possible (Fischhoff et al., 1995; Slovic, 1996; Fischhoff et al., 1984). We present some of the commonly accepted interpretations of risk. Kaplan and Garrick broadly define risk as equal to the uncertainty plus the damage; it is the probability and consequence (Kaplan and Garrick, 1983). Scientists readily use this definition and accompanying formulae (Kumamoto, 1996; Kaplan and Garrick, 1983), to help determine the risks involved in systems, technology applications, such as remediation technologies. The latest report from the Presidential/Congressional Commission on Risk Assessment and Risk Management defines risk as the combination of two factors: probability that an adverse event will occur and the consequences of the event (1997). Others involved in the characterization of risk, frequently define risk as the probability of a hazard occurring multiplied by the impact of that hazard (Susskind and Field, 1996). There is an elementary difference in these two approaches to the definition of risk. Societal definitions of risk and mathematical definition do not convey the same message, thus if a risk manager is to try and address the problem, the definition must first be clarified. There are also differences in how scientists themselves define events and even assign probabilities to the events; these biases, can be a function of education, political persuasion, organizational objectives, or simply psychological differences.

Beyond the quantitative description of risk, the lay person views *risk* in a different fashion, as a function of social status, gender, education, psychological make-up, experience, and possibly numerous other factors (Slovic, *Trust, Sex...* 1996; Jasanoff, 1993; Flynn and Slovic, 1994). These biases are frequently said to be perceived risk, while the risk as analyzed by scientists is the "real" risk; yet just as the scientist draws on her education to help her formulate and calculate the risk associated with a given event, so does the public. The resulting divide in the meaning of risk lies at the heart of the controversy that has arisen around the formulation of environmental policies.



## 3.2 Risk Assessment

Risk assessments are performed to estimate the potential health, environmental and economical consequences of an action, traditionally been thought to be free of value judgments, as they attempt to establish scientific estimates of health and environmental risks of a given action. Commonly performed by governmental agencies ideally in efforts to identify the risks, the art and science of risk assessment were developed as an objective tool for scientists and politicians needing more facts (Douglas and Wildavsky, 1982) and has been promoted through the agencies as a meaningful tool in policy making (Ruckelshaus, 1985; DOE, 1994). However, it is often the case that these analyses come into question by the public, or other 'experts,' the roots of these controversies are planted in subjective judgments, political, social and industrial pressures, and the capabilities of science itself.

Risk assessment is not only used to evaluate environmental and health risks but also in other risk laden areas, specifically in relation to systems operation. In the nuclear industry, for example, the risk assessment examines the system using fault and event tree analysis, to determine the basic events, probability of those events, and associated consequences. This analysis feeds into decision analysis which utilizes the assessment to establish a logical framework to guide the decision maker in the selection of alternatives, whether it be the plant manager, or the regulatory agency. In analyzing the risks, be it environmental, epidemiological or nuclear reactor systems, the analyst is required to make judgments concerning the importance of data or the structure of the fault tree, such as scenario development and the quantification of public risks (Kumamoto, et al., 1996; Keeney, 1994, *Creating...*; Apostolakis, 1990). These judgments, while based on experiments, education and professional intuition, are nonetheless, judgments and along with the analyses must be communicated to those responsible for "managing" the risks. This transferring of data and knowledge from one body of individuals to another - uninvolved in the assessment - is an additional communication pathway which can result in a further misunderstanding or interpretation of the results, and yet, it is these results that the managers depend on for managing the risks. Those

traditionally responsible for managing the risks may be simultaneously faced with additional political, social or industrial pressures which do not allow their sole attention to be focused on mitigating the risks presented by the analysts.

### *Biases*

The biases and subjectivity of risk assessment are frequently raised in relation to the discrepancy between the scientists, or 'experts' and the public. When performing an assessment, it is necessary to make judgments concerning the model used, and the approach to the assessment. Often, risk assessors have the task and the responsibility of making assumptions concerning elements that are non-quantifiable, concerning values related to ethics and culture. Technological choices sometimes involve weighting the value of a river vista, small town style of living, a holy place, or the survival of an endangered species, in addition to human health, against probable benefits. Such matters are ultimately of values. (NRC, 1989:51), and the subsequent assumptions are highly contestable when the consequences of the decision affect the public.

### *Framing*

*Framing* the risk situation is perhaps the most consequential aspects of risk analysis as it is an exercise in power. "If you define risk one way, then one option will rise to the top as the most cost effective, or the safest, or the best. If you define it another way, perhaps incorporating qualitative characteristics and other contextual factors, you will likely get a different ordering of your action solutions. (Slovic, *Trust...1996*)". Those in charge of the analysis determine the methods and subject of the assessment, and therefore set the foundation for how the analyses proceed. Pressures and judgments force the framing of the situation; if there is a questionable assumption made from the initiating event of problem definition, the stability of the entire structure is questionable. Framing the problem also involves making assumptions, assumptions which can lead to omission of vital data. Omitting data can result in stakeholders opposition of the decision to the extent that its implementation is blocked and costs, social and financial ensue, as was the

case in Granite City, Illinois concerning the health and environmental decision regarding the future of a lead smelter (U.S. EPA, 1997, *Presidential Commission...*).

### *Pressures*

Risk Assessment, is not only vulnerable to the biases of framing and the inherent uncertainties, but the direction of the assessment is also open to political and social pressures which may push the direction of the assessment in a particular direction. Granted the raw tools for the assessment, expected utility theory, probabilistic risk assessment, may not be open to the political pressures however the utilization of those tools - as employed by human beings - are (Apostolakis, 1990). Jasanoff (1993) states that the search for objectivity in scientific assessment has kept the risk assessment and risk management components separated. This separation is based on the assumption that separating these two elements will eliminate the political and social pressures and thus allow the assessment to be "correct" only precipitates further problems(NRC, 1996). The political and social pressures do in fact guide analyses and definitions of risk as demonstrated in the on going assessment of the Yucca Mountain high level radioactive waste site in Nevada, which is burdened by a myriad of political pressures(Hassel, 1995). Similarly, opposing side in court cases have little difficulty locating scientists to draw contrary conclusions from the same data (Harr, 1996; Susskind and Field, 1996). Money continues to be spent on the risks that social pressures deem worth the expenditure, while scientific assessments, demonstrate that other risks would be better served (Slovic, 1994; Kunreuther and Slovic, 1996) Risk is not only relative to the observer, as stated by Kaplan and Garrick(1983), but also relative to the situation and the interactions between the participants and the backdrop.

### *Scientific Uncertainty*

As our ability to measure the impact and affect of various does of certain chemicals, our expectations of mitigating these risks increases, while uncertainty of the assessment perseveres. There are numerous types of uncertainty that must be addressed in environmental decision making (Morgan et al., 1990, 1992). In modeling and assessing the risks involved in the given situation, scientist must

make assumptions and account for uncertainties, both in the models used and in the parameters within those models. Furthermore, the concept of zero risk levels continue to be supported through many legislative pressure groups, as well as the desire for a *certain* assessment of the consequences grows, yet the capability of risk assessment is devaluated if its disadvantages are ignored. Ozawa(1992), rather than arguing about the uncertainties or assumptions in scientific analysis, supports that criteria for acceptable scientific information be openly negotiated or discussed prior to the decision making or conflict resolution. In order to adjust for the biases in science which can compound difficult policy choices, she supports the utilization of science to facilitate the decision making and conflict resolution.

Risk assessment is a tool to aid decision makers, it was created by scientists and as with any human creation can be employed in a myriad of ways, thus the technology of risk assessment cannot be, in and of itself, the foundation of democratic and socially wise policies, yet it can be a critical compliment to regulatory decision making.

### **3.3 Risk Management**

Historically, risk management has followed from risk assessments. Once a risk is identified, steps to mitigate that risk are taken although the steps taken to manage an identified risk are not always proportionate to the scientific assessment of the risk. In order to incorporate the risks into more sustainable decisions, policy makers, industries etc. have turned to risk management, although it does not necessarily decrease the risk as measured; it is the process of implementing precautionary measures which minimize the overall risk of a situation.

Risk management actions can also take the form of reaction, rather than precaution. As illustrated in the case of Alar, a chemical once used by apple growers, the EPA announced in 1989 that in a 70-year period, 5 in 100,000 people exposed to the chemical would get cancer. The agency subsequently announce that it would not ban the chemical since there was not an imminent hazard according to studies. However, once the media publicized additional reports as announced by the

Natural Resources Defense Council which stated that 5 in 20,000 children exposed to Alar, ran the risk of getting cancer prior to their sixth birthday, Uniroyal withdrew the product from the shelves. (Leiss and Chociolko, 1994).

### *3.3.1 Approaches to Risk Management*

Techniques, such as those employed by industries in which there are significant consequences, such as the nuclear power industry and the chemical industry, provide a framework for making managerial decisions. In the context of regulatory environmental decisions, risk management is the process of identifying, evaluating, selecting and implementing methods/actions to reduce risk (*Presidential Commission on Risk Management*, 1997). Management strategies proposed for severe accident management strategies uses an influence diagram to map the decision variables for pressurized water reactors (PWRs) blackout sequence, and rank the strategies according to reduction of the probability of early contaminant failure (Moosung et al., 1993). By defining the important criteria that must be considered in performing the analysis, the analyst proceeds to determine the associated probabilities of occurrence, including a best estimate that the strategy will be successfully implemented by personnel.

Combining risk assessments with decision analysis in risk management to identify the major accident or event scenarios through the use of event and fault tree analysis, allows the decision maker to create and examine the options, as applied to the following questions:

- What are the possible options for reducing risk?
- How effective and reasonable are these options in reducing risk?
- How desirable are these options?

These questions provide risk assessors with a general framework that begins to integrate the assessment process with the management process from the start. Some ideas for management strategies drawn from illustrate how a ranking of

strategies can be decomposed to determine the primary contributors to the risks involved (Kazarians et al.,1985). By decomposing the risk scenarios to determine strategies for minimizing risk is used increasingly in environmental restoration problems (Wheeler, 1993). This structured problem technique of evaluation and decomposition provides useful insight into the management and characterization of the risks, alleviating the scientific pressures associated with minimizing risks. Addressing these questions, the Environmental Protection Agency, for instance, has relied on cost-benefit analysis, and more recently risk-benefit analysis to determine the optimal alternative for mitigating environmental problems (EPA, 1997; *Climate Change*; Kerr, 1997). In the promulgation of environmental regulations, such as the “as low as reasonably achievable” of ALARA criteria, which requires emissions reductions based on a combination of risk analyses and costs assessments to the industry in question. These methods and fundamental assumptions are defined and determined by the agency on behalf of public and social welfare, yet employing risk analysis techniques from a one sided perspective, the agency side have overlooked community or industry values and subsequently proceeded with an erroneously framed analyses.

### *3.3.2 Factors that influence Risk Management*

As with risk assessment, risk management is not a purely objective practice; it is influence by social and political pressures which are usually a function of the perception of the risk. This is whether or not the pressures come from the public who learn about a disastrous consequence through the media, or from industry which feels the health risks from their actions are minimal, or from scientists who perceive the consequences of a continued action to be detrimental (Sandman, 1987; Kerr, 1997; NRDC vs EPA, 19 ). “The bulk of the EPA’s budget in recent years has gone to hazardous waste primarily because the public believes that the cleanup of Superfund sites is the most serious environmental threat the country faces. Hazards such as indoor air pollution are considered more serious health risks by experts but are not perceived that way by the public (Leiss, 1994)” Political pressures can also impact the management of risks (Slovic, Fischhoff and

Lichtenstein, 1979; Ozawa, 1992). Political needs can influence the definition of the problem; however, political goals, such as “zero risk” are not practical or technically feasible.

<b>Risk</b>	<b>Cost of a year of life saved</b>
Flu shots	\$500
Water Chlorination	\$4000
Pneumonia vaccination	\$12,000
Breast Cancer Screening	\$17,000
All medical interventions	\$19,000
Construction safety rules	\$38,000
All transportation interventions	\$56,000
Highway improvement	\$60,000
Home radon controls	\$141,000
Asbestos controls	\$1.9 million
All toxin controls	\$2.8 million
Arsenic emissions controls	\$6.0 million
Radiation controls	\$10.0 million

Source: Adapted from Slovic, P. *Trust...*(1996).

*Table 3. 1: Annual Cost of Risk*

In recent years, some managers have tried to attain zero risk yet this is not only scientifically but socially incomprehensible. “An uncompromising insistence on a no-risk society may contribute to tedious litigation and bureaucratic inertia and many major hazards may go unregulated as a result. (Sagoff, p199,1996).” How, with so many interpretations as to what is actually a risk, could Congress or any other manager of risk, hope to attain a level of zero risk for all involved and affected?

In an effort to improve the decisions of the regulatory agencies, risk management and risk analysis must be integrated from the start. Given the uncertainties of the

parameters and models used in risk analysis, we can no longer rely on the assumptions of one expert to define the problem, analysis method and scenarios which formulate an analysis on which to base management decisions, for too often the assumptions made neglect key objectives and preferences from those with a vested interest or specialized knowledge of the situation at hand. Both components provide indispensable information and thus cannot not be discounted, particularly in the areas of both a technological and social nature, since technology and society are forever intertwined, as they have been from the beginning and end of time.

### **3.4 Risk Communication and Perception**

In an effort to integrate assessment and management of risk, communication and perception issues must be addressed as well. Often, the public perceives that the agency does not fairly distribute the risks, consequently, the decision is questioned and trust in the agency's ability to make sound decisions diminished (Dillon,1996) In dealing with inequities, neither normative, nor utility theory are sufficient, and yet the technical issues can often be evaluated best using such analytical techniques.

An individual's perception of the risk involved in a certain set of actions will undoubtedly influence their feeling towards a certain action. This is illustrated in the discrepancy that is seen when normative decision models are manipulated to try to describe human behavior. To address the causes of misunderstanding or differences in perception about risk, Leiss and Chociolko(1994) highlight three main factors that have been shown to influence perceived risks:

1. The degree to which the hazard is understood
2. Degree to which it involves feelings of dread
3. Size and type of the population at risk

These factors can be defined differently and in the agencies' efforts to "communicate" their definitions to the public, trust can be lost if the agency



patronizes or neglects the public. On the other hand, the public may perceive the agency's actions as insincere, thus the result would also be a loss of trust. To establish trust, is to establish a relationship and a relationship can only be established over time. The best way to begin is with an open and flexible process that promotes collaboration on solving the problems that affect the community. It requires a commitment on the part of the participants to define the risks as relative to the affected parties, while simultaneously taking into account the technical evaluations and limitations.

### *3.4.1 Decisions : the individual and risk perception*

In order to reach the goal of successful integration of the stakeholders and the multiple dimensions of risk, the way in which an individual stakeholder makes decisions under risk must be examined. In cases in which risks enter, the decision maker (the stakeholder) is no longer relying on pure rational logic, but rather draws on additional experience and information (Tversky and Kahneman, 1992; Einhorn and Hogarth, 1990 ) which influences the fact that individuals construct different understandings of the risks of a decision situation (Slovic et al, 1987, 1996). These perceptions which are subtle, and often beyond the explanatory capacity of present science lead the individual to make choices which may not in fact "maximize" the analyzed utility of the options available (Dennett, 1981; Tversky and Kahneman, 1995). Moreover, even the perception of what is a maximization, differs. Many from the field of risk analysis have also recognized the limits of a purely normative approach (Slovic 1995; Jasanoff, 1993; Fishburn 1988). Jasanoff states:

How people interpret a given set of facts about risk may depend on a host of variables, such as their institutional affiliation, their trust in the information provider, their prior experience with similar risk situations and their power to influence the source of risk. Far from being irrational, these private calculations generally represent sophisticated attempts to translate risk information down to meaningfully intimate scales of personal experience (1993).

Kahneman and Tversky's Prospect Theory (1979) of human behavior attempts to account for the decision making rationale under risk, describing the risk behavior of individuals. In a given decision situation, the resulting choice of options will differ amongst individuals depending on the individual's perspective of a situation, that individual will be risk-seeking, risk-adverse, or risk neutral. (Kahneman and Tversky, 1979, deNeufville, 1990). Such a distinction in perceptions of individuals also exhibited in the difference between lay and expert perception of the risks attributed to nuclear power (Slovic et al., 1980). Accordingly, the way in which the situation is framed can significantly influence the individual's actions or choices. In the following example, the affect that the framing of the problem has on an individual's perception is demonstrated.

	Mortality Rates		Survival Rate	
	Surgery	Radiation	Surgery	Radiation
Treatment	10%	0%	90%	100%
After 1 year	32%	23%	68%	77%
After 5 years	66%	78%	34%	22%
Subjects choosing radiation therapy	44%		18%	

(McNeil et al. 1982 in NRC 1996)

*Table 3. 2: Risk Perception: A question of framing*

The above chart tabulates the results of a survey given to the public concerning cancer treatment. The same question was asked, but it was first framed in terms of mortality and second in terms of equivalent survival rates. The *mode of questioning* had a significant impact on the individual interpretation and willingness to undergo treatment. When the individual's were asked if they would undergo cancer treatment and the risks were framed in the mortality context, they were more likely to undergo treatment. However, when the risks were presented against the background of survival after treatment, interviewees tended to decline treatment.

The underlying meaning of both questions is the same, in terms of technical meaning and yet the public and experts alike had the same tendency in their responses. The framing of the situation varies depending on the individual's point of reference, a point which can be varied by the simple labeling of the outcomes, or more deeply, based on the background and experiences of the individual. Additionally, Kunreuther and Slovic(1996) has shown in a study of disaster research that individuals do not make decisions simply in line with an expected utility model of decision making under uncertainty. It indicated a difference between expressed preference and the actual preference or cost the individual was willing to incur.

Another example is the societal concern over nuclear and hazardous waste, which concerns both inequities and risk. The concerns and opposition indicate that adequate communication, or rather interactive learning are of high value and that there is a basis for a clear explanation of the technical issues involved in such decisions(Jasanoff 1993, Daniels, 1996; Keeney and Merkoffer, 1987). The dangers or hazards that kill us or do the most harm, are often not the ones which we fear most. The factors which contribute to risk perceptions have been studied :

Factor	Description
Voluntariness	A voluntary risk is much more acceptable than a coerced risk
Control: Have those affected chosen to accept the risks?	When prevention and mitigation are in the hands of the individual, the risk (though not the hazard) is much lower.
Familiarity	Exotic, high tech facilities provoke more outrage than familiar ones
Process/Fairness	Does the agency come across as trustworthy? Are the risks equally distributed? These questions can be at the heart of outrage and thus, opposition.
Framing (morality, ethics, aesthetics)	How can the value of nature be accounted for in decision making? How do individual morals affect the evaluation? "There is no such thing as objective risk." - Slovic, P.

Factor	Description
Catastrophic/Memoriability	A memorable accident, such as Bhopal, the Space Shuttle Challenger, makes risks easier to imagine and thus considered more likely to occur.

*Table 3.3: Factors that contribute to risk perceptions*  
(Sandman, 1987; Kunreuther and Slovic, 1996; Slovic et al., 1979 *Rating...*)

What underlies the perception of risk is the individual whether because of education, chosen career path, the individual's inherent value structure or environment. Deeper than these issues are those factors that make us individuals, whether it be genetics, environment or upbringing, we all approach a situation with some innate preconceived notions; the perception of risk can be a result of gender, race or political persuasion (Flynn et al. , 1994). What contributes to the way in which a person judges whether a risk is voluntary or involuntary, catastrophic or agreeable? Studies are beginning to show that race and gender also influence these perceptions (Flynn et al, 1994; Slovic, *Trust, Emotion..., 1996*). In light of these findings an implementable solution that addresses these behavioural components is needed; it must be able to also be efficient and flexible as time, issues and findings change and progress.

In the context of decision analysis, many of these issues come down to the question of framing the problem and evaluating the preferences of those involved. If those about whom the decision is concern are not involved in the evaluation of their own preferences, if they do not have *control* over the definition of or choice to accept certain risks, how then can those preferences be accurately or adequately determined? Thus, with respect to agency decision making, an inaccurate representation of the individuals preferences concerning risk, leads to an unstable decision, the resolution is built on an weak foundation and thus easily shaken.

### *3.4.2 Multiple Stakeholders*

While an individual has difficulty deciding in the face of risk based on numerous factors described above, the task of bring together stakeholders, each in their own

right an individual decision maker, is inherently more complex. How can these stakeholders decide on the methods for handling risk? Often theoretical decision making techniques in regards to the theoretical aspect of risk assessment hold up under the case of a single decision maker (stakeholder), however in cases with multiple stakeholders or experts, these techniques alone do not suffice (Apostolakis, 1990). New approaches to regulatory decisions in the Nuclear Regulatory Agency, require the input of expert opinion, yet expert opinion differs, despite some claims that given the same scientific data, experts should reach the same conclusions (Susskind and Field, 1996; Tversky and Kahneman, 1988). Stakeholders must come to an agreement concern the assumptions, the treatment of the uncertainty, the modeling techniques used, all of which require communication. While the mathematical formulae used in addressing questions of risk and decision making may suffice in certain instances, i.e., financial risk management, they cannot simply be aggregated to yield an overall solution representative of multiple stakeholders (Apostolakis, 1990; deNeufville, 1990; Keeney, 1992; Arrow, 1988). As stated by Apostolakis, (1990), “two decision makers may be individually coherent and still be unable to reach the same decision....(thus), the quantification of preferences and maximization of expected utilities are replaced by ad hoc decision making criteria.” An individual may choose differently in social decisions than in individual decisions, furthermore the fact that there are others to consider influences the individual’s perception and choice (Arrow, 1995; Fischhoff et al., 1995).

To overcome the mathematical difficulties in obtaining a formula which satisfactorily represents the preferences of individuals in regards to social decision making, deliberation techniques offer the forum for stakeholders to come together to reach social decisions.

#### *Techniques to communicate risk*

Communicating the risks, once defined is another challenge. If the stakeholders have been involved in the definition process and the integrity of the process has been maintained, the elements of risk should be understood by the multiple parties. Past risk communication has suffered because of the flow of information in only one

direction (NRC, 1989) from the agency to the public. Kaplan and Garrick(1981) offer a quantitative framework for analyzing and defining risk, while Sandman points out that the public does not necessarily characterize “risk” in the same scientifically logical fashion (1987). There are other elements, such as emotions and values that go into what an individual defines as risk. Moreover, risk can imply a number of different meanings: financial risk, health risk, risk of failure, political risk etc. When dealing with social and environmental decisions, an equilibrium must be sought between the political, technical and public understandings and concepts of risk. If society is going to redefine or “characterize” how we handle risk, communication and perception between the participants, focused on the substance of the risks and decisions is equally important. The National Research Council has identified the following areas where risk communicators usually stumble:

- Lack of Credibility: It is almost impossible for effective risk communication to take place when the public does not trust the agency.
- Confusing Language: The ability to convey technical, scientific assessments to people who have different fields of expertise
- Access: If the public feels that it does not have access to information which has influenced a decision, it will become skeptical and distrustful. This has the potential for the public to misconstrue the risks involved in a certain situation. Such was the case in Japan, when the operators of the fast breeder nuclear reactor, Monju, tried to hide the details of the accident. This secrecy lead to a great public outcry for openness and investigations. Furthermore it precipitated stronger opposition to nuclear power development in Japan, as indicated by the Maki Town referendum in which the public for the first time in Japan voted against the construction of a nuclear power plant in the town.

Decisions such as these, whether in the US or in Japan, are not left up to a vote, but rather made by experts or single decision makers who flail at their attempt to model the social welfare. Decision makers have previously recognized the myriad of issues in risk laden decision and have tried a number of risk communication techniques to “educate’ the public as to the real risks involved. Most often these have simply lead

to additional controversies and feelings of mistrust. The public does not want to be educated; they want to be heard. However, communicating such issues as remediation technologies and associated uncertainties to a group of stakeholders with a range of backgrounds involves creativity. As each stakeholder has a different, individual way of learning and receiving information, complete communication of every aspect of the process may not be possible. Past studies have shown that even with the use of graphs and visual aids, different stakeholders understand the information presented slightly differently.

The main issues in risk characterization result from framing of the problem, communication of uncertainty, political, social pressures from varied interests groups, yet how do we account for these issues in environmental decision making? The main argument is that involving the affected stakeholders will result in a long, costly, inefficient process.

### **3.5 An Integrated Approach to Risk**

Depending on the definition of risk, the evaluation will lead to a different answer. "To imply that no moral judgment is involved, implies that the major dangers are so obvious that they hit the mind like a beam of light on the retina (Douglas and Wildavsky, p31,1994)." To bridge the gaps between risk assessment and risk management, science and society, risks and values, the limitations of science cannot be ignored, nor can the pressures simply be pushed aside. The so-called "black boxes" - both technical and political - must be opened and the decision making process broadened.

Risk whether social or technical is subjective and contextual. Scientific definitions of risk may tend to seem more objective, simply from a preconceived notion throughout society that science itself is objective, when in actuality, science too has a perspective. If social decisions which are both value and risk laden on all levels (most of which are interconnected), these decisions and their corresponding assumptions, objectives and tradeoffs must be made by all the affected parties. The attempt to analysis risk and then communicate to the public does not achieve

anything, as defining the framework for defining the risks is an exercise in power (Slovic, 1996) and to take this control out of the hands of those involved and affected will only lead to controversies. Furthermore, as Jasanoff (1993), points out, there must be an integration of both quantitative and qualitative risk characterization. This view has recently been adopted as well by the NRC in their new description of an integrated risk characterization process. It is interesting that society has accepted that the experts who define risks are those in the science field, however, in the case of social and technical risks, the prioritization of the issues must stem from the integrated society in which we live, balancing and recognizing the inherent subjective in judgments and complementing it with a structured yet flexible way to

“Even if the experts were much better judges of risk than lay people, giving experts exclusive franchise on hazard management would involve substituting short term efficiency for the long term need to create an informed citizenry.(Slovic et al, 1979)”

### **3.6 Chapter Summary**

One of the basic premises in a democracy is that the people will be adequately represented by those they have put into office. Additionally the decision making system in a democracy is to be open to public comment and influence. As technologies continue to impact the way in which we live, we continually encounter an ever complex model as to how those decisions are to be made and what criteria they are to be based on. There is “no right answer.”

“Success in risk communication is not to be measured by whether the public chooses the set of outcomes that minimizes risk as estimated by the experts. It is achieved when those outcomes are knowingly chosen by a well informed public (Russell, 1987).” Addressing the multitude of issues means involving the stakeholders from the start of the process and seeking a balance between the technical and social concerns inherent in environmental decision making.



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## CHAPTER 4: INTEGRATION OF RISK ASSESSMENTS

“The history of science is rich in example of the fruitfulness of bringing two sets of techniques, two sets of new ideas developed in separate contexts for the pursuit of new truth, into touch with one another. ....Once again this means the scientist may profit from learning about any other science.”

Robert Oppenheimer

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This chapter describes the method used to integrate the stakeholder preferences and results of the risk assessments. The first section discusses integration of stakeholder values and risk assessment. The next section discusses the need for a tool by which an agency can actually successfully integrate the values and risk assessments, as such a decision tool must be able to meet the fairness and efficiency requirements of democratic decision making. The integration tool selected for this project, multi-attribute utility analysis(MAUA), is described in the next section, including the challenges, drawbacks and benefits of MAUA in multiple stakeholder environmental decision making. The integration method is then explained briefly as it contributes to the deliberation process. Lastly, the integration results and pre-deliberation analyses are presented.

### 4.0 Introduction

Decision analysis is a way to set regulatory priorities, such as cost/benefit analysis or risk-benefit analysis. When the agency acts as a single decision maker, it alone attempts to set the objectives, frame the problem and decide how to “maximize social welfare”. In environmental decision making, both in regards to the need to address risks, as well as in regards to traditional decision theory, the initial framing of the problem must be correct and substantiated throughout the process; otherwise, there will be a greater likelihood of an incorrect assessment, perhaps based on the wrong assumptions, consequently opening the door for opposition. This is also seen in the practice of traditional risk assessments. Early incorporation of the stakeholders broadens the definition of the problem, elucidates hidden objectives, and clarifies some of the misunderstandings that have previously limited

the effectiveness of agency solutions. By attempting to incorporate multiple stakeholders in the decision making process, the agency faces the challenge of integrating many single decision makers into an overall priority setting decision situation. Thus begging the questions of how then do individuals set their priorities? How is the agency to evaluate these priorities and integrate them into its own decision making procedure? It is these questions with which this project is concerned. To overcome the failings of normative decision approaches, agencies must go a step beyond, combining behavioural decision insights into a decision making process.

#### **4.1 What is Integration?**

Integration, combining both social and technical goals to achieve a just and efficient outcome, is a formidable task. Through an on going deliberative process, the social input to a technical task can help elucidate hidden objectives and build a stronger foundation for a sustainable decision. In environmental decision making, selecting the optimal alternative for remediation means choosing between various technologies which have different consequences and impacts on the site.

As the decision must not only be fair to those stakeholders but also technically efficient/wise, the technical issues and facts must as well be considered. As was mentioned earlier, there are often be biases or framing discrepancies which lead to the consideration of the “wrong” problem, and consequently, the solution does not withstand the questions and probing from the opposition, or other parties. Integrating the stakeholders means involving the affected or interested parties in the decision making process: jointly defining the problem and assumptions, addressing concerns, and making the objectives and methods explicit.

#### **4.2 Selecting a decision tool**

How to integrate stakeholder values and risk assessment is a question which DOE is currently probing (DOE, 1997). The first and foremost requirement for successful integration is participation of all relevant parties from the start of the decision making process. Assuming that all stakeholders are involved, a tool for guiding the process is

needed. Diagram 4.1 describes the overall decision analysis framework into which the stakeholders' values and concerns must be integrated. To accomplish this task first requires issue, or problem, identification. If DOE were acting alone in this identification, the issues identified would be necessarily less than the amount brought to light by involving a multitude of perspectives and thus broadens the problem identification stage early on and ideally minimizes the amount of opposition later in the process. Once the main issues are identified, a method is needed to measure the performance of the alternatives available or suggested for the remediation against these criteria. The method must account for the risks and values as defined by the stakeholders, as a group - i.e. via the consensual characterization of the group. To this end, an iterative process that is both qualitative - in defining the objectives, measures and also verifying the results, and Quantitative - in performing the so-defined assessments and impact analyses is required.

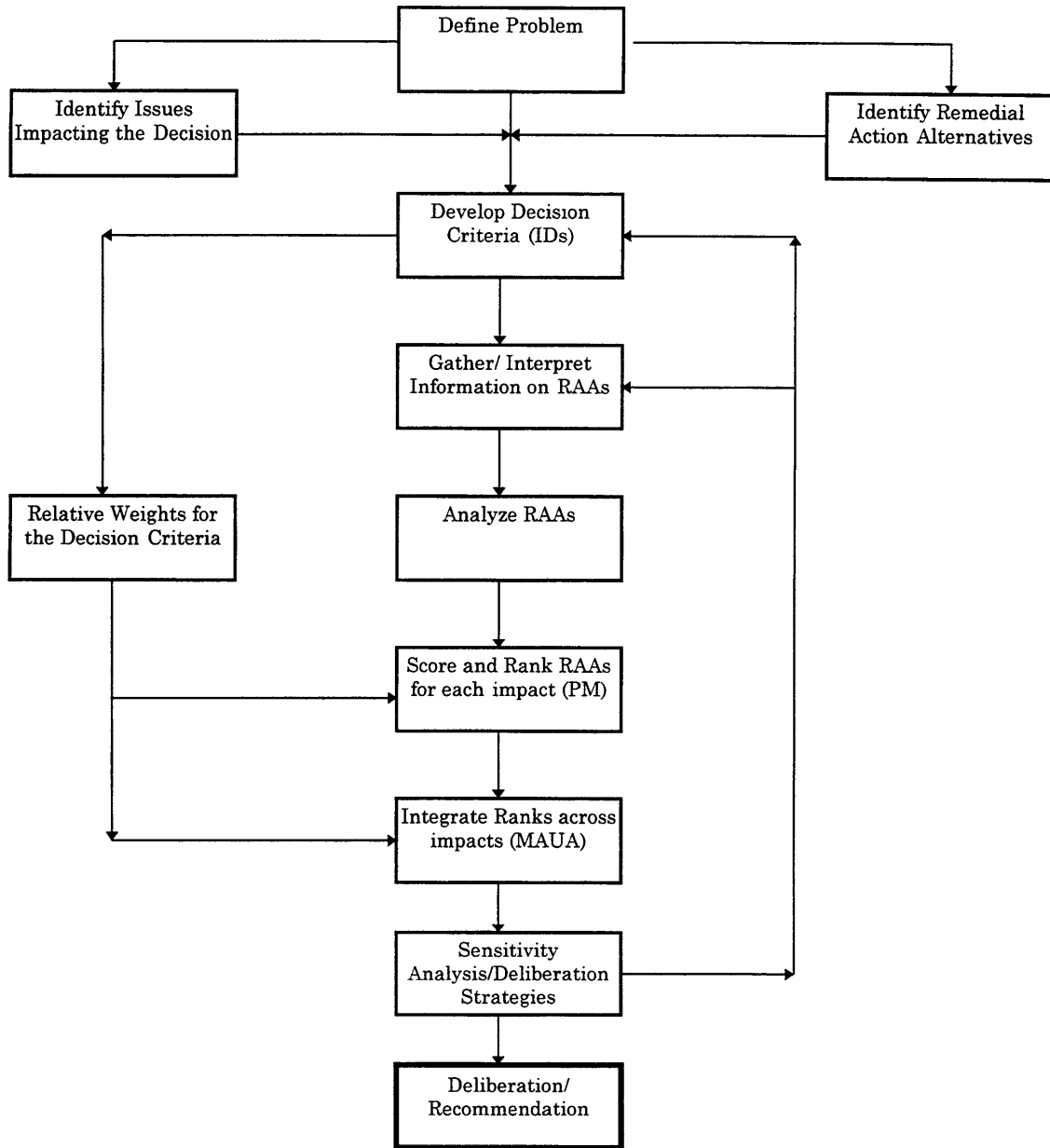


Figure 4.1: The Decision Process for a single stakeholder

One method which has been successful in aiding agency decision making is multi-attribute utility theory (Keeney and Raiffa, 1976; deNeufville, 1990; Keeney, 1994). Multi-attribute utility allows the translation of non-commensurate measures to one common unit: utility, a measure of an individual's preferences for a given attribute, providing an analytical framework which considers multiple objectives by assessing the individual's utility and relative preference (weight) for each objective. Using equation 4.1, the single attribute functions which measure the individual's utility for the alternative in regards to that attribute (referred in this project as Performance Measure(PM)) are combined to determine the stakeholder's multi-attribute utility (Preference Index (PI)) for each alternative. We use MAUA as the primary integration methodology from which the deliberation strategies are planned. The main components in a structured decision making can be combined with new methods that focus on the sharing of ideas and viewpoints in order to achieve consensus or mutual gains. The following description is presented as background information so that the reader understands the multitude of elements considered in such a complex decision making process; we do not explain the mathematical details of each component that went into the construction of the utilities (See Zio, 1997).

A milestone in the development of MAUA is the work of von Neumann and Morgenstern (1947), who have formulated a set of axioms leading to the existence of utilities with the property that the expected utility is an appropriate measure for consistent decision making. This normative approach assumes that the individual adheres to the two main assumptions in MAUA (Keeney, 1973, 1981):

- Preference Independence
- Utility Independence

One of the benefits of MAUA is that it utilizes a cardinal scale rather than an ordinal scale and thus allows the comparison between objectives which are not commonly measured on an ordinal scale. Furthermore, the use of assumptions, does not intend to be prescriptive, but rather descriptive; unlike purely normative theories, MAUA, intends to be descriptive, making no ethical judgments of a decision maker's rational behavior (deNeufville, 1991).

In the evaluation between various alternatives, say  $(A_1, A_2, A_3 \dots A_n)$  under a set of attributes (or performance measures) that commonly have different metrics, MAUA transposes all metrics to the common metric of utility, although the shape of the function may differ between attributes. By evaluating an individual's relative preference between those performance measures,  $w_n$  - the relative weight for each performance measure, and constructing for each PM, a utility function  $(U(x_n))$  which specifies the way the individual prefers the range of the measurement, assuming the three assumptions are met, the Overall Utility (Preference Index) for each Alternative can be determined (deNeufville, 1990, Keeney, 1981, 1975). If the assumptions hold and the function is consistent with the preference attitudes of the decision maker, the equation for determining an individual's overall preference is expressed as:

$$PI(x) = \sum_{i=1}^{N_{PM}} w_i u_i(x_i)$$

Equation 4.1

where  $w_i$ , the priority weight of the  $i$ -th performance measure (attribute), gives an indication of the relative importance of the  $i$ -th performance measure,  $u_i$  is the single-attribute utility function for performance measure  $i$ ,  $x_i$  is the associated consequence variable, and  $N_{PM}$  is the total number of performance measures.

Utility independence permits the decomposition of a complex problem into its components. If the decision maker adequately decomposes the objective hierarchy, Figure 2.2, mutual preferential independence is a reasonable assumption (Clemen, 1995). Preference independence states that the individual's preference for a given attribute does not depend on the level of another attribute. For example, in the environmental restoration decision at hand, an individual's preference for a given objective, say, socio-economic impact, will always remain the same no matter how the impacts in another performance measure, for example, human health and safety vary. In a decision under certainty, mutual preference independence is enough, however under uncertainty, a further condition must be satisfied, that of utility independence. Utility independence is a slightly stronger requirement which

independence is enough, however under uncertainty, a further condition must be satisfied, that of utility independence. Utility independence is a slightly stronger requirement which states that an attribute Y is considered utility independent of attribute X if preferences for uncertain choices involving different levels of Y are independent of X. Again, in relation to the decision situation, this means that for a given values of consequence of performance measure, socio-economic impact, the stakeholder's preference for a different uncertain measures of an alternative performance measure, human health and safety, do not change.

Utilizing this approach, the weights and single-attribute utility functions for each stakeholder are determined , and the assumptions are verified by the analysts. To each attribute and objective, a relative weight is then assessed through elicitation then using Equation 4.1, the stakeholder's individual ranking of the alternatives is determined.<sup>8</sup>

### **4.3 Benefits of MAUA**

Unlike cost benefit analysis which is frequently used in environmental policy decision making(EPA, Sagoff, 1996; McAllister, 1982), multi-attribute utility analysis does not convert non monetary objectives to dollars in order to draw a comparison.<sup>9</sup> It allows a decision model which accounts for the interaction between attributes. Often, questions of complex preference interactions are raised concerning such interactions in the decision model, yet evidence from behavioral decision theory indicates that modeling such intricacies is rarely necessary (Clemen 1995), when used as a tool in decision making.

Multi-attribute Utility Analysis(MAUA) has been used in case to highlight or create alternatives (Keeney: 1994,1996; Field, 1990). For example, in Sabah, East Malayasia, a decision concerning the issuance of a drilling permit to explore coal brought together multiple stakeholders to help define the objectives and criteria for deciding prior to the analysis(Keeney, 1994). From the stakeholder defined objective hierarchy, the decision makers focused their decision on the issues important to those affected.

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<sup>8</sup> Elicitation methods for stakeholder preferences vary; see Keeney and Raiffa, 1972; Keeney, 1992; Saaty, 1980; deNeufville, 1991.

<sup>9</sup> References for Cost Benefit Analysis:

It was also used to determine the relative values of major objectives considered in decision making at British Columbia Hydro Project. The process consisted of: listing the objectives, distinguishing between means-ends objectives and strategic objectives, identifying attributes to measure the strategic objectives and assessing an overall objectives function; it involved the key decision makers in the company from different departments - the stakeholders - and resulted in a list of strategic decision opportunities for the future (Keeney, 1994; Leiss et al., 1994).

In these and other such complex scenarios (deNeufville, 1990), MAUA has been used as a tool for agencies and governments, where the ultimate decision has been that of one agency or government. In another example, concerning the location of a repository for nuclear waste, Merkhofer and Keeney (1987) employed MAUA to assess the site alternatives while simultaneously incorporating non monetary values. From their study, they recommend the following for use in future studies:

- A portfolio analysis to explicitly account for the value of diversity and interdependencies among the uncertainties in estimated site impacts
- Use of technical panels to broaden the basis for scientific impact
- Invitation and involvement of stakeholders

Keeney and Merkhofer recognize the difficulties in assessing a multiple objective decision situation in which the objectives are non commensurate as with the objectives in environmental decisions.

### *Multiple Stakeholders*

Addressing the issues of risk management involving more than one decision maker, Hong and Apostolakis (1993) use utility theory in combination with influence diagrams (IDs) to integrate the multiple objectives into the decision making process. This methodology recognizes the different perceptions of each stakeholder and that each will act to maximize their own benefit. An “optimal” decision is one which is acceptable to both stakeholders. The influence diagram is the structure upon which each decision alternative is evaluated using MAUA and produces a overall utility for each stakeholder for each combination of decisions. The unique aspect of this work is the use of game theory to identify optimal



decisions. One could then use the resulting bi-matrix to try to convince the stakeholders that it would be to their best interests to cooperate. It is further noted that achieving the “optimal” solution requires cooperation and trust by the stakeholders(Bell,1995). This use of influence diagrams can be used to accommodate multiple stakeholders as decision makers to analyze potential conflict and resolution options between stakeholders in environmental remediation decisions.

#### **4.4 Challenges with MAUA**

Despite its apparent benefits, MAUA does have its shortcomings, particularly when decisions involve multiple stakeholders, for there remains no absolute method to mathematically integrate the multiple values and preferences of multiple stakeholders, as well as the questions that are raised by behavioural decision theorists concerning the legitimacy of the normative foundations of expected utility as a decision tool (Bell et al.,1988; Hershey et al., 1988). When decisions are risk and values laden, it has been shown that individuals do not always adhere to normative principles (Simon,1978; Einhorn and Hogarth, 1990; Svenson, 1996). Some of the questions that are raised concern:

- elicitation of preferences
- ability to compare incomparable objectives
- structuring of values which are not normally viewed in a hierarchical fashion
- preference reversal

How can we guarantee that the preferences which were elicited are the correct preferences? Did the stakeholders understand the questions? Were the analysts able to communicate their needs to the stakeholders? How can preferences be elicited, if the individual does not feel it is valid to express his/her preferences in such a fashion? Can we then say that they have no preference? “If theoretical difficulties make a social welfare function impossible, the analyst, in hopes of preserving neutrality then transforms individual preference ordering into collective ordering of social states, which the analyst may argue as maintaining neutrality. However, this neutrality is only that neutrality

amongst competing preferences and not amongst the competing perceptions of the role of the policy regulation in a democratic society (Sagoff, 1988:43).”

#### *4.4.1 Elicitation of Preferences*

In a simple decision making situation involving one objective, say obtaining a greater financial reward, the decision maker will have a varying preference for different amounts of money. Depending on the individual, this preference may be linear, exponential or some other functional form. When there is more than one objective, this preference is then weighted between the objectives. As with risk, the *framing, or perception* of the situation influences the preference that the decision maker expresses for a certain objective. The individual in accordance to expected utility theory would commonly act to maximize his/her utility however, this may change under risk.

#### *4.4.2 Comparing Incomparable Objectives*

*Values and judgments* are a part of human natural. We are not “super rational” beings in the economic sense of the word. In the case of a single decision maker, that when policy maker takes the responsibility for deciding for society, the policy maker burdens him/herself with the assessment of society’s preferences, such as in the case of risk assessments where the assessor must make underlying judgments regarding the values and ethics of the affected parties. Furthermore, the policy maker must then compare objectives that a single individual may find incomparable. In keeping with the case of a single decision maker, limitations of normative theory become evident, even in the case of MAUA. If we apply subjective expected utility theory, a decision maker must decompose her preferences and judgments about consequences; s/he must think about the choices and tradeoffs in a confined space and not reverse her preferences. However, it has been shown that often the individual, upon learning the possible consequences of an action will want to “reverse” his/her preferences, thus changing the outcome of the MAUA ranking (Bell, Raiffa and Tversky, 1988). Sociologists and cognitive scientists give more weight to the fact that the individual’s preferences may change upon the acquisition of knowledge and that there are additional elements which factor into the individual’s decision making process (Simon, 1955; Svenson, 1996), as is often the case in environmental decisions.

These issues are particularly important in the environmental decisions because of the numerous elements associated with the concept of risk, as explained in Chapter Three. Risk influences the scientific, social and political judgments on the social level and in the same sense, interact synergistically with the individual's perception and evaluation of the situation.

#### **4.5 Utilizing MAUA**

To balance the drawbacks of MAUA, a behavioral component must be incorporated into the decision situation involving multiple stakeholders(Arrow, 1951). Despite its limitations, multi-attribute utility theory does provide a useful guideline to aid in the decision process(Merkofer and Keeney, 1987; Keeney et.al, 1978; Merkofer, 1987). As no decision tool can be complete without necessary qualitative and behavioral feedback of the parties involved, we proceed with MAUA and a quantitative integration of the stakeholder values in order to guide the deliberation process.

In sum the main steps for making a decision are

1. Define the objectives
2. Define the performance measures (or attributes) along which the performance of the alternatives can be measures
3. Establish relative preference weights for each objective and performance measure
4. Construct a utility function for each performance measure
5. Plot the performance of each alternative along the utility
6. Determine the overall utility for the alternative in question
7. Decide amongst the alternatives, or create new alternatives.

The definition of objectives is often done in stages, starting with the higher level objectives and then the corresponding attributes of the higher objectives are those which allow for the measurement. One common way to define the decision problem is to construct an objective hierarchy (Keeney, 1992; Keeney and Raiffa, 1987), which allows the distinction between the higher objective and their corresponding attributes. The goal is to ensure that the

hierarchy of objectives reflects the concerns of the individual or group. Once the stakeholders, as a group, agree on a objective hierarchy, or influence diagram, the process of eliciting their relative weights, stakeholder by stakeholder begins.

#### *4.5.1 Influence Diagrams*

Influence diagrams are used to help determine how each objective contributes to the overall objective. The basic concept behind the influence diagram is that directed graphs can be used to determine the structure of a decision making problem and by outlining the objectives, attributes and influencing factors, determine the respective probabilities and compute the important quantities. The stakeholders defined the two influence diagrams that were used throughout the analysis. In creating the diagrams, there were two groups of stakeholders, those that felt that public health is an objective under environment, and those that placed it under the Objective Category of Health and Safety, as shown in Figure 4.2a and 4.2b. These two diagrams will form the basis for the development of conditional influence diagrams to evaluate the impacts of the various Remedial Action Alternatives. Influence diagrams were used in similar stakeholder involvement investigations by Hong and Apostolakis(1993) to examine the outcomes of a hypothetical situations utilizing game theory to evaluate options and determine the optimal choice, which showed that a cooperative agreement between the stakeholders would result in the optimal solution. We draw on this work, using IDs as a tool to aid deliberation.

#### *4.5.2 Integration*

Once the stakeholders decided upon the Objective Categories, the stakeholders were asked questions in order to determine their relative preferences in order to determine  $w$  in Equation 4.1. According to classical normative decision making theory, the way in which an individual's relative preferences should not change or be dependent upon the consequences of a given action, thus the stakeholders' completed the preference ranking forms, prior to seeing the results of the risk analysis. Since preference reversal can occur (Arrow, 1988), an additional component is needed beyond the quantitative evaluation.

Upon the elicitation of preferences, Table 4.1a and 4.1b, The construction of the utility function for each stakeholder, per Equation 4.1, was done through an interactive meeting

where the stakeholders, with the aid of the analysts. Then the results of the risk assessments for each alternative under each performance measure are combined to determine the stakeholder's utility (or preference) for that alternative. Table 4.2 shows the utility for each PM and then the overall performance index (PI) for each remedial action alternative (RAA) for each stakeholder. Thus, in accordance with MAU theory, from the expected utilities for each remediation action alternative, the RAAs are ranked for each stakeholder(Keeney and Merkhofer, 1987; Field, 1991).

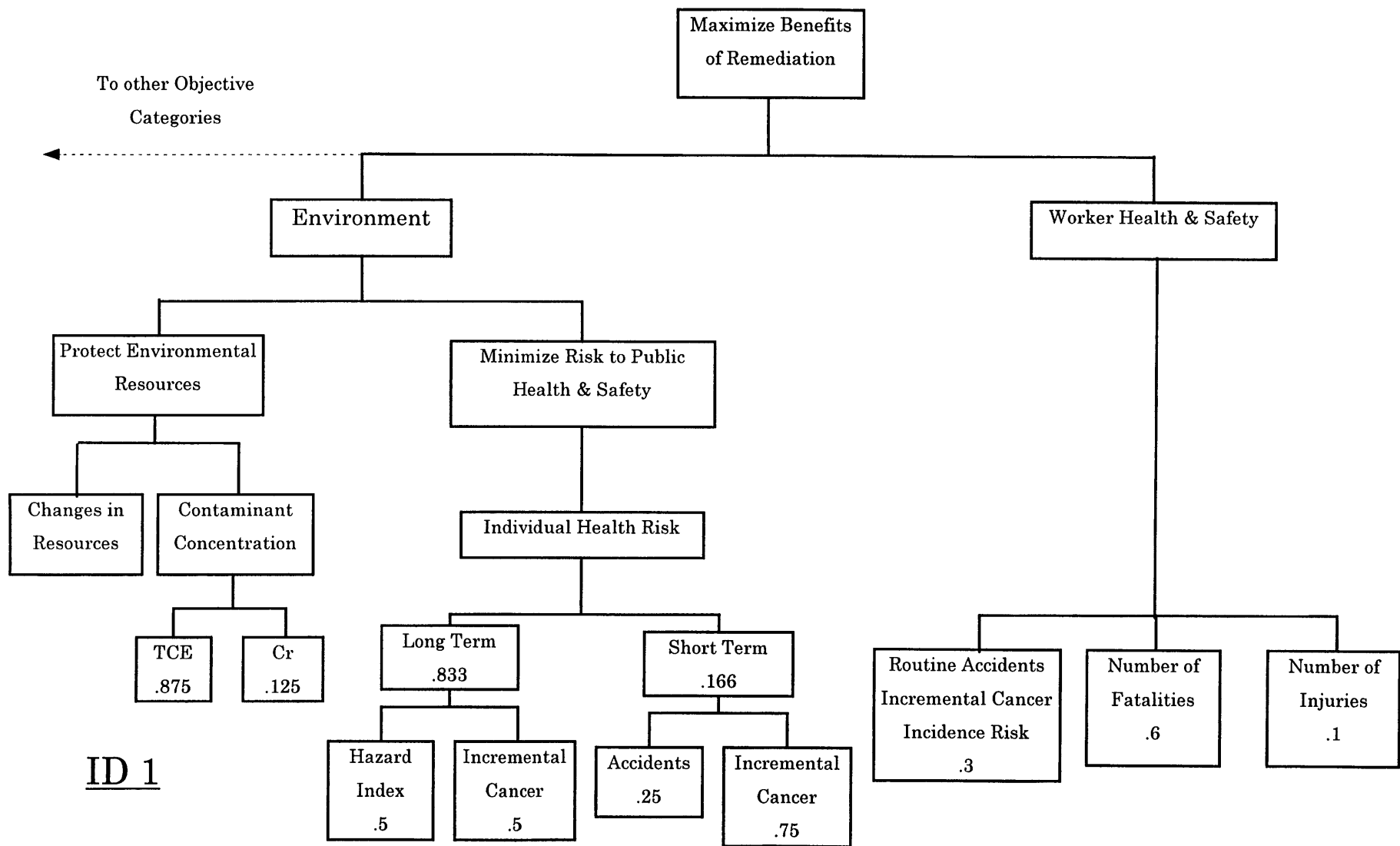


Figure 4.2a:  
Influence Diagram 1

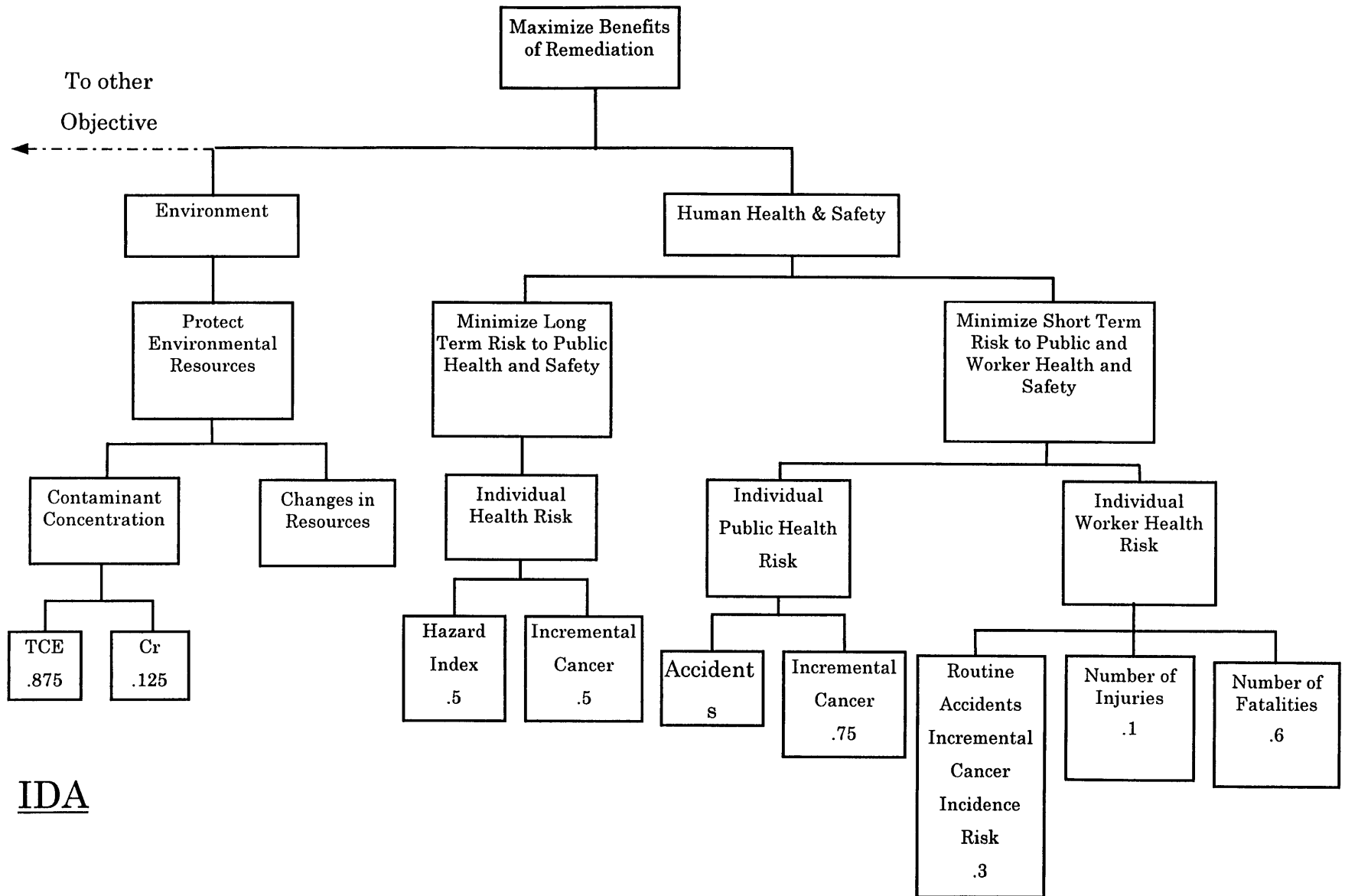


Figure 4.2b: Influence Diagram A

Category	Objective	Performance Measure	3	4	1	6
Programmatic Assumptions	Minimize Waste	Quantity of Waste Transported	0.005 (11)	0.033 (8)	0.061 (5)	0.040 (6)
		Quantity of Process Waste Generated	0.005 (11)	0.012 (10)	0.012 (10)	0.040 (6)
		Quantity of ER Waste Generated	0.016 (8)	0.005 (13)	0.005 (11)	0.040 (6)
Life Cycle Cost	Minimize Direct Costs	Implementation Costs	0.058 (4)	0.019 (9)	0.019 (8)	0.015 (13)
		Completion Costs	0.012 (9)	0.058 (4)	0.096 (4)	0.030 (10)
Socioeconomic Issues	Promote Community Quality of Life	Impact on Local Economy	0.001 (13)	0.040 (6)	0.0005 (13)	0.024 (11)
		Changes in Ambient Condition	0.006 (10)	0.010 (11)	0.0045 (12)	0.071 (4)
	Promote Environmental Justice	Compare Total Population Health Effects	0.035 (7)	0.199 (2)	0.034 (7)	0.032 (9)
Cultural, Archaeological & Historic Resources (CAH)	Protect CAH Resources	Number Impacted / Severity Impacted	0.078 (3)	0.041 (5)	0.042 (6)	0.104 (3)
Environment	Protect Environmental Resources	Contaminant Concentration	0.3045 (2)	0.007 (12)	0.153 (3)	0.051 (5)
		Changes in Resources	0.0435 (5)	0.035 (7)	0.017 (9)	0.017 (12)
	Minimize Risk to Public Health & Safety	Individual Health Risk	0.039 (6)	0.126 (3)	0.170 (2)	0.204 (2)
Worker Health & Safety	Minimize Risk to Worker Health & Safety	Individual Worker Health Risk	0.398 (1)	0.415 (1)	0.386 (1)	0.333 (1)

Table 4.1a: Performance Measure Weights, after stakeholder confirmation



Category	Objective	Performance Measure	5	2
Programmatic Assumptions	Minimize waste	Quantity of waste transported	0.618	0.685
		Quantity of process waste generated	0.086	0.234
		Quantity of ER waste generated	0.297	0.081
Life Cycle Cost	Minimize direct costs	Implementation costs	0.167	0.25
		Completion costs	0.833	0.75
Socioeconomic Issues	Promote community quality of life	Impact on local economy	0.25	0.167
		Changes in ambient condition	0.75	0.833
	Promote environmental justice	Compare total population health effects	1	1
Cultural, Archaeological & Historic (CAH) Resources	Protect CAH resources	Number impacted / severity impacted	1	1
Environment	Protect environmental resources	Contaminant concentration	0.167	0.167
		Changes in resources	0.833	0.833
Human Health & Safety	Minimize long term risk to public health & safety	Individual health risk	1	1
	Minimize short term risk to public & worker health & safety	Individual worker health risk	0.125	0.5
		Individual public health risk	0.875	0.5

Table 4.1b: ID A: Stakeholder Weights After confirmation

The ranking, of the alternatives, shown in Table 4.2: Stakeholder Rankings, highlights the major tradeoffs between the alternatives in respect to the stakeholders. Table 4.3 details the specific contributions to the Performance Index for Stakeholder 3, illustrating the major contributors to that stakeholder's overall ranking and providing the basis for further analysis from which deliberation strategies are drawn. The complete data for the six stakeholders is found in Appendix 1. This framework helps the mediator to focus on the interests of the stakeholders as they manifest themselves in the selected components of the technologies. By pinpointing the components of the technologies that contribute to the risks, as perceived by the stakeholders, alternatives may be created in the deliberation process (Keeney, 1992).

EXPECTED PERFORMANCE INDEX							
RAA	1	2	3	4	5	6	Mean
A	.0936	.0475	.0711	.0529	.0501	.1297	0.0742
B	.2045	.1718	.1543	.1111	.0910	.1594	0.1487
C	.2157	.1281	.1771	.1217	.0908	.1547	0.148
D	.1829	.1152	.1786	.1200	.0820	.1385	0.1362
E	.2225	.1852	.1324	.1353	.1065	.1135	0.1492
F	.2576	.2052	.1808	.1276	.0888	.1944	0.1757

RANKINGS							
RAA	1	2	3	4	5	6	Mean
A	6	6	6	6	6	5	5.83
B	4	3	4	5	2	2	3.33
C	3	4	3	3	3	3	3.17
D	5	5	2	4	5	4	4.17
E	2	2	5	1	1	6	2.83
F	1	1	1	2	4	1	1.67

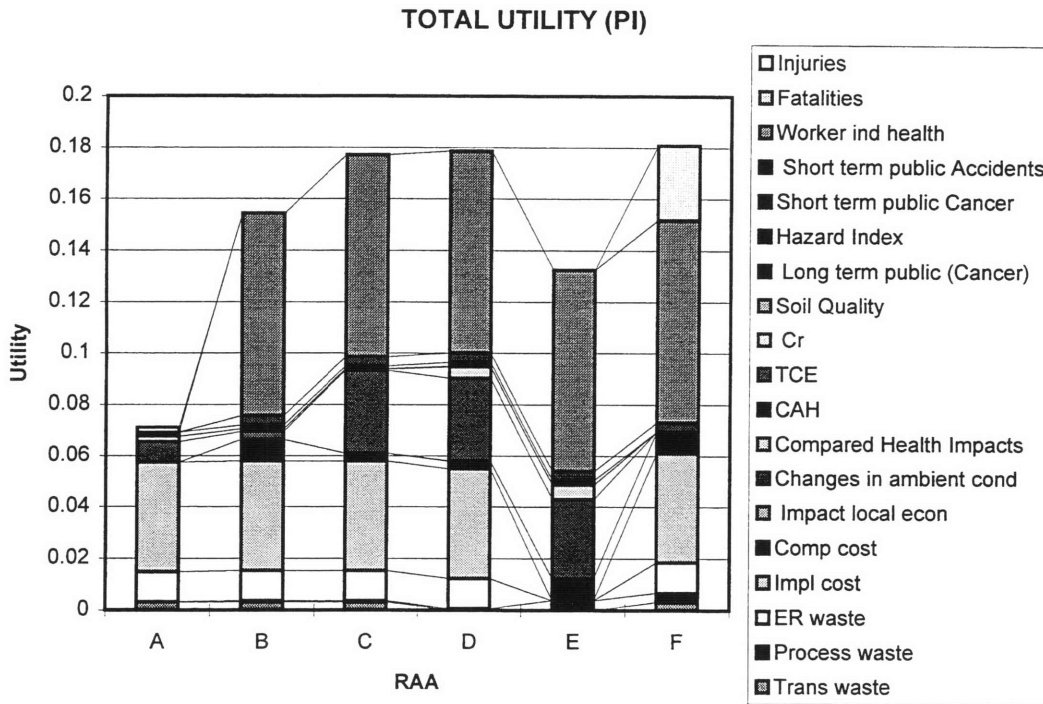
Table 4.2: Overall Rankings for all stakeholders

The following table illustrates the overall results for one stakeholder. From these results, we rank the RAAs and proceed with the major contributor analyses.

RAA/ Stakeholder 3	A	B	C	D	E	F	Utility
Transported waste	1	1	1	0.0194	0	1	0.0031
Process waste	0	0.1479	0.1479	0.1479	1	1	0.0037
ER waste	1	1	1	1	0	1	0.0117
Implementation cost	1	1	1	1	0	1	0.0425
Completion cost	0	1	0.369	0.369	1	1	0.0085
Impact on local economy	0.8	0	0.45	0.55	1	0	0.0001
Changes in ambient conditions	NaN	NaN	NaN	NaN	NaN	NaN	0
Compared health impacts	NaN	NaN	NaN	NaN	NaN	NaN	0
CA&H resources	NaN	NaN	NaN	NaN	NaN	NaN	0
Contaminant concentration: TCE	0.25	0.1	1	1	0.95	0	0.0322
Contaminant concentration: Cr	0.3978	0.1577	0.0985	0.7993	1	0	0.0056
Soil Quality	NaN	NaN	NaN	NaN	NaN	NaN	0
Long term public (Cancer)	0.25	0.1	1	1	0.95	0	0.0001
Hazard Index	1	1	0.6314	1	1	0	0.0016
Short term public (Cancer)	0	1	1	1	1	1	0.0036
Short term public (Accidents)	NaN	NaN	NaN	NaN	NaN	NaN	0
Worker individual health	0	1	1	1	1	1	0.0787
Fatalities	NaN	NaN	NaN	NaN	NaN	NaN	0
Injuries	0.0657	0	0	0	0	1	0.0291
Ranking	6	4	3	2	5	1	

*Table 4.3: Stakeholder #3: Performance Measure and Overall Utilities as determined by integration*

From the above Table, we construct the following graph which provides a snapshot of the contributors to the overall rankings for the stakeholder.



*Figure 4.3: Performance Index indicating Major Contributors*

This graph indicates the contribution of each PM to the overall utility. From this, we can see which performance measures are the prime contributors. Again recalling the goals of agency decision making and the process goals of deliberation, we directed our analysis at the causes of the disagreements and agreements between the stakeholders as well as the extent of those difference as a method to help us guide the deliberation towards consensus.

#### 4.6 Analysis of the Results of the Integration <sup>3</sup>

Three types of analyses are performed on these rankings: uncertainty, sensitivity and major contributor analysis, in order to help formulate strategies for deliberation. We focus here on utilizing these studies in the major contributor analysis, to prepare for multi-

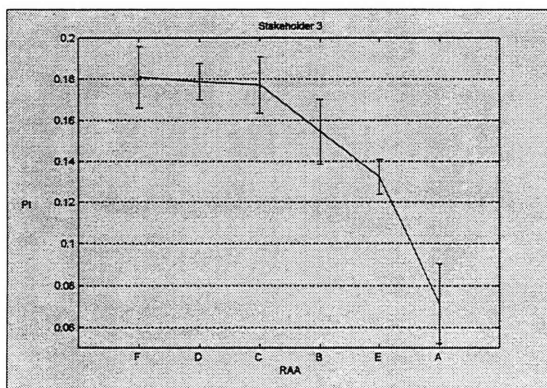
<sup>3</sup> The sensitivity studies were done by Roberto Accorsi, Enrico Zio and Susan Pickett. Zio, E, 1997, Doctoral Thesis, Nuclear Engineering Department, Massachusetts Institute of Technology.

stakeholder deliberation, supporting them with the sensitivity studies to provide a logical explanation of the technologies as they relate to the stakeholders.

#### 4.6.1 Uncertainty Analysis

The uncertainty analysis was performed on the overall spread of the PI for each RAA. If the uncertainty bands are large enough, there is a greater likelihood that the stakeholder may easily reverse preferences and thus re-order the rankings, from the quantitative standpoint. Again, there maybe hidden, or psychological factors which are impossible to predict quantitatively. However the uncertainty analyses do provide insights into which RAAs may need further investigation. Thus, we examine some of the causes of these uncertainties so to better address the needs of the stakeholders. The results of the uncertainty studies are shown in Table 4.3 for one stakeholder, complete results are in Appendix 2.

Stakeholder 3	F	D	C	B	E	A
Ranking	1	2	3	4	5	6
Mean PI	0.1808	0.1786	0.1771	0.1543	0.1324	0.0711
Standard deviation	0.0149	0.0089	0.0138	0.0156	0.0085	0.0191
Lower	0.1659	0.1697	0.1633	0.1387	0.1239	0.052
Higher	0.1957	0.1875	0.1909	0.1699	0.1409	0.0902



### *4.6.2 Sensitivity Analysis*

The sensitivity analyses investigate how sensitive the overall rankings are to small changes in various components of the PI: both the weights and the utilities. Again, this aspect of the study can only go so far in substantiating the overall ranking since it is based in the elicitation of preferences from the stakeholders which have foundations in both normative and behavioural theory, and may be reversed, for so-called “irrational” reasons, beyond the analytical ordering of mathematics as we currently know it. In the sensitivity analysis, we can hold certain performance measure weights constant, and then by varying the PM we wish to examine over a given range, we determine the amount of variation that would actually cause a change in the overall ranking. Samples of this analysis are found in Appendix 2.

### *4.6.3 Major Contributor Analyses*

The major contributor analysis focus on the individual stakeholders to determine which performance measures most greatly influence the overall ranking. From which we examine the elements of those PMs in each RAA, similar to the way in which game theory was employed by Hong and Apostolakis (1993). This tells us which components of the RAA are the major factors in the rankings, and thus provide insights into what alternative actions can be taken. As the mediator, we can then present the root causes and help in the consensus building process, either by presenting the reasons against certain aspects, or illuminating options and openings for the creation of new alternatives.

The major contributor analysis looks at Table 4.2 and for each stakeholder breaks down the PI into the major components that either add or detract from that overall utility. It examines the overall picture for each, in order to determine which PMs make the difference for each RAA, for each stakeholder. We also draw on the graphical representation, Figure 4.3, to identify the primary contributors. From this we proceed with an examination of the characteristics of each RAA that cause this utility, to provide a logical and understandable communication and deliberation forum, as will be explained in the next two chapters.

## **4.7 Chapter Summary**

To integrate stakeholder values and risk assessments, a tool for integration must be selected or created. Using MAUA, we integrate stakeholder preferences and risk assessments, to compute an overall ranking of the alternatives for each stakeholder. From this ranking we perform three types of analyses: sensitivity, uncertainty and major-contributor in order to devise deliberation strategies aimed at both substance and process goals. In the next chapter, we describe how these results are analyzed and the strategies prepared for deliberation.





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## CHAPTER 5: DELIBERATION

So much of what we think, our acts our judgments of beauty and of right and wrong, come to us from our fellow men that what would be left were we to take all this away would be neither recognizable or human. Oppenheimer, *The Sciences and Man's Community*

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In order to bring together the risk assessments and stakeholder values, a quantitative integration alone is not sufficient. The uncertainty and human values involve dictate that a more comprehensive balance is needed which addresses the various perspectives and technical issues which yields a socially and technically fair and efficient decision. A consensual deliberation has the potential for successfully serving this dual purpose. To do so it must not only adhere to a fair process but it must also be efficient, in terms of time, and technological capability - it must result in a feasible decision.

This chapter discusses the rationale for and goals of a deliberation in the environmental decision making process. It presents the dual nature of the goals and describes why they are often at odds with each other, and elaborates on some of the more pertinent issues in a multi-stakeholder deliberation that must address the varied interests and technical issues inherent in such a process. Then, it presents an overview of the steps involved in preparing a deliberation, from which we design a deliberation drawing on the integration results to help achieve a fair and efficient process.

### 5.1 Rationale for Deliberation

Deliberation, as defined by the National Research Council is **“any formal or informal process for communication and collective consideration of issues. Participants in deliberation discuss, ponder, exchange observations and views, reflect upon information and judgments concerning matters of mutual interest and attempt to persuade each other.”** (NRC, 1996:4). Deliberation which offers a forum for the discussion of interests which move away from the polarization of the interested parties

towards a discussion of mutual interests is often referred to as a “mutual gains approach” or consensus building (Susskind and Field, 1996; Fisher and Ury, 1981).

Deliberation in its many forms offers an open forum for the discuss of interests which moves away from a discussion of the values or individual differences and more towards a discussion of the mutual interests and alternative ways of satisfying those interests (Susskind, 1987; Ury, 1981, Keeney, 1992 *Creating Value*) . Deliberation techniques have been employed in a number of agency and industry decision situations involving multiple stakeholders and conflicting values (Susskind and Cruikshank, 1987; Renn et al, 1993; NRC, 1996; Crowfoot J. and Wondolleck , J., 1990). Similarly, acts of Congress, mandate that the stakeholders be involved prior to the promulgation of certain regulations (APA, CERCLA, EPCRA). Calling for the involvement of the interested and affected parties, the stakeholders, offers a method through which the agency can build support for the decision in the long run where consensus amongst the conflicting parties can be facilitated; if the relevant stakeholders are involved from the start of the process, the chances of ensuring that the framing of the situation is acceptable and understood by all is improved(NRC, 1994; 1996; Presidential Commission, 1997).

### *5.1.1 Defining Deliberation*

A consensual deliberation offers the best opportunity to build consensus around each step of the decision making process, ensuring that the stakeholder interests are met and the risk assessments are appropriately framed and substantiated. In sorting through the myriad of literature on deliberation and negotiation, it is a challenge to find one definition of deliberation appropriate to all circumstances, as such, deliberation in this project is defined as a face to face discussion of the interests of the stakeholders and technical issues of the site as the manifest themselves in the alternatives of remediation in order to reach a recommendation concerning the clean up. We are not concerned here with other concepts of deliberation which are extended to imply litigation but rather deliberation as the culmination on iterative meetings amongst the affected parties and the on-going risk assessments which have parallel and flowed out of those meetings.

To this end, Glasbergen (1995) discusses the evolution of the management of environmental disputes as an evolving process which is “no longer seen as an entirely rational process, (but) rather a process of consultation and negotiation among public and private actors representing different positions and interests.” He proposes a new form of decision making with respect to environmental conflict that incorporates both governments and interests groups; *building consensus through collaborative problem solving*.

Such a dual process helps to account for the range of factors, psychological and emotional, that constitute an individual’s decision making mechanism (Svenson, 1996; Slovic, 1996; Kunreuther and Slovic, 1996; Einhorn and Hogarth, 1991; Arrow, 1951; deNeufville, 1991; Apostolakis, 1990; McAllister, 1982; Stone, 1996).

Although science intensive disputes must not sacrifice technical integrity in order to reach agreement amongst the participants; the agency should not presuppose that the stakeholders are incapable of technical comprehension and thereby sacrifice the fairness or legitimacy of the process. Previous agency decisions, such as the infamous case at Yucca Mountain fail because of numerous pressures from interest groups, concerning social, technical and political issues (Schaefer-Frechette, 1996). Perhaps if such a deliberative process had been initiated regarding Yucca Mountain, and the process had been fair and open to the affected parties from the start, there is a greater likelihood that the decision for a permanent or temporary waste repository would not still be in its present controversial evaluation state.<sup>10</sup>

Consensual approaches permit a forum for interactive learning, risk communication, and representation and have evolved on the premise that early involvement of the stakeholders in the decision making process will minimize the problems and delays traditionally experienced when the stakeholders have been neglected in the process (Ashford, 1991; 1997).

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<sup>10</sup> Additional examples of successes and failures are found in Susskind and Cruikshank, 1987, NRC, 1996; Presidential Commission, 1997

## 5.2 Goals of Deliberation: Fairness vs. Efficiency

Despite nominal differences, analytical-deliberative process and the consensus building process aim to open the “black boxes” of prior decision making policies of governmental agencies (Susskind and Ozawa, 1989; Ozawa, 1991), bringing together the multiple parties to discuss the pertinent issues in order to reach an implementable solution that addresses the interests of the affected parties. Consensus building, negotiations, deliberations and other forms of alternative dispute resolution techniques have evolved in hopes of achieving a long term sustainable decision that does not result in delays, litigation, cost overruns and the other detrimental factors that may be associated with opposition (Bercovitch, 1996).

Although legislation and mandates from congress as well as the agencies themselves call for this early involvement of the stakeholders, there are challenges to balancing the interests of the stakeholders and the technical necessities of the problem. The deliberation must be fair and efficient; two concepts which are often thought to be at odds with one another, however, they are also interdependent. Efficiency can influence fairness - for example through a prioritization of the important concerns of the stakeholders, equal opportunity for participation; And fairness can influence efficiency - a fair process may be more efficient in the long run, as it is less likely to create opposition if the affected parties are actually those responsible for the decision.

Similarly, fairness and efficiency coincide with wisdom. As they are inherently linked, a fair process which offers the stakeholders an equal opportunity to participate in a meaningful fashion will initiate communication and joint-problem solving practices, such as those needed in addressing the multidimensionality of risk, so that the stakeholders not only define the problem and assessment methods, but also work together to find a solution (Slovic, 1996). Fairness, furthermore, implies that all of the stakeholders have equal access to resources and technical data pertinent to the decision (Susskind and Field, 1996; Laws, 1996). Again, ensuring equal access to this data has been a stated problem of risk assessment in the past (Jasanoff, 1993, Susskind and Field, 1996).

As the agency strives to be fair in the process, it must also be efficient. Environmental decisions concern objectives that if not reached in a timely manner, can result in poor implementation plans, excess costs to the public, increase hazards, and in the extreme cases, undue deaths or injuries to both the ecological and human environment. Technical efficiency is also a concern. The decision must be feasible - the technology must be available, accessible, and financially possible (DOE, 1997, 1995). It must also adequately address the immediate and long term risks of the problem, both elements that are often perceived differently by the stakeholders. In this regard, early involvement of the stakeholders can contribute to the correct definition of the risks and assessment methods as well. The assistance of outside "experts" is often needed in such a decision process, in order to provide the technical data and ensure feasibility of the methods and technologies. This thus requires that the "experts" are able to convey the technical data and risk impacts to the stakeholders, while simultaneously incorporating the stakeholders inputs into the actual assessment methods used. Again, this is an iterative and on-going process, where the stakeholders must work together to define the problem, while recognizing some of the technical limitations. This definition is then utilized by the analysts in the risk assessments. Each component of the process, as they are interrelated must be improved in order that the entire quality of the decision making process is elevated and sustainable; simply focusing on one component in the abstract, will only yield a temporary or narrow improvement.

Addressing the intersection of fairness, wisdom, and efficiency, the numerous perspectives of the stakeholders can raise an infinite amount of questions: How do we decide which technology is "best"? and "best" for whom? An environmentally wise decision can be defined in countless ways. If we were to take the perspective of an environmentalist, we may say that an environmentally wise decision is one which does not change any part of the eco-system (Leopold, 1945); whereas, an economist may say that an environmentally sound decision is one in which the financial benefits of development outweigh no action and therefore development of a local park must proceed. If we were to enter the environmental ethics debate here no solution would be reached, and as such define a wise solution to be one in which the technical and social considerations are evaluated in a logical

fashion with the necessary framework to be flexible, and still provide sound support and justification for the decisions made.

“A dispute resolution process open to continuous modification by the disputants is... the approach most likely to be perceived as fair (Susskind and Cruikshank, 1987, p21).” The stakeholders themselves need to feel a part of the process. Susskind and Cruikshank (1987) highlight some of the key questions that provide an indication of such a process:

1. Was the offer to participate genuine, and were all the stakeholders given a chance to be involved?
2. Were the opportunities provided for systematic review and improvement of the decision process in response to concerns of the stakeholders?
3. The process perceived as legitimate after it ended, as well as when it began? Did anyone feel taken advantage of as a result of the negotiation?
4. Was a “good” precedent set?<sup>11</sup>
5. Were the participants responsible? Was there a sense of accountability established on the part of all participants?

### *5.2.1 The Role of the Agency*

With respect to agency decision making, the responsibility for the ultimate decision often remains with the agency and thus requires the agency to organize the stakeholder involvement and decision making process. Questions have been raised as to whether or not the process is truly fair, if in fact the stakeholders involved are only deciding on what to recommend to the DOE; the process will be fair so long as this responsibility and the context of the decision is clarified with the stakeholders at the start of the process. If the stakeholders operate off the wrong assumptions and feel that their work and problem solving effort is to be the final decision, when in fact it is a recommendation, further opposition and mistrust may follow.

The deliberation needs to focus on the issues and tradeoffs relevant to the decision; disagreements over values have a tendency to consume multi-stakeholder decisions and yet the decision to be made should not try to appease each stakeholder's system of values, but rather, by addressing the interests of the stakeholders, reach a settlement which is acceptable to all the stakeholders.

By moving towards a consensual deliberation, the responsibility of understanding is not solely on the shoulders of the public or agency; it becomes the responsibility of each stakeholder to try to understand and communicate in an understandable fashion the factors, alternatives, consequences of the decision as they perceive them. Deliberation is a learning process which can be employed to explicate the constraints and communicate the risks (Daniels, 1996). From which the product, is a resolution that sufficiently addresses the interests and elements, and ideally commitments from the stakeholders to follow through on the resolution - one which is efficient, fair, and wise.

These are the broader reaching goals into which are incorporated standards expressed by both the Department of Energy and the National Research Council. Those requirements being that the decision is technically feasible, economically feasible, environmentally sound, health and safety conscious, attune to public concerns and values, fair and just.

### **5.3 Challenges in Multi-stakeholder Deliberation**

In the quest for democratic decision making, a multiple stakeholder decision making process, can be time consuming and open the door to otherwise hidden controversies. The greater the number of stakeholders involved in the process, the longer it will take to select and organize those parties. Furthermore, the more interpersonal conflicts that are likely to erupt in the deliberation phase. Individual vested interests do not always coincide, even though stakeholders may be able to agree upon a common set of objectives, it is unlikely that they will immediately agree on a method through which to meet those objectives. By opening the process, the agency must be able to contend with these issues, however it is better that they are dealt with openly and upfront rather than after the decision to act or not to act has been made.

Anytime a number of stakeholders come together in a negotiation process, conflicts and disagreements are likely to arise. One of caution in utilizing negotiation in order to smooth out the differences amongst the multiple stakeholders is that often the technical issues fall to the wayside, or remain solely the responsibility of the “experts” and therefore such a negotiation, while smoothing out the conflicts, does little in terms of improving the risk assessment or securing a technically and economically feasible solution (Hyman, Bacow and Wheeler, 1984). Furthermore, Crowfoot(1990) points to the need for appropriate representation depending on the type of negotiation, for example, a scientist representative from a stakeholding organization may not be comfortable with an entirely political processes of negotiation. This example also substantiates the claim that in some negotiations, vital technical issues can fall to the wayside.

Another criticism of negotiation is that it creates incentive for parties to portray the other’s interest as negatively as possible, consequently contributing to the conflict(Dimento, 1986). Thus, there is a need to bring together these two seemingly conflicting approaches to environmental decision making; there is a need to focus on both the substance of the decision as well as the process through which resolution is reached.

When employing such decision aids as influence diagrams (Hong and Apostolakis, 1993),

Further issues include:

- *Risk and perception:* communication and definition of technical issues including: the amount of information presented to the stakeholders, the timing of the introduction of that information, the areas of risk characterization on which to elicit feedback and input and, the defining of the risks.
- *Alliances that form between the stakeholders.* If the stakeholders are involved in an ongoing process, often teaming between the stakeholders can result. While this may appear beneficial in reaching an initial agreement, it can result in ill-feeling or controversy in the long run if one of the stakeholders regrets the alliance that formed. He or she may feel that the alliance caused a reversal, or transformation of the original



intended stance. It may also result in problems if the stakeholder is a representative of a larger organization.

- *Building Expectations* (Ashford, 1997) When stakeholders are involved in an agency decision process, it has been shown that their expectations may rise concerning the degree to which their input will be utilized by the agency. Similarly, the stakeholders must also realize their commitment. The agency has certain expectations on the stakeholders which should be made clear to the stakeholders. The agency needs to be clear as to how much responsibility it can yield to the stakeholder.
- *Exclusion of relevant stakeholders.* In the stakeholder selection process, it is difficult to decide which stakeholders ought to participate, specially if the decision model is of the Working Group<sup>12</sup> nature. When the agency opens the process to the stakeholders, it is necessary to determine, how many stakeholders are to be involved, the method of that involvement and the time frame within which a decision must be made.
- *Time.* As the stakeholder deliberation becomes more intense, the process could continue indefinitely if strict guidelines are not defined upfront. Both the stakeholders and the agency need to plan. While reaching consensus is the goal of the process, it must be achieved in a time efficient fashion. Stakeholders will loose interest and forgo their responsibility if the process drags on too long, and will continue to harbor discontentment with the process.
- *Access to resources.* The involved parties all need equal access to the relevant information. This raises questions concerning how much information about the site the agency ought to provide to the stakeholders about the site in question, and how much the stakeholders should be responsible for investigating the site on their own accord(Susskind and Field, 1996).<sup>13</sup>
- *Defining consensus.* What is the form of the recommendation? What determines consensus? These questions challenge both the stakeholders and the agency and should be address early and explicitly (Susskind and Cruikshank, 1987).

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<sup>12</sup> Working group is a representative group of stakeholders who represent the public.

<sup>13</sup> In this project, some analysts took the view that the stakeholders should be responsible for investigating various aspects of the site and that they should maintain their own running memory of the preceding presentations.

When embarking on a deliberation, from the perspective of the agency which is trying to bring together the multiple stakeholders, these issues, stakeholders relationships, building expectations, stakeholder selection, time, stakeholders interests/accountability , access to resources need to be addressed. Other issues include the analysis method used, the perspective of the scientists, the underlying assumptions in the evaluations, the inherent uncertainty in the parameters being evaluated as well as in the model and the communication of this uncertainty.

## **5.4 Deliberation Design**

### *5.4.1 Forms of Deliberation*

Depending on the structure of the decision-making process, there are a range of alternative forms of deliberation which the responsible agency may choose from to convene a deliberation: alternative dispute resolution, consensus building techniques, working groups or public meetings (Crowfoot, 1990; Gardner, 199 --,; Constantino, 1996). We look specifically at a type of consensual deliberation. Typically, such deliberations may be either assisted or unassisted. There may be times when a group of stakeholders decide amongst themselves to come together to try to resolve a problem and feel that they can proceed without the involvement of a third party; however, when the decision problem fall under the umbrella of agency decision making, the process is most likely to be mediated by a third party.

Unassisted negotiations occur when the disagreeing parties agree to come together for the purpose of reaching an agreement. A negotiation in the strict sense of the term, is a process by which the disputing parties come together to reach an agreement, without the aide of a third party. In the narrow context of local environmental decisions, it would be difficult to employ such a technique given the diversity of interests and range of stakeholders involved. In an unassisted negotiation, the participants choose to be involved, and would not be involved if they felt that they could do better without a negotiation. A successful negotiation is contingent on this incentive. Negotiation researchers refer to this term as BATNA (Best Alternative To a Negotiated Agreement) (Fisher et al: 1981). Each party, to participate in the negotiation feels the outcome it can achieve will succeed its BATNA.

This, as in all interactions, has much to do with the perceptions of the participants, which is inter-linked with their risk profile, as discussed in Chapter 3. An individual who is risk adverse may assess his/her personal BATNA to the lowest acceptable outcome, while an individual who is risk seeking assess the maximum expected gains of a complete win (Fisher, 1981; Susskind, 1987). Once the stakeholders have agreed to come to the table they must then proceed to determine the negotiation methods, goals and groundrules. Unassisted negotiations can in fact incorporate technical data into the process, yet when the decision is that of an agency, it is unlikely that the stakeholders will come together to make a unified recommendation to the DOE on a pressing issues; although, groups of stakeholders may unite to prompt the agency to action.

Assisted negotiations similarly require the agreement of the parties to come together for the purpose of reaching an agreement. Once this has been agreed upon, the next step is the determination of the type of assistance to be employed. The literature draws distinctions between the kinds of third party intervention, and even within these general classifications, the definitions vary. The hypothesis we explore here is that deliberations which involve multiple stakeholders and risk assessments require third party intervention of a mediator who is familiar with the technical and social aspects of the problem, so that he/she can guide the deliberation, ensuring that it meets both the fairness and efficiency criteria. In regards to assisted negotiations, facilitation, mediation and non-binding arbitration differ in the proportion of responsibility assigned to the intervenor (Susskind, 1987; Moore, 1986).

Facilitation is the simplest form of assisted negotiation. The role of the facilitator is primarily to ensure that the agreed upon process is followed. The role of a facilitator is to assist the parties from a neutral and detached position. The facilitator acts in many ways as a moderator, time keeper and over all assistant to the parties involved. The facilitator does not offer proposals or strategies but tries to keep the participants focused and communicating. The facilitator is a person(s) who all parties agree on. "The facilitator is a skilled manager and takes whatever procedural steps that are necessary to keep discussion on a useful course (Susskind, 1987:p157)."

## Mediation

Some authors have equated mediation and facilitation, however, we feel it is necessary here given the complexity of scientific/risk laden disputes to make the distinction between the two. Mediation is “the intervention into a dispute or negotiation by an acceptable, impartial and neutral third party, who has no authoritative decision making power to assist disputing parties in voluntarily reaching their own mutually acceptable settlement...the mediator works to reconcile competing interests of the parties(Moore:13, 1986).” Mediation has been employed in decision situations in the policy arena concerning such issues as power plant siting, and dam construction. Mediation provides a framework through which the technical complexities involved in environmental decisions can be explained while simultaneously providing a mechanisms for integrating both the substance and process goals of the decision situation. The role of the mediator in deliberation is more interactive than that of a facilitator. Again, as in facilitation, the parties should agree on the mediator; however depending on the circumstances of the deliberation, or structure of the stakeholder involvement process, a direct selection process may not be possible, especially in regards to the current policy making structure and willingness of the agency to relinquish such control. The mediator helps to bring the interests of the parties and possible options to the bargaining table. The mediator remains neutral and yet strategizes and helps the parties understand what is tradable. The mediator guides the participants through joint problem solving, substantiating arguments with available facts. The mediator must therefore be well aware of the issues and interdependencies in the problem at hand.

Non-binding Arbitration is a method which more closely resembles that of a judiciary process, however is one that does not commit the participants to the outcome and is therefore not in the realm of our concerns.

### *5.4.2 Deliberation Design*

The deliberation in this project has goals of both a substantive and process-oriented nature. Substantive, in that, a recommendation is to be made which addresses the needs

of remediation; i.e., an actual written agreement regarding the remediation will be produced (Susskind and Cruikshank, 1987). Process-oriented refers to the manner, fair and efficient, in which the recommendation is achieved. We, the mediation team, want to ensure both fairness and efficiency. We are acting as the mediation group and thus present the design of strategies and deliberation framework from that perspective. Our goal is to help the stakeholders reach a recommendation concerning the remediation of the Chemical Waste Landfill<sup>14</sup>, we therefore focus on developing strategies from the integration of the previous three stakeholder meetings that will aid the mediator in guiding the deliberation and focusing it on the interests of the stakeholders while also addressing the issues discussed in Section 5.3. The preparation for this consensual deliberation began at the very first meeting with the stakeholders when they provided their preferences and constructed the influence diagrams. In designing the deliberation, *we stress that we anticipate the creation of alternatives and that we therefore prepare for a flexible discussion which is not cemented to the quantitative results. We present here an overview of our deliberation design and describe the strategies developed to help prioritize and focus the discussion.*

#### *5.4.2.1 Overview of the deliberation*

The consensual deliberation - the culmination of an on-going iterative process<sup>15</sup> - involves three main steps: pre-deliberation, deliberation and post-deliberation. The pre-deliberation phase is the preparation phase, where the mediation team prepares a tentative agenda, a set of groundrules, and a description of roles and potential goals of the process. Depending on the circumstance the detail of each of these varies, however in all cases the final discussion and definitions are those of the stakeholders. The mediation team defines these only as a starting point for the stakeholders and should take caution in doing so to remain flexible when facilitating the discussion.

The next step in pre-deliberation is to propose/devise possible strategies to aid the stakeholders in reaching a resolution. These strategies are drawn from the quantitative

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<sup>14</sup> The reader is reminded that this a prototype decision situation.

assessment, the integration equation 4.1, of the stakeholder interests and ranking of the alternatives for each stakeholder. It is also to prepare any pre-deliberation material necessary for the stakeholders so that they have adequate time to consult the mediator beforehand in regards to their ranking. We stress the need to reassure the stakeholders that the rankings are used only as a guideline for deliberation to determine the major contributors and potential tradeoffs necessary for selecting/creating an alternative.

Once these strategies are devised and the pre-deliberation material distributed to the stakeholders, the mediator must then consult with the analysts so that the analysts are prepared for and aware of the potential questions that may arise in the deliberation.

The deliberation itself begins with a discussion of the roles, groundrules and goals. Before preceding with the deliberation on the remediation technologies, the stakeholders reach a consensus on these three elements. Upon agreement, the deliberation ensues regarding the site in question.

#### *5.4.2.2 Tentative Goals and groundrules of deliberation*

To begin any type of deliberation the goals, groundrules and the roles of the participants must be established and acknowledged by the parties involved. The draft groundrules and goals were established based on stakeholder concerns and interviews, as well as theoretical insights (Susskind and Cruikshank, 1987; Ury and Fisher, 1981; Doyle, 1976; EnDispute, Inc., 1996). In order to clarify the objectives, a set of process goals, as well as a set of substance goals, were defined and presented for discussion. Since the deliberative process had begun from the initial problem definition (i.e. the first meeting with the stakeholders and the analysts), and since there is no single, adequate mathematical model for decision making involving several stakeholders, which captures the complexity of the problem, or provides an implementable solution, a interactive deliberation is required. It supports a systematic traceable and defensible decision making method.

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<sup>15</sup> The deliberation is the culmination of 3 previous stakeholder meetings in which preference data concerning the objectives were elicited.

The result of deliberation, what the stakeholders and agency expect to get out of the process, should be clarified and succinctly stated (Stone, 1996). Both the process of the deliberation and the final form of the written agreement ought to be established by the stakeholders. In order to guide the deliberation, we prepared a set of questions

- Do we wish to have multiple levels of consensus?
- Should we recommend one alternative by voting?
- Should we recommend a combination of alternatives?
- Should recommend an alternative most acceptable to all stakeholders?
- Should we recommend against some RAAs?

In our effort to establish accountability of all participants, we hypothesized that interaction and communication amongst the participants is an integral component of achieving this accountability and that a preliminary, explicit discussion of the process goals should accompany the setting of the agenda (Susskind and Cruikshank, 1987; Moore, 1986; Fisher and Ury, 1987). The possible process goals that were presented to the stakeholders as suggestions, are shown in the figure below.

*Fairness:* It is a process for and by the stakeholders;  
perceived fairness depends upon participation.

*Wisdom:* A process which is time efficient including all  
available evidence and technical results.

*Stability and efficiency:* A process whose outcome is  
feasible and has been arrived at through exchanges  
that benefit all parties to some extent and penalize  
none.

The background from which these goals are arrived can be found in a number of readings on legitimacy, democracy and consensus building (Susskind and Cruikshank, 1987; Susskind and Field, 1996; NRC, 1994; NRC, 1996).

### *5.4.2.3 Roles of Participants*

Beyond the process and substance goals of the deliberation are the roles of the participants. What are the guidelines for involvement and interaction between the participants? How is accountability achieved? As discussed earlier, building responsibility and accountability of all the participants is a difficult and intricate challenge. If a person does not feel part of the decision, he/she is less likely to be accountable for that decision. In respect to elements of risk characterization, familiarity and framing of the risk are improved by involving the stakeholders (Sandman, 1987). Thus, defining and clarifying the roles with the stakeholders, can help to ensure participation.

“A mediator or neutral convenor may be able to set up a process that translates these concerns into practical terms and may help manage it in a way that makes the guarantees effective and believable. (Laws, 66, 1996)” The role of the mediator should be defined and acknowledged by the stakeholders, which will help to ensure trust, respect and accountability - all factors essential in establishing a fair process (Ashford, 1991). As Sandman(1987) notes, the public is more comfortable and the process of communication more successful when they have actually defined and created the process. This is echoed by Laws(1996) in his discussion of fairness.

Although all the stakeholders had agreed to participate in the decision making process from the start, it was not always possible to ensure attendance at every meeting over the eight month process. How can we, as the mediators of the process, help to develop incentives and a sense of commitment? Determining the exact practices that lead an individual to accept responsibility for the decision has been explored by numerous psychologists, however in regards to this project, we propose to clarify the roles, thus making explicit the responsibilities of all those involved; the purpose is to develop a greater sense of accountability and actual stake in the decision, which leads to a more sustainable decision. In *Getting to Yes*, Fisher and Ury (1981) note that the substantive issues “need to be disentangled from the relationship and process elements,” highlighting the relationship issues to be: balance of emotion and reason, ease of communication, degree of trust and reliability, attitude of acceptance, relative emphasis on persuasion, and degree of mutual understanding. These issues are identical to those raised in the communication and



characterization of risks (Slovic, 1990, 1996; Kunreuther and Slovic, 1996; Fischhoff, 1990; Ahearne, 1987). This leads us to believe that the role and understanding of the role and position of each participant, be it the agency or the local realtor, are important contributors to the establishment of trust and respect: two elements proven to be characteristics of successful decisions (Ashford, 1996).

In light of these issues, we proposed the following role definitions for discussion amongst the stakeholders, at which time the stakeholders were able to amend, alter, or delete them as they found necessary:

#### Role of the stakeholders

- Influence the decision maker's choice
- Communicate concerns, interests, and ideas
- Listen actively

#### Role of the Analysts

- Provide clarification on technical questions
- Provide technical data on the impacts of each RAA

#### Role of the Mediators

- Coordinate agenda
- Guide deliberation
- Promote understanding of all viewpoints
- Facilitate discussion
- Promote a fair, wise and efficient process
- Identify major reasons for agreement and disagreement

#### *5.4.2.4 Role of the Responsible Agency*

In this project, under DOE's current decision making model, the agency will not relinquish its responsibility for the final decision and thus the stakeholders' input will not be considered as the final action item, but rather as a recommendation to DOE. In regards to

DOE's position and increased reliance on multiple stakeholder participation in the decision making process, DOE is more likely to give greater weight to a recommendation made through a legitimate process in which the affected and interested stakeholders reach a feasible and efficient recommendation. Therefore, the DOE, in future stakeholder involvement practices, would be well-served to be explicit about its own responsibility and constraints.

In stating that stakeholder involvement is necessary for successful decisions, it must be prepared to define what is meant by *stakeholders*, *involvement*, and *success*, otherwise it faces possible conflicts later on. The result of deliberation, what the stakeholders and agency expect to get out of the process, should be clarified and succinctly stated (Stone, 1996). The stakeholders need to be aware of where they stand in the agency's decision process.

#### *5.4.3 Tentative Conclusions*

Drawing on the risk integration, Table 4.2, we draw tentative conclusions beginning with those areas most likely to achieve the greatest consensus. These conclusions aim at drawing out the interests of the stakeholders as they relate to the RAAs and prioritizing their importance so that a meaningful and effective discussion may ensue. Systematically, we refer to the Table 5.2, using the following questions as a guideline:

- What are the possible options for reducing risk?
- How effective are these options?
- How desirable are these options?

These questions are derived from risk assessment and management techniques that aid in the development of management strategies; strategies which parallel the types of flexibility and management needed in a multiple stakeholder deliberation (Moosung et al., 1993).

To prepare the mediator to guide the discussion, propose alternatives, and read cues from the participants (Moore, 1986; Riskin, 1990), we developed the proposals shown in Table 5.4.2 to present in the deliberation; in addition, we prepared alternative proposals and substantiating documentation to be used depending on which way the discussion with the

stakeholders turned. A mediator must be able to guide an ad hoc process, as the directions of human discussions can not be, and are not, planned.

#### *5.4.3.1 Devising Conclusions*

In devising the potential options to be used through the deliberation as proposals the stakeholders may decide to recommend to DOE, we begin with those proposals which seemed to have the broadest level of consensus amongst the stakeholders. Looking at both positive and negative proposals, i.e. in favor of or disapproval of an RAA, we hypothesized that by beginning the deliberation with the points of agreement amongst the stakeholders, followed by a substantive explanation of the causes, that we could not only contribute to the development of mutual cooperation, but also achieve greater consensus; thereby keeping the group moving towards a point of agreement without becoming entangled in a needless net of destructive arguments (Doyle, 1976).

In order to draw tentative conclusions, we proceed to analyze the components of the rankings, examining why each stakeholder ranked the RAAs as he or she does. To this end, we examined the Major Contributor Analyses, as described in Chapter 4, for each stakeholder, which provides us with substantial information concerning the most important contributors to each stakeholder ranking. Comparing the utility across the RAAs for a given stakeholder, an initial list of tradeoffs is made and then substantiated with a corresponding sensitivity analysis, the results of which are found in Appendix 2. These analyses provided the necessary support to be used in deliberation so that the discussion, while flexible, could maintain a focus on the key issues of stakeholder concern.

Proposal	Reasons For	Reasons Against
1. A is the least preferred alternative	<ul style="list-style-type: none"> <li>• Both worker and short-term public health risks are high due to airborne Cr particulates released</li> <li>• All stakeholders put a strong value on worker health risks</li> <li>• Highest completion costs</li> <li>• Five stakeholders rank it #6; one stakeholder ranks it as #5</li> </ul>	
2. C is neither strongly disliked nor liked by stakeholders	<ul style="list-style-type: none"> <li>• Smaller worker risks</li> <li>• Some impact on local economy</li> <li>• Less transported wastes</li> <li>• Removes some of the contaminant</li> </ul>	<p>High completion costs vs. B</p> <p>C results in greater short term public cancer risk</p> <p>C results in a lower impact on local economy</p>
3. D is less preferred than C by all except possibly one SH	<ul style="list-style-type: none"> <li>• All stakeholders put a high weight on worker health risk</li> <li>• Off-site treatment</li> <li>• More transported wastes</li> <li>• More worker health risks</li> </ul>	
4. F is a candidate to be the “preferred” alternative	<ul style="list-style-type: none"> <li>• Avoids risks to workers</li> <li>• WHR is weighted strongly by all SH</li> <li>• Low cost</li> </ul>	<ul style="list-style-type: none"> <li>• Leaves the contaminant in the ground</li> <li>• greater long term public health risk</li> <li>• No cost and therefore no impact on local economy</li> </ul>
5. E is a candidate to be recommended	<ul style="list-style-type: none"> <li>• Removes all of the contaminant</li> <li>• Low long term public cancer risk</li> <li>• Impact on the local economy</li> </ul>	<ul style="list-style-type: none"> <li>• High Worker Health Risks</li> <li>• Requires a lot of workers</li> <li>• Large amounts of transported wastes</li> <li>• High implementation costs</li> </ul>
6. F and E are the two preferred options	<p><u>Reasons for E</u></p> <ul style="list-style-type: none"> <li>• Long term public</li> <li>• Impact on local economy</li> <li>• Removal of contaminant</li> </ul> <p><u>Reasons for F</u></p> <ul style="list-style-type: none"> <li>• Worker injuries and fatalities</li> <li>• Costs</li> <li>• Wastes generated</li> <li>• Preferred by most stakeholders</li> </ul>	<p><u>Reasons against E</u></p> <ul style="list-style-type: none"> <li>• Worker injuries and fatalities</li> <li>• Implementation costs</li> <li>• Wastes generated</li> <li>• Lowest ranked for one stakeholder</li> </ul> <p><u>Reasons against F</u></p> <ul style="list-style-type: none"> <li>• Long term public</li> <li>• Impact on local economy</li> <li>• Removal of contaminant</li> </ul>

Table 5.4.2: Tentative Conclusions for Deliberation

The first proposal stems from the apparent fact that all the stakeholders feel least preference for RAA A. This observation may prove useful, if we can determine what the causes are that lead them to dislike RAA A; the values of the stakeholders may differ yet the underlying characteristics of the technology may cause a similar manifestation of these values in the overall ranking of the technology. The technology employed in this RAA leads to the highest risk to worker health of all the alternatives which have been evaluated. An analysis of the performance measures driving this preference indicates that risk of worker fatalities and implementation costs are of primary concern for most stakeholders. In particular, all stakeholders place a large weight on the objective category of worker health risk, and in this regard, technology A has the worst performance. From this analysis, the proposal is thought to be one in which a consensus could be reached.

Advancing from the most agreed upon proposal, proposal 2 has both pros and cons in relation to its acceptance by the stakeholders. RAA C is ranked average by all stakeholders. Although there are lower worker health risks and less transported wastes, if it were to be implemented the tradeoff made would result in greater short term public cancer risk and a lower impact on the local economy. The greater short term cancer risks are a result of the release of TCE during the thermal desorption process as well as the vapor release of Cr and TCE during excavation and handling.<sup>16</sup>

The third proposal, D is less preferred than C by all except possibly one stakeholder, introduces the discussion of uncertainty. This proposal is directly from the integrated ranking and does not try to presuppose or group the stakeholders, therefore necessitating the discussion of uncertainty. The primary drivers which indicate that D is less preferred than C are that the stakeholders put a high weight on WHR, which is adversely affected by the excavation involved in the technology of alternative D, and the fact that D has larger amounts of transported wastes since the stabilized media containing Cr will be shipped off-site. As indicated by the influence diagrams, this transportation also impacts costs and worker health and safety.

The fourth proposal, F is a candidate to be the “preferred” alternative, is a stretch to see if the stakeholders may agree on one alternative which they all seem to prefer highly, yet two of the stakeholders do not rank it first. Furthermore, it is the “no action” alternative, which for the sole fact that nothing will be done, may raise some controversy for reasons that are hidden to any qualitative or quantitative preliminary discussions. Additionally, one stakeholder’s strong aversion towards long term public cancer risk caused RAA F to be ranked fifth. As mediators of the deliberation, we remained conscious of this and therefore did not expect complete agreement on this proposal, but rather opted to present it as a starting point of a discussion that may serve to draw out a more in depth discussion of the tradeoffs involved and the alternatives that could perhaps be generated.

The last two alternatives serve as supplementary proposals to be used if deemed appropriate by the mediator. We do not wish to constrain the deliberation by holding fast to the presentation of all our analyses. Two stakeholders seem to prefer alternative E. One of these has a second preference for the “no action” alternative, F; the other ranks B as second. The main reasons for these stakeholders to support option E seem to be the low completion cost, the high efficiency of contaminant removal and the low risk of long term cancer.

#### *5.4.3.2 Stakeholder Specific Conclusions*

From the analysis, we derived reasons for each stakeholders’ ranking, they are summarized in Table 5.4.3 and the results of the sensitivity studies are presented in Appendix 2. These analyses substantiate the conclusions shown in Table 5.4.2 and provide reasons for the stakeholder specific tradeoffs in order to steer the deliberation towards a recommendation, providing logical reasons founded in the values and technological alternatives available to aid the deliberation.

Stakeholder 2	Stakeholder 3	Stakeholder 4
<p><b>RAA F is preferred</b></p> <ul style="list-style-type: none"> <li>No short term public accident</li> <li>Strong concern for public health</li> </ul> <p><b>RAA E performs worse than RAA F</b></p> <ul style="list-style-type: none"> <li>E has more transported wastes</li> <li>lower performance on implementation costs, due to the number of workers and trucks involved</li> <li>E is better than F in removal of contaminant yet poor performance in short term health due to transportation of waste</li> </ul> <p><b>RAA B is similar to E in preference</b></p> <ul style="list-style-type: none"> <li>B is on-site and thus lower costs and less transported waste</li> <li>B has higher long term public risk of cancer</li> </ul> <p><b>RAA C and D are less preferred</b></p> <ul style="list-style-type: none"> <li>higher completion cost due to technology (thermal desorption) and the cost of the disposal of the treatment of the residuals.</li> </ul> <p><b>D transports wastes off-site which leads to higher costs</b></p> <ul style="list-style-type: none"> <li>RAA A is least preferred</li> <li>Poor performance under worker and public health risks</li> <li>High completion cost.</li> </ul>	<p><b>RAA F is slightly preferred over the other RAAs</b></p> <ul style="list-style-type: none"> <li>No worker injuries unlike the other RAAs yet leaves the contaminant in the ground</li> <li>Transportation of waste is the performance measure which adversely affects the other RAAs in comparison to F</li> </ul> <p><b>RAA C and RAA D perform closely with RAA F</b></p> <ul style="list-style-type: none"> <li>The tradeoff here is that they remove the contaminant which counteracts their poor performance in regards to worker health</li> </ul> <p><b>RAA B is average</b></p> <ul style="list-style-type: none"> <li>B performs worse than C and D in contaminant removal since the contaminant remains on site</li> <li>B has a lower Completion Cost than C and D</li> </ul> <p><b>RAA E is less preferred</b></p> <ul style="list-style-type: none"> <li>High Implementation Cost</li> <li>Significant ER and Transported Waste compared to C and D</li> <li>Higher volume of transported waste, therefore E is more costly</li> </ul> <p><b>RAA A gives substantially lower performance</b></p> <ul style="list-style-type: none"> <li>In-situ Vitrification which yields high worker health risks</li> </ul> <p>Uncertainty analyses on the performance output of the RAAs show that these preferences are rather stable and that F, D and C are not markedly different.</p>	<p><b>RAA E is preferred</b></p> <ul style="list-style-type: none"> <li>Low completion cost and substantial impact on the local economy</li> <li>Lower long term cancer risk as compared to the next ranked RAA F</li> </ul> <p><b>RAA F performs nearly as well as E</b></p> <ul style="list-style-type: none"> <li>No impact on the local economy</li> <li>High risk of long term cancer</li> <li>Performs better than E in terms of waste transported, implementation costs, and worker health risks</li> </ul> <p><b>RAA C and RAA D are less preferred than E and F</b></p> <ul style="list-style-type: none"> <li>Higher completion cost</li> <li>E performs significantly better in process waste generated</li> <li>D does perform better in the area of ER and transported wastes</li> </ul> <p><b>RAA B is slightly less preferred than D and C</b></p> <ul style="list-style-type: none"> <li>Lower costs and thus lower impact on local economy</li> <li>Performs well in terms of worker injury risk yet has a high long term public cancer risk</li> </ul> <p><b>RAA A is less preferred</b></p> <ul style="list-style-type: none"> <li>In-situ Vitrification which yields high worker health risks</li> </ul> <p>The uncertainty analyses show that these rankings are rather stable.</p>

Table 5.4.3a: Stakeholder Specific Conclusions

Stakeholder 6	Stakeholder 5	Stakeholder 1
<p><b>RAA F is preferred</b></p> <ul style="list-style-type: none"> <li>• Does not generate any waste</li> <li>• Cost-free</li> <li>• Does not employ workers, thus no worker health risks</li> </ul> <p><b>RAA B and RAA C are less preferred than F</b></p> <ul style="list-style-type: none"> <li>• Produce more process waste than F</li> <li>• Perform better than F concerning groundwater contamination</li> <li>• Have significant worker health risks</li> </ul> <p><b>RAA D is less preferred than B and C</b></p> <ul style="list-style-type: none"> <li>• Treatment of residuals occurs off-site, thus greater transportation activity</li> <li>• Poor performance in worker health risks and transported waste</li> </ul> <p><b>RAA A is slightly less preferred than RAA B</b></p> <ul style="list-style-type: none"> <li>• In-situ Vitrification which yields high worker health risks</li> <li>• RAA E is least preferred</li> <li>• Large amounts of transported and ER waste</li> <li>• Higher worker health risks (Transportation has a worker health risk two times higher than that of other RAAs)</li> </ul> <p>Uncertainty analyses on the performance outputs of the RAAs have shown that these preferences are stable and that B and C do not present marked differences in their ranking best.</p>	<p><b>Slight preference for RAA E</b></p> <ul style="list-style-type: none"> <li>• Low completion costs</li> <li>• Over site treatment of contaminant therefore lower long term public health risks</li> </ul> <p><b>RAA B, C, and F are slightly less preferred than E</b></p> <ul style="list-style-type: none"> <li>• Pose significant long term cancer risk as compared to E</li> <li>• Perform better than E in waste management and implementation costs</li> <li>• C is more expensive than F and E yet has a better performance index in long term public cancer risk</li> </ul> <p><b>D is ranked fourth</b></p> <ul style="list-style-type: none"> <li>• Greater transported waste</li> <li>• RAA A is inferior to the other RAAs</li> <li>• Greater long term public cancer risk</li> <li>• High completion cost</li> <li>• Greater worker health risk</li> </ul>	<p><b>RAA F is preferred</b></p> <ul style="list-style-type: none"> <li>• Does not employ workers, no worker health risk</li> <li>• Does not generate waste</li> <li>• Leaves contaminant in the ground</li> </ul> <p><b>RAA C and RAA E are less preferred than RAA F</b></p> <ul style="list-style-type: none"> <li>• B and C have substantial reduction in groundwater contaminant risks</li> <li>• RAA F performs better in Worker health risk</li> <li>• C has higher completion costs</li> <li>• E transports more wastes off-site</li> </ul> <p><b>RAA B is slightly less preferred than C &amp; E</b></p> <ul style="list-style-type: none"> <li>• Yields a higher amount of contaminant in the groundwater</li> </ul> <p><b>RAA D is less preferred than B</b></p> <ul style="list-style-type: none"> <li>• Transports more waste off site</li> <li>• RAA D has a higher completion cost</li> </ul> <p><b>RAA A is inferior to other RAAs</b></p> <ul style="list-style-type: none"> <li>• High completion cost</li> <li>• High worker health risk</li> </ul> <p>Uncertainty analyses on performance output indicates that the rankings of RAA B, C, and F are not significantly different. RAA F and B indicate a lower uncertainty &amp; perhaps less likely to fluctuate in the deliberation. E and A appear stable (quantitatively).  </p>

Table 5.4.3b: Stakeholder Specific Conclusions



#### ***5.4.4 Pre- deliberation material***

We present these results, in written and graphical form to the stakeholders prior to the deliberation. Despite much research on the communication of technical data to the public, there remains no concrete method for ensuring that all stakeholders understand the data presented [Kunreuther and Slovic, 1996; Morgan et al., 1992; Dillon, 1995; Johnson et. Al, 1995]. To best achieve understanding of the data and process, the deliberation allows questions and iterative learning to develop. The graphs and explanations provided are found in the Appendix 2. All stakeholders cannot be expected to fully understand every aspect of the uncertainty analysis, however we maintain that it is vital to the development of trust that they have the opportunity to question and receive all information and analysis results. By making the data available to the stakeholders prior to the deliberation, the stakeholders had the opportunity to read through and cross check the analysis with information they previously received. In this sense, time was available for them to formulate questions and ideas, prior to the group meeting. Similarly, it also prepared the analysts for the deliberation.

### **5.5 Chapter Summary**

In order to achieve fairness and efficiency in a deliberation which aims to integrate multiple stakeholders and risk assessments the key challenges must be addressed. This is accomplished by both a quantitative and qualitative assessments, as well as explicit explanation, definition, and acknowledgment by and amongst the stakeholders of the roles, goals, and groundrules inherent in such a deliberation. It is aided by a mediator, familiar with the participants and issues in the decision, who is able to guide a meaningful discussion, promoting fairness and efficiency in order to reach a recommendation that is technologically feasible and efficient. To this end, we propose the use of integration (Chapter 4) to develop strategies to illuminate tradeoffs, assess the important impacts of the technologies, and promote creative resolutions amongst the stakeholders. The next chapter details the conduct and results of deliberation.



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## CHAPTER 6: DELIBERATION CONDUCT AND RESULTS

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“Men and women have the goals and purposes that are meaningful to them because a biological structure in their needs and satisfactions underlie either directly, or indirectly, their creation of meaning.” Irving Singer, *The Creation of Value*

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Upon completion of the pre-deliberation analysis and preparation, the stakeholders and analysts begin the deliberation. The main goal of deliberation is to reach an agreement amongst the stakeholder concerning the remediation of the site. The analysts are to provide support for the technical questions that arise, and for the process in general. The decision of the recommendation is that of the stakeholders involved.

As Chapter five defines some of the major issues and priorities of a multi-stakeholder deliberation, briefly discussing the associated problems that can arise, chapter six is devoted to the pre-deliberation results; that is, the stakeholders discussion of the goals, groundrules and participant roles.

Section 6.2 deals with the conduct and the results of the deliberation. It reviews the actual discussion that ensued, and the responses of the stakeholders to the integration. It also highlights some of the key moments in the deliberation, and the stakeholders' discussion.

Section 6.4 deals with the deliberation goals and how they were met through the deliberation, elaborating of the substance and process related goals of deliberation. Then in Section 6.5, we expand on the analysis of the risk communication aspect of the deliberation, the various tools of communication that were used in this project and the lessons we can draw from the deliberation. In Section 6.6, we assess the interactions between the various participants and provide some possible reasons and insights into the

relationships that evolve during a deliberation. Relationships and interactions have an interest impact on the decision making process, and should be recognized for their influence. Lastly, Section 6.7 discusses the general conclusions which can be made in respect to the integration and deliberation as they pertain to multi-stakeholder decision making.

## **6.1 Introduction into deliberation**

The deliberation begins with the presentation of the integration results. By presenting the results before the meeting of the group, the individual has the opportunity to formulate questions and review the information in a timely and efficient fashion. Granted, we cannot guarantee that all stakeholders will diligently review the material presented, however, by providing the details, we can guarantee the opportunity to question and the time to carefully think out the information and concerns. The main issues in a multi-stakeholder deliberation revolve around communicating technical data, mitigating on the disagreements that arise, maintaining a fair and efficient process, supporting a meaningful discussion, and addressing the multitude of views, while dealing with hidden objectives that may not be explicit.

## **6.2 Pre-deliberation results**

The deliberative process began six months before this working meeting, when the stakeholders and the analysts discussed the general approach to the development of the overall decision methodology, as well as the underlying assumptions. In order to bring the process full circle, the mediator presented a summation of the methodology used up until the point of consensual deliberation. The stakeholders seemed to understand the presentation and raised relatively few questions.

The first hour of the deliberation focused on reviewing the groundrules, the goals of the deliberation and the roles of the participants. The mediator reviewed the integration process with the stakeholders, allowing for a question and answer period. This served to bring the stakeholders to a point of group understand and comfort, while simultaneously

warming up the deliberation with issues that have been touched on previously. Once all the stakeholders were satisfied with their understanding of the integration, we proceeded to a discussion of the fundamentals of deliberation: the goals, the groundrules and the roles of the participants. As these reasons were similar to those discussed in the initial project definition, there was minimal discussion amongst the group. The stakeholders seemed comfortable and familiar with the reasons for deliberation.

### *6.2.2 Goals and Recommendation Discussion*

The mediator presented the possible goals, concerning what the recommendation should look like and what type of consensus is needed for an action to be included in the recommendation. The product component of deliberation in regards to this project was preliminarily presented to the stakeholders by the Team, as follows:

*Goals of the deliberation:* Identify the major agreements and disagreements concerning the selection of RAAs

*Form of recommendation:* What exactly should the group include in its recommendation to DOE ?

These two components must be addressed before the potential resolutions can be discussed; they address the issue of consensus and what it means for this group of stakeholders. The stakeholders felt strongly that the mediator should not define the form of the recommendation to DOE. They may not have agreed on what that form ought to be yet they clearly agreed that it should be their decision with respect to the goals of the deliberation. One stakeholder in particular expressed concern as to the extent that the stakeholder input would be utilized by the agency. Concerning the substance of the recommendation, the stakeholders did not reach a predetermined conclusion as to what it should include, for instance, the stakeholders did not state at this point that the recommendation should include a singularly agreed upon alternative, but rather that the substance of the recommendation should be such that all stakeholders are satisfied with it. It is not something which can be agreed upon before the discussion. They agreed on the

general structure of the recommendation and a flexible method by which to reach a recommendation which all the stakeholders upon which all can agree.

As the discussion followed, the stakeholders themselves to be creative and collaborative with the information and data presented. The stakeholders were against voting and drawing absolute lines between any of the alternatives, agreeing that “voting” had a major weakness in that it may result in the alienation of some of the stakeholders, and in effect perpetuating the conflicts. One stakeholder offered that the recommendation prioritize the RAAs on which the stakeholders agree. The final agreement on the form of recommendation was that the level of agreement of each point submitted to DOE should be explicit and the stakeholders ought to reach agreement without voting. The fact that no hard and fast rule or definition as to what to recommend was sought permitted a flexibility amongst the group to respond to the facts as they were presented.

The stakeholders felt comfortable with the goals specified. In the initial interviews with the stakeholders, similar concerns had been expressed, so it appeared that the previous three meetings had helped to establish an understanding of these goals amongst the participants. One stakeholder suggested that the following are crucial to the process: shared goals and objectives, necessity of trust, and necessity of respect. An alternative explanation as to why this discussion appeared limited is that the participants were overly familiar with the site and the workings of the group that the process goals were assumed.

### *6.2.3 Roles of the Participants*

To establish a sense of accountability and responsibility for the decision amongst the participants, the roles must be clear and agreed upon. Regarding their role, the stakeholders raised concerns over the metric that might be used to determine whether they themselves adhere to the role throughout the process. For instance, one stakeholder was concerned that he might not actually be able to influence the decision maker’s choice no matter how actively he participated, and therefore worried, “I can’t feel that I have abdicated my role as stakeholder.” Although these proposals were intended to be a baseline from which the discussion of roles could ensue, many of the stakeholders

interpreted our presentation as forcing these roles on them. The communication of suggestions to stakeholders is a delicate process. Trust and understanding of the roles of the participants can help this process. Trust seemed to develop over the iterative process and allowed the mediator to easily elaborate on the presentation of the roles. They were primarily concerned with having time to express their opinions on any and all matters discussed. Early on in the decision making process, the responsibility of the stakeholders should be expressed with the stakeholders in the deliberative sense, in parallel with the discussion of the roles of the other participants.

The stakeholders were in agreement with the roles of the mediator and analysts. The minimal discussion on these roles may be due to the fact that the stakeholders were well acquainted with the mediator and analyst as a result of the iterative meetings, or it may be a function of apathy on the part of the stakeholders. Although the eight month time frame was discussed with the stakeholders at the first meeting, it might not have been internalized by the participants, as the project had originally had eleven stakeholders, however, by the consensual deliberation phase, only six stakeholders were actively participating.

### **6.3 Deliberation Conduct**

Once the pre-deliberation phase was complete, the discussion evolved into a question and learning process aimed towards the goals mutually defined in the pre-deliberation. *Since the stakeholders are responsible for the definition of the goals and rules, their stake in the process is strengthened.* The mediator had the lead role in guiding discussion in an efficient fashion to help the stakeholders reach their goal. Culminating from the iterative process, the consensual deliberation began with the presentation of the assumptions and the results of the integration. The stakeholders were eager to begin and to express their views on the integration and rankings, however, the review of the assumptions was vital in bringing all the participant, including the analysts to the same starting point or, reference frame.

The mediator and the court reporter both spoke up to stress the importance to speak one at a time. The stakeholders stated that they wanted to see the actual descriptions of each of

the RAAs once again. The mediator reiterated the goals of the deliberation and assured the stakeholders that each would have an opportunity to address the integration results and other issues that may arise during deliberation.

### *6.3.1 Review of the Assumptions*

Although a comprehensive review of the assumptions was not planned it flowed from the early discussion in the deliberation that such a review was needed. At the commencement of the deliberation, some of the stakeholders disagreed with the results that had been mailed to them; for example, many immediately took issue with the high ranking of RAA F, “no action,” which, according to the integration analysis, was ranked first by most stakeholders. One of the participants<sup>17</sup> raised the issue that he wanted to see the view graphs that described the RAAs. All of the stakeholders agreed. The analyst responsible for Programmatic Issues presented the slides reviewing the RAAs. Some of the stakeholders spoke out in a disorderly fashion, expressing their concerns:

- “I am very concerned about TCE reaching the groundwater and do not want the “no action” alternative.”
- “‘No action’ is not my preferred option.” This stakeholder went on to imply that she felt that the mediator was attempting to impose his own preference for no action on the stakeholders.

At this point the mediator reassured the participants that each would have the opportunity to review and discuss all the results, stressing the openness of the process. As the review of the RAAs were presented, the following observations and comments were made by one of the analysts:

- We should have qualified the “No Action” alternative to mean “No action beyond the current VCMs.” At the present time, SNL is implementing corrective measures which remove some of the

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<sup>17</sup> Participant is a person who came and listened and participated in some of the sessions yet was unable to participate in the entire process



contaminated soil. The assumption used in the analyses is that the “No Action” alternative occurs after the VCM has been completed. Many of the stakeholders had not realized that the assessments were carried out based on the assumption that the current VCMs were completed. Restating this assumption, helped to clarify the reasons behind the ranking of RAA F as first.

- Did the team pick the right starting point? The analysts inquired into their own methodology of assessment, given this broad misunderstanding of the assumptions.
- What were the baseline assumptions? The stakeholders continued to express a confusion over the basic assumptions of the assessment, despite the fact that these assumptions had been explained at the first meeting.
- Were all the stakeholders starting with the same assumptions in mind? The framing of a situation influences an individual’s perception and subsequent choices in any decision making process, consequently, it is of the utmost concern that in risk laden decisions the stakeholders (decision makers) are operate under the same assumptions.

The participant raised a question directly to the others, “Are you satisfied that these two viewgraphs (those presented by the analyst) are complete enough for us to have a deliberation?” This stakeholder left after the break and did not return. It is difficult to gauge at what point the mediator or intervenor should accept responsibility for the stakeholder’s apparent unwillingness to participate. We can only say that the responsibilities and commitments should be explicit from the start, and reiterated often in a non-dictatorial fashion. This requires that the mediator be well-trained and adept at such tasks.

The answers to the participant’s question, “ Are you satisfied that these two view graphs (those presented by the analysts) are complete enough for us to have a deliberation?” varied; some felt comfortable with the graphs, while others indicated that they needed more explanation. Reiterating the assumptions and elaborating on the graphs through

interactive face-to-face discussion eased the flow of the deliberation which began somewhat sporadically with the stakeholders eager to express their concerns and issues that they had either with the integration methodology or the results. Some of the incipient comments include:

“I am having a tough time separating my two hats” This stakeholder (#6) was referring to her dual positions, one as citizen representative, and second, as an employee of the National Laboratory.

“I don’t want stuff trucked off because that is just as dangerous.”

“I am looking at it from a non scientific perspective and sometimes that is difficult.” This stakeholder (#4) was fairly quiet throughout the entire deliberation.

At one point, when the mediator was discussing the assumptions, one of the stakeholders got up from her seat and handed him a marker, saying, “Write it down!” an indication that some stakeholders need to see things visually.

The assumptions that were written on the flip charts in front of the room as they were reviewed:

- All actions at the CWL are post VCMs
- The first fifteen feet of soil have been removed
- The first fifteen feet have been replaced with clean soil
- Soil vapor extraction is being conducted - 20% of the original amount of TCE remains
- Some of the remaining TCE is still in liquid form
- No TCE has been removed from the groundwater
- On-site disposal refers to CAMU on-site facility<sup>18</sup>
- Off-site disposal refers to a site in the state of Utah
- *Scenario Z1: the closest public receptor is fifty feet away, with residential/agricultural development*

- *Scenario Z2: the closest receptor is three miles away; federal control, and industrial development (This scenario is used as the “No Action” alternative, RAA F)*

Concerning these assumptions, the stakeholders stated that more information and clarification of land use, both present and future, was necessary. One SH (#5), employed at SNL, brought up the fact that, in his work at SNL, the definitions of on-site and off-site differed from those used by TWG, again, stressing the need for consistent clarification and reiteration of the assumptions and definitions. Studies on mediation point out that securing a sufficient “group memory” is important in laying the groundwork for a successful deliberation (Doyle, 1976; Moore, 1981). This can be done for example by utilizing a note taker, involving the stakeholders in an interactive discussion which is collaborative seemed to help group memory in that certain stakeholders were able to better recall certain data from the previous discussions.

The participant representing the National Laboratories, Community Involvement Division brought up the following points for the mediators consideration:

- Clarification between CWL and other sites
- A hypothetical site vs. a real site
- SH values and concerns

The mediator reiterated the aim of the project: to integrate the results of risk assessments into deliberation, raising the question to the stakeholders, “How do we do it without becoming overly technical? We hope that we can become specific and show the main drivers...”

At this point, one stakeholder challenged the mediator. The stakeholder expressed his concern that, “the decision maker does the community a disservice, if they can’t articulate technical information,” and then asked the mediator to restate the concern as he, the mediator, understood it. The mediator, in a calm and neutral fashion, stated, “I think that you don’t want the descriptions to become to technical. You want the analysts to present

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<sup>18</sup> See Appendix 3 on CAMU

the results in an understandable fashion. We have to somehow build a bridge between the technical people and the stakeholders.”

### *6.3.2 Discussion of the Integration Results*

Once the assumptions were clarified, the mediator then began the discussion of the integration results. It was necessary, for the mediator to raise the question of anonymity to the group, rather than proceed with an assumption that the stakeholders would not mind having their identities shown to the group. The stakeholders agreed that the individual rankings could be shown to the group with the corresponding names attached to each graph. Since the stakeholders were been invested in the process from the beginning, this agreement was expected. However, as the decision is theirs and not that of the mediator, the mediator had the responsibility to offer the stakeholders the opportunity to decide on such an issue. These graphs, indicating each stakeholder ranking of the RAAs with the associated uncertainty bars were place on the overhead projector, as the names were inserted. In a systematic fashion, the mediator discussed the integration results with each stakeholder. The overheads which were presented were the culmination of the graphs of each stakeholder had received prior to deliberation, and are shown in Appendix 1. The subject of discussion expanded around the relevant points and the new issues were open for discussion, if so deemed by the group. The analysts and mediator served to support and lend credence to issues that were raised. The integration results provide a trail map, stringing together the most relevant issues.

#### *Details of the Deliberation*

Throughout the deliberation, the stakeholders revised their rankings of the alternatives (Table 6.1a-e), and discussed alternatives. A detailed description of the discussion is presented below in the sequence followed in the actual deliberation.

#### *Stakeholder #4*

Many of the stakeholders voiced their opposition to RAA E, excavation and off-site treatment and disposal, for the reason that it simply would move the problem elsewhere and they did not feel that that would be a responsible alternative (to burden another community). When the first stakeholder(#4) was asked whether the rankings correctly

identified his preferences, he said he was surprised at the high ranking of RAA E. The reasons why he would prefer RAA E were that he had placed a high value on low cost, yet had also placed a significant preference weight on Impact on Local Economy (.04), and as such, seemed to prefer E over F, the “no-action” alternative. Again, the cost of the RAA has a direct correlation with “Impact of Local Economy,” since it was the cost of the technology that would bring more tax revenues to the town (see Appendix 3). In the area of completion costs, the stakeholder preferred F and E. When the stakeholder asked for more detail, we were able to provide him with the reasons from the contributor analysis: Completion Costs, Process Waste Generated and Long-term Public Health Risks. The analysts provided support from their risk assessments, demonstrating for example that RAA E based on the scenario assumptions, had a favorable result in regards to Long Term Public Health Risk, because it excavated and removed all of the contaminated soil. Although the stakeholder agreed with the reasons stated and the representation of his preferences, in the process of discussing the finer details of the RAAs and the external factors, such as the undesirability of simply moving the problem elsewhere, he chose to eliminate RAA E from his top ranking.

<b>Rank</b>	<b>Integrated Ranking</b>	<b>Revised</b>
1	E	E
2	F	C/D
3	C	
4	D	F
5	B	B
6	A	A

*Table 6.1a Stakeholder #4*

*Stakeholder #1*

The next Stakeholder (#1) asserted that she would choose neither E nor F, which had, in fact, been the apparent top two ranked alternatives according to her preference weights and elicited ranges. She was opposed to E, because it would put a lot of people at risk. The analyst confirmed this, which substantiated the stakeholder’s claim in the presence of the group. In accordance with her position in the community, as a Realtor she expressed her concern regarding the contaminant in the as it pertained to the construction of homes on

the site. At this point, the analyst spoke up, reminding the stakeholder of the two scenarios under which the evaluations were conducted. The stakeholder remained committed to her presently expressed preferences, thereby re-ranking alternatives F and E. She, then, had a difficult time discerning between RAAs C and D. And, although the reasons she gave against RAA E are also found in RAA D, she initially maintained that she wanted RAA D ranked first. The analyst spoke up to aide the stakeholder in distinguishing between the various alternatives. She again expressed a strong preference for the removal of the contaminant from the ground. Initially, she wanted all the contaminants out of the ground, yet through group discussion it seemed that she became convinced that Cr did not present the same risks as TCE. It was this preference that caused E to be ranked high in the integration rankings since it removed everything, indiscriminately, from the site; however, the underlying *ethical concern* in regards to transferring the problem of waste remediation to another location *was not* identified through the rankings. She seemed to heed the advice of some of the other stakeholders, as well as of one analyst in particular. The familiarity between the participants enhanced the group understanding and seemed to foster a commitment to one another. Although we were able to explain the primary characteristics of the RAA which the stakeholder's preferences indicated to be detrimental or undesirable, there were some underlying issues that arose during deliberation that were unable to be captured in the quantitative assessment alone, such as the base line criteria of wanting the contaminant removed in its entirety from the site. This issue could only ensue from discussion. Her original preference weights indicated that the Objective Category, "Worker Health Risk" was weighted equally with "Environment"; however, in discussion it seemed that she preferred a lower public health risk - attribute of the "Environment" Category(see Figure 4.1 ID1, Chapter 4 ) over "Worker Health and Safety". This *verbal expression* of her preferences is a *reversal* from her initially elicited preferences.

Rank	Integrated Ranking	Revised
1	F	D
2	E	C
3	C	F
4	B	A or B
5	D	E

<b>Rank</b>	<b>Integrated Ranking</b>	<b>Revised</b>
6	A	

*Table 6.1b Stakeholder #1*

*Stakeholder #2*

The next stakeholder (#2) stated, as she had done consistently throughout the process, that, if she had had access to the risk impacts of each RAA, she would have weighted her preferences differently. “I would have adjusted the weights depending on what the analyses showed.” When asked, however, about the ranking of the alternatives, she stated that it was accurate based on the preferences she had provided previously. She felt that had she known that certain Performance Measures were not discriminating across the alternatives, she would have redistributed her weights. In response, the mediator explained the concept of relative preferences and asked if the remainder of the weight would be distributed evenly across those PMs that were discriminators, and if so, whether this would result in the same calculation. She did go on to reassess her rankings, finding the results shown below. She was the only stakeholder to make use of the on-site analysis capability. It seemed that the access to the actual program used to compute her rankings, and the freedom to vary her inputs in real time authenticated the process while establishing a bridge between the stakeholders and technology.

<b>Rank</b>	<b>Integrated Ranking</b>	<b>Calculated Revision</b>	<b>Revised</b>
1	E	F	E
2	F	E	C/D
3	C	B	
4	D	C	F
5	B	D	B
6	A	A	A

*Table 6.1c Stakeholder #2*

*Stakeholder #6*

The next stakeholder (#6), a representative of the Community Advisory Board (CAB), brought up the issue of risk and the fact that there was a difference between assessed and

public perception of risk. This led to a discussion of the choice of the prototype site, which caused her to feel obliged to act on behalf of the public. "At the Chemical Waste Landfill public perception of the problem is not good; although risks may now be minimal, the long term problem overshadows the issues." She felt that as a member and representative of the CAB, she could not choose the "no action" alternative. "I cannot ignore my role as representative of the public." The mediator asked the stakeholder directly, "Whom are you trying to represent?" She expressed a concern as to her personal understanding of the issues and the fact that they might conflict with the views of the people she was representing. She wanted clarification as to whom she ought to represent in the context of this project. As the Community Advisory Board representative, she was quite frank about the attitude of the public towards DOE. The Department of Energy has made mistakes in the past and is now "paying a price for past sins." In reference to the opposition to a no action alternative, she stated, "I have heard too many opinions against a "no action" alternative, that I put it low." She was referring to the public's demand for some type of action on the part of DOE.

As a member of CAB, this stakeholder was very knowledgeable about the costs and technologies of the RAAs, since she had participated in prior stakeholder involvement activities. She held some very strong opinions about many of the RAAs. Particularly, she did not think that RAA E made sense since it transported the problem elsewhere. The issue of ethics apparent in this concern, especially in light of the recent NIMBY cases (Hamilton, 1996), is somewhat surprising. Other stakeholders also agreed that RAA E was not preferable, since it would not be fair to simply transplant the problem elsewhere. This value was another which was difficult to quantify, yet, through the stakeholders' disagreement with the results of the integration, although admittedly logical, the stakeholders clearly explained why they did not prefer E. Her knowledge of the site and participation in previous stakeholder involvement groups enabled this stakeholder to express the exact reason why she did not like certain aspects of a given RAA. Referring to RAA A, she stated, "I don't like in-situ vitrification because it is a bad idea to vitrify soil and leave it in the ground." Here the mediator pointed out that the *Performance Measures themselves were not the sole preferences that a stakeholder wanted to express about the alternatives*. This was an important point in developing future strategies out of this



methodology. One of the analysts raised the issue of selection of the Performance Measures, “Did we choose the wrong PMs? Could we have defined a different set?” The CAB representative went on to explain that ISV changes the ecosystem and she was strongly against such a change.

<b>Rank</b>	<b>Integrated Ranking</b>	<b>Revised</b>
1	F	A1 and B2
2	E	A with B
3	B	D
4	C	C and F
5	D	
6	A	E - not responsible as an alternative

*Table 6.1d Stakeholder #6*

*Stakeholder #5*

The last stakeholder to discuss his rankings, was somewhat surprised. After a discussion of the assumption, we learned that he was operating off of a very different set of assumptions. This was admittedly because he was not present in the first of the stakeholder meetings in which the descriptions of the RAAs were presented in entirety. He clarified that fact that the RAAs were evaluated after the current VCMs and indicated that had he understood this, his rankings might have differed. Based on his technical expertise, he was quite confident that he was not at all interested in any technology which had in-situ vitrification. His reasons for opting for a combination of B and A were based on his preferences, as elicited, however, the integration did not indicate this ordering. This is primarily because of a misunderstanding of what the basic assumptions in the assessments were. This stakeholder was instrumental in recommending alternative RAAs. He also had gained the respect and trust of the other stakeholders. His familiarity with remediation issues, was evident in the insights he provided, for example, when the analysts clarified certain assumptions, this stakeholder spoke challenging the validity of the assumption, based on his current work with the site. Again, we see here the need for continual, concise and clear representation of the assumptions, which is aided by consistent participation by

the stakeholders. This stakeholder also provided insights into stakeholder communication and expressed concern that the stakeholders were adequately calibrated.

Rank	Integrated Ranking	Revised
1	E	B/A with no in-situ
2	B	
3	C	F
4	F	C
5	D	D
6	A	E

*Table 6.1e Stakeholder #5*

### *6.3.3 Points of Consensus*

Once each stakeholder had had the opportunity to discuss their individual results with the mediator and the others in the group, there was consensus on the following issues in regards to the technologies and integration:

1. Dislike of in-situ vitrification of RAA A
2. Dislike of “No Action” alternative
3. Dislike for RAA E: agreement not to transport waste to other communities
4. Cr is not a primary concern for long term health, therefore the stakeholders were willing to tradeoff more Cr left in the ground for less TCE left in the ground

Of the proposals found in Table 5.4.2, the stakeholders agreed with proposal one, RAA A should not be selected, and also with proposal two that D is less preferred than C. They adamantly disagreed with proposal four which stated, “F is a candidate to be a preferred alternative” primarily because they felt that action of some sort was necessary and that long term public health risk must be considered. We did not discuss proposals five and six.

The substance oriented goals were achieved in the sense that the stakeholders reached an agreement as to what to present to DOE regarding the remedial action at the Chemical

Waste Landfill. Furthermore, the important tradeoffs between the original six RAAs were put into context through the integration which allowed a meaningful discussion around the most relevant risks, as determined by the stakeholder preferences. Consensus was achieved on the following points:

- I. RAA A should not be selected
  - Both worker and short term public health risks are high due to airborne Chromium particulates released
  - All stakeholders put a high value on worker health risk and thus did not like the high risk of worker injuries that accompanied the original RAA A.
  - High Completion Costs
  - In-situ vitrification causes irreversible geological changes
- II. C+ is better than D, yet this is not to be included in the recommendation
- III. F+ is a candidate to be the preferred alternative
- IV. F should not be selected
- V. A+ is a candidate to be the preferred alternative
- VI. E should not be selected because of the ethics of shifting the problem to another area
- VII. B should not be selected

Based on the tradeoffs and technologies discussed, the stakeholders collaborated, generating new alternatives that were hybrids of the original six alternatives. Some stakeholders proposed hybrid alternatives that would in essence do away with the components of the RAAs that were least preferred. The hybrids that were proposed include:

Hybrid RAA	Description	Changes from original
C+	Excavation and thermal desorption of organics to be disposed of off-site Soil stabilization of metals (Cr) with on site treatment	Off site disposal of organics (TCE) rather than on-site
A+	Soil Vapor Extraction of TCE ( <i>No in-situ vitrification</i> )	No in-situ vitrification
F+	Continue with VCMs as indicated in	Added action of

	the bas assumptions, with the addition of focused soil vapor extraction on the TCE in liquid form	focused soil vapor extraction on the TCE in liquid form
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*Table 6.2: Hybrid RAAs*

F+ takes care of the TCE problem which the stakeholders decided was a prime concern, while minimizing process waste and addressing the concerning amongst all stakeholders about worker health risk. Although it did not do anything about Cr, the stakeholders were satisfied that Cr is a minimal risk at this site. Additionally, in the deliberation, a quick calculation indicated that this would cost less.

The next issue for discussion was the form of the recommendation to DOE. Which of these proposals should be included in the recommendation? Should just the top two proposals be recommended? One stakeholder(#2) suggested that F+ be recommended over A+ because:

- The cost /benefits are not worth it to address Cr which was the main difference between the two alternatives.
- Over time, evidence indicated that Cr6 deteriorates to Cr3, which was of minimal risk. This statement was confirmed by the analyst.

The representative from Sandia (#5) agreed with this recommendation, as did all the other stakeholder. Consensus was reached that F+ was the first preferred alternative and that A+ was the second. In addition, it was agreed that this was to be the recommendation to the DOE. Upon reaching this consensus, the analysts and mediator initiated a feedback discussion on the methodology itself, of which the lessons learned can be found in greater detail in the following section.

### *6.3.3 The Stakeholders' Relationship*

Further insight into the benefits of deliberation can come from observations of the group interactions and decision making behavior. Although groups interact uniquely, an awareness of potential areas of interaction can be helpful in formulating future deliberation strategies.

This group of stakeholders was very familiar with the site and the previous actions that had been taken. One stakeholder suggested that the fact the site was real and there were actually remedial actions taking place made it difficult for the stakeholders to separate the prototypical RAA issues from what was actually occurring at the site. This also may have clouded the stakeholders understanding of the assumptions.

Throughout the process (both pre-deliberation meetings and the deliberation), the stakeholders seemed to develop a teamwork type attitude in which they worked together to try to reach an agreement. At times throughout the deliberation process, the stakeholders seemed to become upset with the analysts and the mediator. One of the stakeholders felt the mediator had imposed his own preferences on the rankings of the alternatives. She appeared determined not to accept the rankings that had been calculated; however she was willing to listen to the opinions of the other stakeholders, specifically concerning the issues that were most important to her.

It was explained to her that the mediator was only presenting the results of the calculations that were based on stakeholder inputs. The mediator did not include his views in the tentative proposals (Table 5.4.2). It seemed that this stakeholder was suspicious. The stakeholders also developed a concern for one another and a desire to ensure that all understood the material presented. This concern can also be attributed to an individual's concern that his/her own desires are the most understood to the extent that the group decides to prioritize the concerns of that specific stakeholder. Upon leaving one stakeholder made a comment concerning this stakeholder's ability to understand some of the more abstract technical data; he suggested that possible calibration techniques be used to familiarize the stakeholders with the technical data.

The camaraderie displayed by some of these stakeholders will not be found in all deliberations and it is important, to note that while it seems to benefit the process, the stakeholders may have additional responsibilities to their respective groups that create inner conflicts.

## 6.4 Deliberation Interactions Analysis

There are a number of interactions that occur throughout a deliberation process. These interactions begin with the initial problem definition and evolve, like all relationships, over time. As such, decision maker, as well as the mediator, must be attuned to the possible responses and perceptions the participants will have and develop, not only of one another, but also of the agency and the mediator. These issues are the quintessence of developing trust between the community and the agency, as well as between the mediator, the analysts and the participants.

### *6.4.1 The Relationship of the Stakeholders with the Analysts*

The stakeholders seemed to develop in some cases a trusting relationship with the analysts and yet in some cases a skepticism regarding the intentions of the analysts. Initially, the stakeholders seemed to feel that the analysts were actually members of the Department of Energy and, therefore, not neutral third parties. This sentiment should be carefully assessed so as not to further the mistrust between the agency and the stakeholders. In the actual deliberation, the stakeholders listened to the analysts' explanation of the calculations and openly asked questions of the analysts, concerning both the assessed alternatives as well as the proposed hybrid alternatives.

At times, perhaps due to the fact that the project was in itself a prototype development project, the stakeholders demonstrated a sense of dissatisfaction with the analysts. There were similarly times when the analysts were uncertain how to proceed and consequently demonstrated their uncertainty in the presence of the stakeholders. The stakeholders in some regards seemed to look to the analysts for the "answers" which actually detracted from the joint fact-finding of the process. The aim of joint problem solving, however, could have been stated with greater clarity early on in the decision making process, and perhaps could have alleviated some of the stakeholders concerns.

The iterative meetings allowed the stakeholders to become accustomed to the analysts. This seemed to create an environment where both the analysts and stakeholders could

openly question and discuss the facts of the decision. As the analysts grew to know the stakeholders better, they were able to assess how to communicate the relevant facts better. There are drawbacks to an iterative process in that, although on one hand the relationship becomes more intimate, on the other, if there are personality conflicts between the stakeholders and the analysts, the relationship could be detrimental to the project. The participation of a group of analysts and stakeholders may help to mitigate such a down side.

#### *6.4.2 Stakeholders and the Mediator*

The mediator presented the results of the inputs and risk assessments. The mediator's role was neutral and yet informed, as the mediator was responsible for the integration of the stakeholders' preferences and the risk assessments. Some of the stakeholders took issue with the mediator concerning this integration. The stakeholders' disagreements with the ranking results led some of the stakeholders to question the motives of the mediator. The mediator delicately explained that the results were starting points for the discussion and would help elucidate the principal drivers which led to each ranking.

One of the stakeholders helped to support the mediator's neutrality by explaining to the skeptical stakeholder how the integration was done and that the mediator had no vested interest in falsifying the results. The skeptical stakeholder took issue with the fact that the mediator came from a different part of the country, when although unbeknownst to this stakeholder, the mediator originated from her side of the country.

Pre-judgments are in all of us, they are what help us to survive. Without a preconceived notion of something, we would always be in a position of having to relearn. Prejudices can be detrimental however when they cause us to take a narrow and judgmental view of some one or something. This is a very real aspect of deliberation and it is up to the organizing agency and mediator to caution against this in the deliberation.

### *6.4.3 Inter Stakeholder Relations*

The stakeholder relationships in this project evolved over eight months, some even longer since four of the stakeholders had been involved in a similar decision making project in the past. This led to an unusual amount of familiarity amongst the stakeholders. In some instances, there was a great deal of comfort amongst the stakeholders. Some had open conversations, frequently chatting during the breaks. There were other stakeholders who remained quiet and not as outgoing. When some stakeholders had to leave early, it was a bit surprising that none of the others openly resented this. The stakeholders tried to explain different technical presentations to one another and, at times, seemed to trust the stakeholders' input over the analysts. There were three technically trained stakeholders, active throughout the process, who also served to corroborate the analysts' input.

### *6.4.4 Stakeholder Expectations*

The stakeholders developed a feeling that their recommendation would be used by DOE. One stakeholder, in particular, continually asked whether the analysts could guarantee that his input would be utilized, despite the fact that the mediator reiterated that while the site of the evaluation was real, the integration methodology and use of risk assessment and deliberation is a prototype. Some stakeholders wanted to be reassured that what they provided was actually incorporated and were slightly confused when the results of the integration did not display the results they expected. Once the moderator explained that the process is iterative and that they could continually change their preferences without being "chastised," the stakeholders slowly became more comfortable - or so it seemed.

## **6.5 Discussion of Deliberation Goals**

The substance goals: reaching a recommendation for the remediation of the site that satisfies the concerns of the stakeholders and is technically and financially feasible, and the process goals: addressing the concerns of the stakeholders, maintain the integrity of their preferences, and ensuring a fair and efficient process, are discussed in this section.



### *6.5.1 Substance Goals*

In terms of substance, the integration and risk assessment of the impacts and stakeholder preferences, allowed for the following:

- Systematic presentation of the major contributors, causes, and tradeoffs
- Focus on the interests of the stakeholders
- Prioritization of the most important risks, as perceived/valued by the stakeholders
- Starting point for the generation of creative alternatives

A key question to ask is whether the stakeholders could have proposed these alternatives without the results of the integration method. If so, to what extent? As discussed by Fisher and Ury, the main goal of a successful negotiation is to focus on interests rather than positions [1981]. The proposals helped the group to deliberate on the merits and demerits of the alternatives in question. This approach does not gloss over the disagreements for the sake of the “relationship”, nor does it focus singularly on the positions of one party.

Focusing on the interests of the stakeholders as related to the technologies and site specific questions brought out the specific issues of concern for each stakeholder, as seen in the discussion of the integration results. Although the integration methodology alone cannot predict the substantive agreement which all stakeholders will agree [Arrow, 1951], the combination of early involvement and technical analyses integrated the values into the decision process. While the project’s underlying goal was to integrate stakeholder values and risk assessments into the decision making process, separating the “people from the problem [Ury, 1981]” permitted a discussion centered on the issue of remediation, rather than possible personal issues, like the realtor’s need to build homes, or the Sandia representative’s interest in future employment, and yet it allowed the expression and integration of these values through genuine participation. Moreover, not only are the results of the integration important, but equally important is the presentation of these results and the openness and perspective with which they are discussed. The sole fact

that integration results are obtained is not sufficient to reach a democratic and fair decision but rather must be interwoven in a tapestry of deliberation.

Arriving at the recommendations, the information that the mediator presented was useful in aiding the timing of the presentation of risk related information. As discussed previously, framing and timing of risk data is one of the most challenging obstacles facing policy makers. By receiving the information ahead of time, the stakeholders were prepared to ask questions and provide input concerning the rankings, how they were determined, and whether or not they chose to change their preferences.

Changes were made in the midst of the deliberation as to what type of alternative best met the interests of the stakeholders. For instance, stakeholder #4 thought that he was in agreement with the other stakeholders, however, the integration of the rankings indicated that he preferred RAA E significantly more than the other stakeholders. When he asked for more details, from the mediators, we were able to return to his original preferences and indicate how those preferences influenced the ranking and the fact that he preferred Impact on Local Economy and strongly led to the high preference for RAA E. He indicated that although he still felt that Process Waste and Impact on Local Economy were important, he was willing to compromise for the benefit of the group, "We are trying to reach a recommendation(as a group)." This speaks to one of the benefits of face-to-face negotiation and the process of group decision making, as opposed to a hierarchical, separated process, by combining analytical integration in deliberation the trades were made explicit. This combined with group defined goals and groundrules helps to open discussion.

During deliberation, alternative RAAs were created, once the baseline assumptions were clearly understood. Ideally, the framing and mutual comprehension of the assumptions will occur early in the decision making process, however given the multiple stakeholder approach, open discussion and deliberation, rather than simplistic presentation of the assumptions is vital to attaining such comprehensive understanding of the assumptions. As such processes bring together a range of individuals, some of whom have little or no previous contact or connection with one another, it is fruitless to expect that all the

stakeholders will completely understand, or care to try to understand the perspective, background or viewpoint of any of the other stakeholders. The substance and logical structure is thus called for if one hopes to achieve a feasible solution to a decision problem involving multiple stakeholders. The final recommendation was agreed to by all stakeholders and the analysts agreed to re-evaluate the new alternatives.

### *6.5.2 Process Goals*

The main element of process goals is fairness. Did all the stakeholders have the opportunity to discuss and present their views? Fairness must be substantiated by the participants involved. The opportunity for discussion should be sincere and open. In negotiations, as it can occur that certain participants dominate the discussion, it is often the role of the mediator to guard against this dominance and present a forum for equal opportunity to participate. Since individuals all have different forms of learning and expression the mediator may also want to adjust the participation settings to accounts for any observed or implied limitations to complete participation of the stakeholders. The substance, or information gathering component of a deliberative process helped to ensure an equal representation of the stakeholders involved. By a systematic elicitation of the preferences, we ensured equal representation to a certain extent of the quantitative assessment, however the drawback to this method is the accuracy of that elicitation for each individual. Additionally, they were able to change their preferences regarding the quantitative input all the way through the decision-making process, including the deliberation. Through assisted deliberation, the mediator worked to ensure equal opportunity for the stakeholders to express themselves in the deliberation. This, in itself, is a difficult challenge, for the mediator must remain neutral, focused and flexible.

There seemed to have formed various levels of connections between certain participants, for example, the apparent trust displayed by one stakeholder(#1) for the input of one of the analysts. While simultaneously, she had little trust in the input from the mediation group. Her reasoning was based on the assumption that the mediation group was from a different geographical location and not in tune with the local problems. The camaraderie between the stakeholders contributed in some respects to the efficiency of the process since it

actually helped certain stakeholders improve their understanding of the situation, by drawing on comments from those stakeholders more familiar with the site.

In terms of the wisdom, the forum of deliberation helped to draw out hidden objectives, such as the ethical concerns and the questions of trust that were undetected by the questionnaire form of elicitation. From this discussion, stakeholders had the opportunity to change their rankings of the alternatives, even though, they admittedly stated that their preferences remained the same. Such a mathematical “inconsistency” cannot be evaluated on a purely quantitative measure; interaction and discussion is vital. Stakeholders are not normative, standardized super rational beings, however, a logical foundation of the arguments does aid the decision making process and provides a systematic framework for reaching an implementable solution [Sagoff, 1996; Dubos, 1991].

A main contributor to the wisdom of the deliberation was the integration methodology in the sense that it focused the discussion on the interests and causes of differences, in a systematic fashion, without getting caught in a morass of conflicting values and arguments. Combined with a flexible, open deliberation the preceding steps for integration help to establish relationships and trust amongst the stakeholders. The integration then makes the tradeoffs explicit while addressing the preferences of the stakeholders. There are criticisms to the overall fairness of such a consensual group process, in regards to the quieter or weaker participant being granted the opportunity to express his or her views. The integration method added an additional vehicle for the consideration of stakeholder values which can be used by the agency to ensure that each stakeholder’s concerns are considered. This point touches on the role and responsibility of the agency (NRC, 1996).

The process goals seemed to be enhanced by the use of a court reporter. The presence of a court reporter was accepted by the participants and served as a guide that only one person should speak at a time. This certainly aided to the process goal of fairness and wisdom. It was on the contrary, difficult to judge whether the stakeholders “actively listened” to one another, although their awareness of the needs of the other participants seemed to indicate that this was the case.

Substance or outcome and process must be considered in parallel. Improving both contributes to the overall wisdom of the decision making process. Similarly, the stability of the decision, in other words its applicability to the site and its feasibility, is enhanced through the ongoing interactive decision-making that brings together substance and process. By opening the process to the stakeholders and providing the opportunity for an interdisciplinary definition of the substance to be evaluated, as well as in the evaluation method itself, the wrong assumptions are less likely to be made. Granted, not every stakeholder will have, or want a say on every issue, as was indicated, when in the second meeting one of the stakeholders (#1) simply yielded to the analysts for their “expert” opinion concerning the amount of TCE in the ground, yet it was her voluntary choice.

Further issues in addressing the challenges of integrating substance and process, risk assessment and values, are centered around: time constraints, stakeholder selection methods, urgency, and budgetary restrictions. However, once the process is defined, the openness and sincerity must come from the agency in charge, given that in this instance the agency’s role is well-defined and the product of the deliberation is a recommendation to the agency.

## **6.6 Chapter Summary**

The major points presented in this chapter are:

- In a deliberation the goals, groundrules and roles of participants should be discussed explicitly.
- Resources and information should be readily available to all participants prior to deliberation.
- Integration and major contributor analyses lead to tentative conclusions which helped structure the deliberation around the stakeholder interests and relevant tradeoffs in regards to the site remediation.
- The deliberation was conducted in a manner which integrated the concepts of fairness and efficiency by drawing on the integration of the stakeholder preferences and risk assessments. The deliberation provide the needed complement to the quantitative analyses.

- Group decision making process are not the simple aggregate of individuals but rather are the product of interactions of the participants striving to reach a common objective although the individual values and methods may be different.
- Integration provided the necessary structure to the deliberation so that the discussion focused on the individual interests as the manifested in the RAAs, and presented a rational discussion of the tradeoffs involved in environmental decision making.
- Stakeholders worked together to reach an agreement acceptable to all parties, finding consensus first on the least acceptable alternatives and proceeding to create new alternatives based on the illuminated tradeoffs, technical analyses, and cooperation.

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## CHAPTER 7: RISK COMMUNICATION INSIGHTS

“The breakdown in communication is complete only when the concepts cannot be related to human experience. The physicist, the biologist and the humanist and the lay person can all find common ground for discourse if they talk about matter, life, or humanity as perceived by the senses or as apprehended in the form of images, analogies and responses...” -Rene Dubos, 1965

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Much of the controversy and loss of trust in agencies involved with environmental decision making can be traced to issues of risk communication, whether it is a result of perception, poor communication techniques, or a neglect of fundamental concerns of the affected parties. Deliberation itself is a communication tool, and when accompanied by supplementary visual aids improves the communication process. This Section will discuss the communication and discussion of risk in deliberation, as well as those elements of the analytic-deliberative process which supported the deliberation.

### 7.1 Influence Diagrams

The tools we used for communication began with the influence diagrams (IDs) at the first stakeholder meeting. The use of influence diagrams also conveyed the stakeholders' concerns to the analysts so that their values could be synthesized into the risk assessments, thereby strengthening the foundation of those assessments and eliminating the tendency to overlook the non-objective judgments, whose omission often lies at the root of the controversies in environmental decisions [Stone, 1996; Sagoff, 1992]. These were successful in helping the stakeholders and analysts outline the goals, which provided support to the deliberation in the form of understanding and acknowledgment of the main issues. Cooperative construction of the IDs allowed the stakeholders to examine the direct inputs into the analyses, as

they define them.<sup>19</sup> The deliberation aspect permits the stakeholders to question the diagrams and debate the various assumptions. In terms of decision making theory, the influence diagrams also aid the analytical process of evaluating the stakeholder preferences[Keeney, 1996].

Furthermore, the use of marker boards, or real time visualization tools seemed to make the stakeholders more comfortable and confident that their opinions were actually being noted and incorporated. It also provided the analysts and mediator with guidance throughout the deliberation as to what issues were discussed and what perhaps needed to be raised.

## **7.2 Timeliness of pre-deliberation material**

Early notification of analytical results prepared the stakeholders and the analysts for the possible discussions and questions that may arise during the deliberation. This pre-meeting information helped communicate the results by providing the stakeholders with the additional time necessary to read through the material and compare it with the facts of the site and previous meetings and discussions. It also guaranteed that the mediator was prepared to answer preliminary questions and concerns regarding the integration of the stakeholder preferences and risk assessments.

## **7.3 Graphs and Diagrams**

Communication through graphs and diagrams was best received when the presenter was able to have the attention of the group and had rehearsed the presentation of the material. The analysts' presentation of the assessment scenarios were well received by the participants during deliberation. These diagrams detailed the exposure pathways that were analyzed, using pictures and familiar representations. In deliberation, clear and explicit descriptions that can be understood by all parties

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<sup>19</sup> The IDs should be drawn as neatly and concisely as possible. Care should be taken that they do not



help establish trust and understanding. With the analysts and the mediators present, the stakeholders have the opportunity to ask direct questions regarding the descriptions, an element which can compensate for the potential misunderstanding, or mis-framing that can occur if there is no “talk.” “As the struggle to begin conversation becomes purposeful, we understand how fugitive its foundations are and how easily they can be subverted . Even with a foundation, we are not on a straight or clear path. What it gives us is the minimal conditions for meaningful disagreement (Laws, 1996).”

## **7.4 Elicitation**

Analysts and agencies must elicit information from the stakeholders in the decision making process, and depending on the complexity of the decision making method, obtaining accurate information can be a substantial challenge it itself. Overall, we found that the combination of verbal and written elicitation served to enhance mutual understanding and made some of the issues more explicit which in turn aided the deliberation in that the stakeholders and analysts were more aware of the diverse range of concerns. Explicit descriptions and objectives pertaining to the use of the elicited information help improve the trust between the parties by providing an overall roadmap to the analytical-deliberative process.

## **7.5 Pre-deliberation Communication**

Anonymous communication of the integration results was offered by the mediation group. As mediators, we did not want to “force” the stakeholders to reveal their identity in the communication of the analytical results during the negotiation, although we did feel that in order to establish responsibility and a substantive discussion, the stakeholders’ identity in the presentation of results should be made known to the group. It was important however that this was the group’s decision.

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become too detailed

Another benefit of this tactic was that it helped to build *trust between the stakeholders and the mediator*.

## **7.6 Risk Communication Summary**

The key lessons to take from this project in regards to risk characterization and communication are :

*Clarify the assumptions early and often.* All the participants, the stakeholders, the analysts and the mediators will benefit from this. It will avoid long term problems, enhance comprehension of the problem, and will help to eliminate unnecessary calculations on the part of the analysts, for they will be more focused on the issues of concerns. By continually presenting and reiterating the assumptions, the group will be more likely to evaluate the situation from the same point of reference during the deliberation. By involving the affected and interested parties in the generation of these assumptions, the problems commonly blamed for poor, or rather contested, decisions will be minimized, if not eliminated.

*Visual aids* help clarify what has been stated and how the process is evolving. The initial tools, such as the influence diagrams, proved useful to the stakeholders, but perhaps more so in communicating the stakeholders concerns to the analysts so that the analysts could carry these concerns through their evaluation. This was evident by the stakeholder who got up during deliberation and handed the mediator a marker to write down the new assumptions as they arose. This strengthened the group memory and minimizes discrepancies concerning the framing of the risks.

*Calibrate the participants.* All the participants, including the analysts and the mediator, needed a frame of reference in order to participate to the best of their ability. Although some stakeholders, particularly those familiar with the site, could easily grasp the meaning of a ton of waste transported, or 3 parts per million (ppm) of TCE in the groundwater, many, including the mediator, did not feel that they

could provide input regarding a particular performance measure without understanding the implications of the statement or measure.

Methods of comparisons and calibration vary, yet from this project, comparisons to familiar events or situations was suggested as a useful tool. For instance, in regards to the performance measure "Impact on Local Economy," comparing the impact of the RAA to the impact felt by the annual ballooning festival worked well as a calibrating mechanism, easily understood by all participants. Regarding the more technical terminology, one stakeholder suggested during deliberation to compare the amount of waste to be transported to the relative amount of dirt one might use in planting a garden. There is a distinct difference between biasing the stakeholders and simply educating the participants and ensuring that each is starting his/her evaluation of the decision situation from the same page . As discussed in Chapter 3, framing of the situation is one of the elements that frequently leads to misunderstanding and associated problems, both legislatively and technically.

*Presentation of uncertainty should be accompanied by verbal descriptions and an open discussion.* Unlike many earlier negotiations, we opted to present the uncertainty bars to the stakeholders, because we felt that some of the stakeholders would be able to understand them. Moreover, with respect to process, it would be inappropriate for us to judge which stakeholders could understand the graphs and which could not, and, thus, we presented the graphs to all the stakeholders, along with a complete qualitative analysis. In corporation with the open deliberation, the uncertainty associated with the analyses could be explained. Most of the discussion, however, did not focus on this uncertainty, perhaps because it was incorporated as only one element of a more integrated, iterative deliberation process. If the uncertainty graphs were to be employed without the benefits of deliberation, it is unlikely that they would be helpful, on the contrary, they would probably serve to create more controversy and distrust of science [Morgan, 1978; Osawa, 1992].

*Communication prior to deliberation aids the stakeholders in preparing for the discussion.* As many of the issues require thought and processing time, we found that early communication of the integration results were helpful in preparing the stakeholders for the deliberation. They came prepared with “questions.” Such information should be mailed about a week in advance; we, however, were unable to meet this criteria, and consequently mailed the information 2-3 days prior to the deliberation.

*Information overload* can occur when the analysts try to elicit too much information from the stakeholders at one time. The variability in technical understanding must be recognized and the desired input should be clearly stated to avoid confusion. Stakeholders do have other commitments and we found that spending an exorbitant amount of time on one area caused some of the stakeholders to lose interest. Additionally, as stakeholders have other commitments, they were not always able to stay for the entire deliberation, which detracted from our ability to get complete sets of information from all of the stakeholders; as we were developing a prototype methodology, we were able to improvise along these lines, however, these concerns are real and should be heeded.

During the deliberation, the stakeholders were concerned with having the opportunity to express things as they saw them. They needed reassurance that their concerns and input was accounted for in the integration. One stakeholder continually expressed here desire to be heard in a behavioral context, as opposed to normative. The integration methodology begins to bridge the disjunction between scientists and the public by both involving the public in a quantitative assessment while simultaneously bringing the analysts into an open discussion with the public.

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## CHAPTER 8: ANALYSIS OF DELIBERATION

“The true development of human beings involves much more than mere economic growth. At its heart there must be a sense of empowerment and inner fulfillment. This alone will ensure that human and cultural values remain paramount...People’s participation in social and political transformation is the central issue of our time...” - Aung San Suu Kyi, Leader of Burma

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As the Department of Energy continues its probe into new methods of stakeholder involvement and integration, we look at the following elements:

- Integration as an aid to deliberation
- Deliberation as a method for communication and characterization of risks
- Deliberation as a mode to involve stakeholders: was it fair?

We look at deliberation in terms of its usefulness in risk characterization and stakeholder involvement.

### 8.1 Integration as an aid to deliberation

In regards to deliberation, the integration provides a systematic process through which the correlation between the stakeholder values and preferences and the remedial action alternative can be made. This allows a prioritization of the major tradeoffs for each stakeholder which can be used in structuring a deliberation.

The underlying assumptions here are that the stakeholders are able to accurately provide their preferences to the analysts throughout the deliberative process; that they understand the material presented; and are able to communicate and quantify their preferences.

Nonetheless the integration aids the mediator in developing strategies which focus on the important contributors, as well as prepares a logical structure of the potential areas of conflict between the stakeholders, so that in the event that conflicts arise, the mediator will be able to negotiate appropriately, focusing on the interests, not the people, so that a cooperative recommendation will be reached.

By allowing the stakeholders to change their preferences in the deliberation, the integration method was not limited by the shortcomings of normative theory. Although the ultimate rankings of the RAAs for each stakeholder were not as the stakeholders expected, the analysis into the causes of those rankings: the major contributors and tradeoffs, provided useful insights to focus the discussion on the issues, both technical and social, pertinent to reaching a fair and efficient outcome.

### *8.1.1 Integration and the stakeholders*

The integration method brought the risk assessments and stakeholder preferences together in a logical format relevant to the problem. By combining the integration with a face to face deliberation, the stakeholders could ask questions and express their changes in their preferences. The mode of integration, allowed for an ongoing process which helped to establish relationships and trust between the stakeholders; given that some of these stakeholders were from National Laboratories and others were from the community, it seemed to also foster that relationship and perhaps begin to establish trust between the groups of stakeholders. Similarly, the interactive discussion format of presentation, rather than just written or pictorial communications, proved very useful in building relationships between the stakeholders and analysts.

Some of the remaining questions lie in the elicitation of preferences, the amount of technical data that needs or should be communicated to the stakeholders. In using a quantitative integration method, we required the stakeholders to quantify their preferences for the objectives they, as a group, had defined. Some people have a difficult time assessing elements they view as non-quantitative in a quantitative

fashion. If such a method is to be used for stakeholder involvement, it must meet the agreement of the stakeholders involved. One way to improve the acceptance of such a model is to combine it with a qualitative or behavioral component, that allows a dual expression of the stakeholders preferences. Granted, there will always be an element of interpretation involved, if those preferences are assessed by “analysts” and then regurgitated back to the stakeholders, for this reason, it must be explicitly agreed upon that the final say and development of the recommendation - the result from the integration - in this case a recommendation to DOE concerning the remediation of the site (again keep in mind this is part of a prototype development), is that of the stakeholders.

### *8.1.2 Improvements to the integration with respect to deliberation*

As a method of prioritizing the risks, the overall integration method proved useful as it began from a process involving the stakeholders from the very beginning of the problem definition. The stakeholders wanted to understand the method being used from the start of the decision process, and given that this was an experimental project an explicit, detailed overview was not possible from commencement. In future stakeholder involvement processes, the method being used should be clearly explained and discussed with the stakeholders as early as possible to provide a road map and end goal. The time and length of the process, while potentially detrimental, in terms of efficiency, served to build trust amongst the participants, which in turn permitted a collaborative learning process. For as much as time can help build relationships and trust, if there are underlying problems, there may be barriers to building such relationships.

## **8.2 Deliberation**

The deliberation itself, the process of talking through the issues with the affected parties, helped the parties to understand the issues and brought forth the objectives upon which the group could agree. It helped to ensure that the problems, as seen and understood by each representative of the public were brought out. Granted,

there may still be some issues that remain hidden, yet in combination with an ongoing deliberative process and prioritization of the major stakeholder concerns, deliberation can improve understanding and enhance the acceptability of the recommendation. Although this took the attention away from the disagreements that may have otherwise formed between particular stakeholders had they gotten into a discussion of individual values, the true success of the process comes in its standing over time.

### *8.2.1 Stakeholder Involvement: Fairness*

The substance of the deliberation, the end recommendation, can not be determined absent the parallel focus on process: similarly, the process, the equal opportunity for fair and meaningful discussion, can not ensue without the substance to that discussion. Both Jasanoff(1993) and Stone (1996) raise similar points concerning the need for a combination of risk assessment and risk management from the start, and in regards to public rule making, Stone(1996) discusses the various aspects of precise versus flexible rules which parallels the duality inherent in achieving both efficiency and fairness.

Assuming that the integration is as accurate as possible, and even in the case that the initial rankings are not acceptable to all stakeholders, the deliberation enables a worthwhile discussion of the tradeoffs and RAAs, which results in a consensus on a recommendation to be made to DOE. For the preferences that are not captured in the quantitative assessment, the deliberation allows the stakeholders and analysts to recognize, hear, and incorporate these concerns into the resulting recommendation. As seen in the deliberation, the verbally expressed preferences sometimes differ from the elicited preferences. As one analyst pointed out perhaps we could have used a different hierarchy tree to capture these preferences. We contend, however, that no matter what set of objectives is used in the integration analysis, there will always be preferences that manifest themselves in a group discussion, either because the individual re-evaluates the situation in real time as he or she gains knowledge from the group, or that a personal situation has caused



such re-examination; there are numerous other possible causes that cannot be captured in such a singularly quantitative model. The group memory is also enhanced through deliberation, as the burden of remembering every past detail does not fall on a single individual.

The time constraints of a deliberation can affect the level of stakeholder participation and the ability of the mediator to cover all the important issues, which, in turn, can affect the quality of the substantive issues of the deliberation. In this regard, the integration and pre-deliberation preparation helps to focus the discussion, so that the major contributors to each stakeholder's concerns can be addressed. Additionally, it allows the open discussion of the risks and the assumptions underlying those risks, ensuring that, although not initially, the stakeholders and analysts are operating from the same framing of the problem. If the decision is based solely on the integration, the concerns of the stakeholders expressed in the deliberation will be overlooked.

Returning to the questions raised in Chapter Five, Was the deliberation fair? Was the offer to participate genuine and were all the stakeholders given a chance to be involved? The stakeholders who had participated in the pre-deliberation meetings were all given the opportunity to take part in the deliberation and during that deliberation, the mediator guided the discussion to provide each stakeholder the opportunity to discuss his or her views and interests. Although all the stakeholders stated that they felt satisfied with the deliberation in this regard, hidden agendas and concerns cannot be measured. Opportunities were provided to revise the decision process, however, given the role of the agency in this decision, the power of the stakeholders is limited. In the deliberation, the stakeholders had the opportunity to revise the rankings and the form of the recommendation. Furthermore, they determined the meaning of consensus, and the exact recommendation to be made. They clearly disagreed with some of the definitions of consensus that the mediator offered, and subsequently devised a meaning that suited their recommendation. Constantino (1996) notes that the mediator is to facilitate the process *with* the stakeholders as opposed to *for* them.

The setting of the goals of the deliberation was done initially by the Team and then offered for discussion to the stakeholders, who could change them if desired. This assumes that the stakeholders needed guidance in proposing a set of goals for deliberation. “ If the community is merely providing input, there remains a question of whether they will ever be satisfied, short of getting what they want—even if the process is fair. This raises the issue of how meaningful community involvement can be, and how motivated the community will be, if they only provide input (and do not design the process) (Ashford, 1996).” For this reason, the decision and involvement in the decision making process must be discussed, agreed and acknowledged by the involved stakeholders.

On the other hand, regarding stakeholder selection and fairness of the overall recommendation to the entire community, particularly in regards to environmental justice criteria comes into question. For example the “wrong” group of stakeholders are selected and on the issues of environmental justice, where the performance measure evaluated in something like percentage of minority adversely affected by the implementation of the technology as compared to the total population. If the stakeholder, represent a particularly bias cross section, a decision left entirely in their hands would result in an inequitable decision. This raises the issue of the role of the responsible agency, and the responsibility of the agency. At present the agency retains the final say concerning remediation activities, yet is more likely to implement a recommendation that was reached by consensus of the stakeholders and is technically and financially sound.<sup>20</sup>

### *8.2.2 Addressing Risk*

The deliberative process, from the problem definition phase, addressed the elements of risk throughout, and ensured that the correct assessments were performed from the beginning. An integrated deliberative process helped to ensure that the risks

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<sup>20</sup> Interview with DOE personel, March 9, 1997.

that were assessed by the analysts were the ones deemed important by the local community, in the appropriate frame. This process helped to familiarize both the analysts and the stakeholders with the numerous elements of risk. The deliberation then, promoted the discussion of the risks and various aspects of environmental decision making with both neutrals, analysts and stakeholders which proved effective in establishing a cooperative problem solving forum. Discussion helps to clarify the perceptions of all parties so that there is agreement as to how things should be assessed and what types of actions are needed. The important part is that this agreement is reached through discussion and collaboration. If the initial framing of the problem was not laid out clearly and understandably, the participants would be drawing conclusions from differently perceived foundations of information, which could consequently weakens the overall process. The one component that could detract from a deliberative process is the lack of recall concerning the basic assumptions, which influence the framing of the problem. In risk communication and assessment amongst parties, the assumptions lie at the core of the problem solving process and therefore need to be reiterated frequently, and any concerns regarding the assumptions should be addressed explicitly, as discussed in Chapter 3; and as noted by Ashford (1991), “disjunction exists partly because agencies look at the problems through the lens of science while the community uses a different frame.” Deliberation based on the substantive risk assessments and stakeholder interests moves beyond the prior decision making techniques, bringing together the qualitative and quantitative aspects.

### *8.2.3 Improvements*

When implementing such an integration method it is necessary that the stakeholders are calibrated, the assumptions are continually restated, in a simple concise form, the responsibility of the agency and the way the product of the deliberation is to be used is clearly presented to the stakeholders - ideally, the agency will be flexible enough to allow the stakeholders to help define the guidelines of the recommendation and its implementation. Not only should the stakeholders define the goals and rules of the deliberation, but also take a role in the

implementation and subsequent activities, in order to establish a true partnership, as called for by DOE(1997).

### 8.3 Additional Questions

While this work attempts to address the integration of risk assessments and stakeholder values, there remain a number of questions which the agency needs to address when making science intensive decisions, many of which are not only practical but philosophical in nature. One question that remains unanswered in the issue of stakeholder involvement, is the selection of the stakeholders. How can the agency ensure that all the relevant stakeholders are involved? How many stakeholders should be involved in an agency decision making process?

Once a stakeholder is selected, he or she may be at odds over which organization they are to represent in the deliberation, if in fact they are members of more than one organization, as was brought up in the deliberation by stakeholder #6. This raises some interesting questions about the representation methods used and how adequate representation in a democracy could be achieved? This question goes hand and hand with the issue of stakeholder involvement and selection of a stakeholder involvement model: should the agency select a small group of stakeholders or proceed with public hearings and large scale community involvement processes (Gardner, 1989; *Community*, 1994; Ashford, 1991).

In regards to evaluating the stakeholders' preferences, the issue of quantification, or more generally speaking, expression of those preferences surfaces. How does the individual best express his or her feelings and preferences? And how do these differ in a group or social setting versus an individual setting? Studies have shown that individuals make decisions differently depending on whether they are deciding for themselves or for the social welfare (Sagoff, 1996; Kraan et. al, 1991). Despite these questions decisions must be made which require both agency responsibility and

honesty. The agency needs to ensure a standard of fairness and environmental justice in the decision making process.

Other questions that arise concerning environmental decision making are founded in the underlying values and ethics of society in addressing the environment. Even in the promulgation of laws, there is a foundation of ethics which guide our laws. Scientists of all disciplines have begun to question the environmental ethics and the place of humans in the natural environment. Beyond the fairness and efficiency questions in the human realm, the deeper questions of environmental ethics should also play a role in the way decisions are made, if we are in fact to preserve the natural environment for future generations.

These questions require further investigation and depend to a large extent on the context of the environmental restoration problem. In light of all these additional questions, decisions must be made and determining the appropriate method which adequately addresses the fairness and efficiency issues of both the technical and social elements of environmental decision making.

## **8.4 Chapter Summary**

The factors that are essential to achieving such a recommendation are trust, respect, access to resources, opportunity and openness in decision-making, accountability and proper framing of the problem. In light of these issues, a flexible recommendation, one which is re-evaluated and able to change as the circumstances demand is necessary. A decision making method must recognize the inherent relationship between technical and social questions in environmental decision making. By incorporating the lessons learned in future applications, the integration and deliberation methods tested in this work provide a starting point to improving the way agencies make decisions.



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## CHAPTER 9: FUTURE APPLICATIONS AND RESEARCH

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The need for adequate decision making tools which address the risks and values inherent in environmental decisions will continue as the anthropogenic impacts on the environment continue. The debate and controversy regarding the appropriate policies and use of risk assessment persist from the local level to the global level, as seen at the recent United Nations Conference on the environment (June, 1997) and the promulgation of the Clean Air Act Amendments.

Policy makers, scientists and stakeholders must address the issues and recognize the tradeoffs while not compromising fairness in risk laden environmental decisions. This can be achieved by involving the parties early in the decision making process, explicitly discussing the objectives of the decision so to clarify the framing of the problem early. Providing a structure which focuses on the problem and the interests of the stakeholders can help to move towards an implementable solution. Although it will not always be possible to satisfy the desires of all participants fully, providing an open forum with interactive discussion can help clarify the elements of risk involved in the decision. Individuals while eager to be involved in the process often do not realize the many tradeoffs that must be made. Tradeoffs that were once made by the policy maker alone are realized when the individual is directly involved in decision making. There are other individuals who take and will continue to take a hands off view in environmental policy making. The agency and policy makers have a responsibility to conduct decision making in an open forum, offering the opportunity for participation. With the opportunity for participation, comes responsibility that needs to be made explicit on all levels.

*Uses of this method*

The deliberation methodology devised in this work offers a method that structures the tradeoffs and issues involved in a risk laden decision problem in order to facilitate a deliberation. In attempts to better understand and manage the risks inherent in environmental decisions, this method offers a tool for addressing the issues, and prioritizing the objectives. It is an appropriate method to be used in decisions that involve numerous technical elements and multiple objectives. One instance where such an analytic-deliberative technique could be used is in the evaluation of the nuclear waste repository at Yucca Mountain - a decision which affects multiple stakeholders. It would be difficult however, to implement this method in circumstances where the agency chooses to involve the entire community in the environmental decision, rather than a representative working group. This is due to the detailed quantitative analysis (MAUA and major contributor analysis) that went into determining each stakeholder's representative ranking of the alternatives.

The Environmental Protection Agency could utilize this method when determining specific permitting processes in local communities. For example, in the recent environmental justice case in Louisiana, a chemical company has proposed to build a new plant in an area where there are currently six chemical plants. Some within the community are opposed to the plants for health reasons, while others support the plant because it will create new jobs. This method of involving the stakeholders through a deliberative-analytical process, could bring the multiple parties together and with the aid of a mediator, jointly evaluate the mutual objectives and preferences to reach an acceptable agreement for all parties, while addressing the perceived and actual health and environmental risks.

This method is not confined to agency decisions alone. It could well be used in narrow circumstances, where the value range is not as broad as it was in this decision. In industry, for example, this method could be used in strategic planning to evaluate options between multiple departments or facilities or, in a local community deciding on planning or zoning alternatives. As no one method is absolute, it must be adapted for different circumstances, yet once the stakeholders



have been identified, the objectives and intent of the method should be clearly stated in the beginning of the decision making process.

### *Areas of Future Research*

In order to incorporate multiple stakeholders and risk assessment in the decision making process, the communication of risks and the level of interaction between the stakeholders and the agency needs to be examined in greater detail. As was seen in this project, not all stakeholders have the same level of understanding of the technical aspects, and yet wanted to be involved. The technical issues need to be put in context and there remains no one method to accomplish this task. The interaction between the analysts and stakeholders created the forum for discussion and clarification throughout the process, however, there was no one method of communication which was optimal for all stakeholders.

With regards to fairness and efficiency, the appropriate level of stakeholder involvement must be determined on a case by case basis. As the level of urgency differs in each decision, the agency must be prepared to assess the situation and determine the appropriate level of stakeholder involvement. The elicitation and quantification of preferences as a means of obtaining stakeholder input is another area which deserves further study. It is important to obtain, whether through discussion, written expression, or mathematical representation, each stakeholder's input and yet, there is not one generic mode of self expression. This issue is one which simply requires time, trust and cooperation.

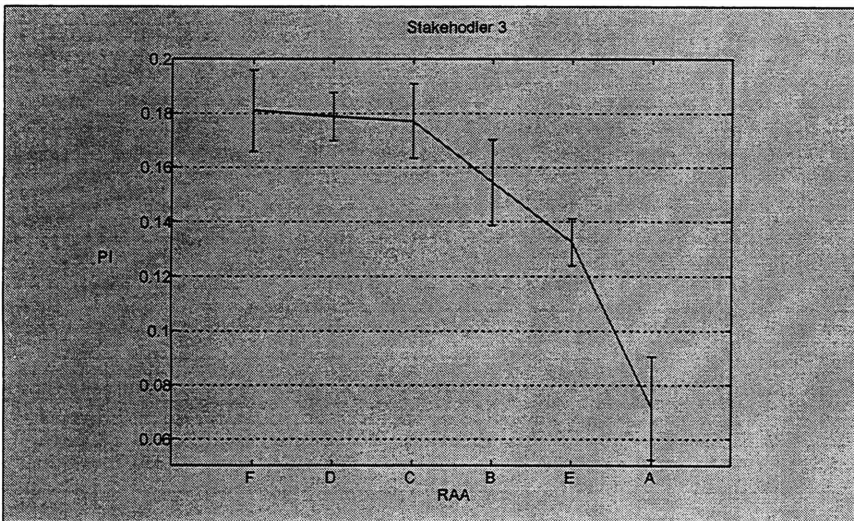
As science and technological advancements continue, we cannot neglect the need to consider social implications of these advancements. The link between normative and behavioral decision theories must be recognized in all social decisions. There is no right answer to these problem, yet a framework is needed that can help, not replace, the decision maker.



# APPENDIX 1

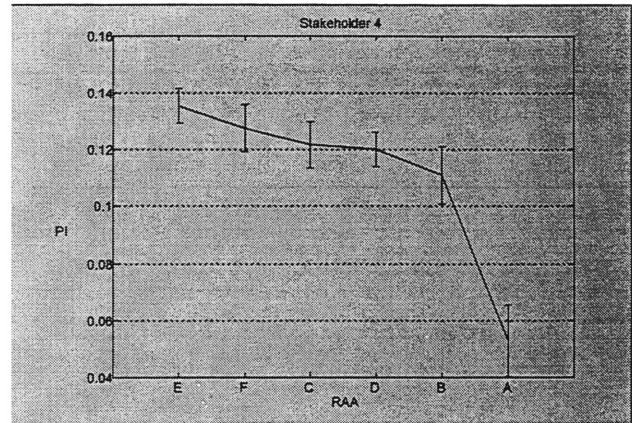
## Results of the Integration for each Stakeholder:

Stakeholder 3	F	D	C	B	E	A
Ranking	1	2	3	4	5	6
Mean PI	0.1808	0.1786	0.1771	0.1543	0.1324	0.0711
Standard deviation	0.0149	0.0089	0.0138	0.0156	0.0085	0.0191
Lower	0.1659	0.1697	0.1633	0.1387	0.1239	0.052
Higher	0.1957	0.1875	0.1909	0.1699	0.1409	0.0902



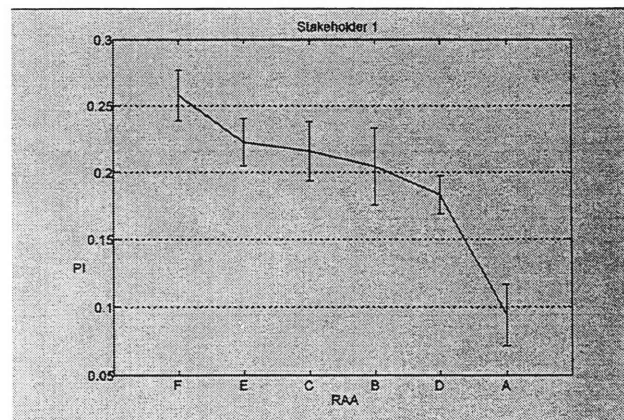
Stakeholder 4	E	F	C	D	B	A
Ranking	1	2	3	4	5	6
Mean PI	0.1353	0.1276	0.1217	0.12	0.1111	0.0529
Standard deviation	0.0062	0.0083	0.0081	0.006	0.0101	0.0126
Lower	0.1291	0.1193	0.1136	0.114	0.101	0.0403
Higher	0.1415	0.1359	0.1298	0.126	0.1212	0.0655

*PI and ranking summary for Stakeholder 4*



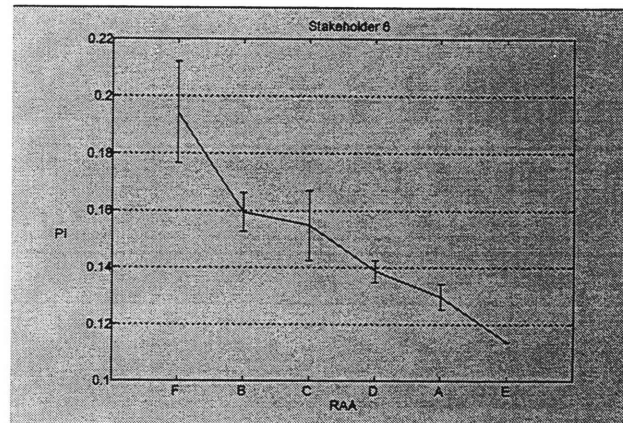
Stakeholder 1	F	E	C	B	D	A
Ranking	1	2	3	4	5	6
Mean PI	0.2576	0.2225	0.2157	0.2045	0.1829	0.0936
Standard deviation	0.019	0.0178	0.0224	0.029	0.0142	0.0225
Lower	0.2386	0.2047	0.1933	0.1755	0.1687	0.0711
Higher	0.2766	0.2403	0.2381	0.2335	0.1971	0.1161

*PI and ranking summary for Stakeholder 1*

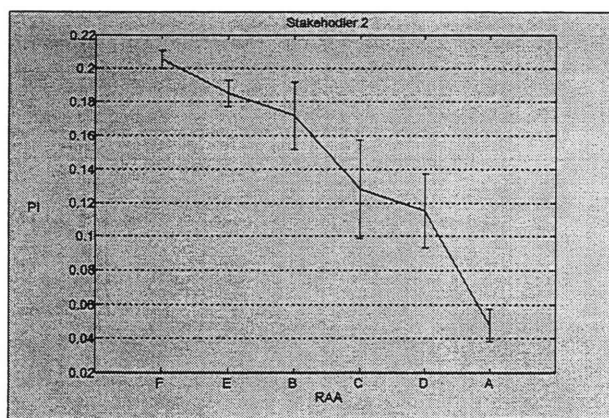


Stakeholder 6	F	B	C	D	A	E
Ranking	1	2	3	4	5	6
Mean PI	0.1944	0.1594	0.1547	0.1385	0.1297	0.1135
Standard deviation	0.0178	0.0068	0.0123	0.0037	0.0046	0
Lower	0.1766	0.1526	0.1424	0.1348	0.1251	0.1135
Higher	0.2122	0.1662	0.167	0.1422	0.1343	0.1135

*PI and ranking summary for Stakeholder 6*



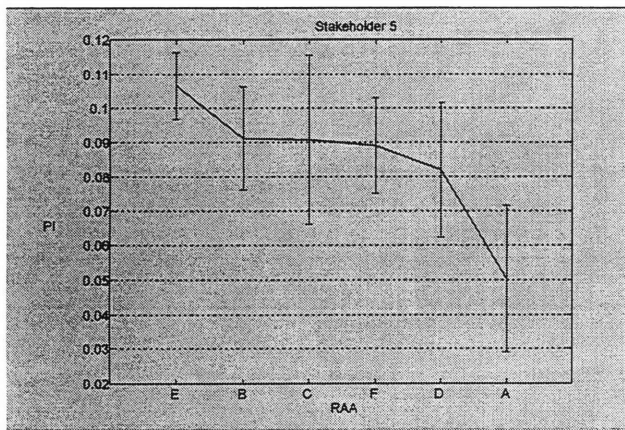
Stakeholder 2	F	E	B	C	D	A
Ranking	1	2	3	4	5	6
Mean PI	0.2052	0.1852	0.1718	0.1281	0.1152	0.0475
Standard deviation	0.0053	0.0079	0.0199	0.0295	0.0219	0.0096
Lower	0.1999	0.1773	0.1519	0.0986	0.0933	0.0379
Higher	0.2105	0.1931	0.1917	0.1576	0.1371	0.0571



*PI and ranking summary for Stakeholder 2*

Stakeholder 5	E	B	C	F	D	A
Ranking	1	2	3	4	5	6
Mean PI	0.1065	0.091	0.0908	0.0888	0.082	0.0501
Standard deviation	0.0097	0.0151	0.0247	0.014	0.0197	0.0213
Lower	0.0968	0.0759	0.0661	0.0748	0.0623	0.0288
Higher	0.1162	0.1061	0.1155	0.1028	0.1017	0.0714

*PI and ranking summary for Stakeholder 5*



The information above can be summarized in as follows:

EXPECTED PERFORMANCE INDEX							
RAA	3	4	1	6	5	2	Mean
A	.0711	.0529	.0936	.1297	.0501	.0475	0.0742
B	.1543	.1111	.2045	.1594	.0910	.1718	0.1487
C	.1771	.1217	.2157	.1547	.0908	.1281	0.148
D	.1786	.1200	.1829	.1385	.0820	.1152	0.1362
E	.1324	.1353	.2225	.1135	.1065	.1852	0.1492
F	.1808	.1276	.2576	.1944	.0888	.2052	0.1757

RANKINGS							
RAA	3	4	1	6	5	2	Mean
A	6	6	6	5	6	6	5.83
B	4	5	4	2	2	3	3.33
C	3	3	3	3	3	4	3.17
D	2	4	5	4	5	5	4.17
E	5	1	2	6	1	2	2.83
F	1	2	1	1	4	1	1.67

*Performance index and RAA rankings by stakeholder*

## Sensitivity Results

Stakeholder	Main Performance Measure Contributors				Zero Utilities <sup>1</sup>
	Main PM	Weight	Rank	Order of RAAs <sup>2</sup>	
1	WHR (fatalities)	.2316	1	F>B=C=D=E; A=0	Changes in Ambient Condition Compared Health Impacts CAH Resources Changes in Resources Long Term Public Cancer Risk Short Term Public accidents
	WHR (routine)	.1158	3	B=E=F>C=D; A=0	
	Contaminant Concentration (TCE)	.1330	2	C=D>E>A>B; F=0	
	Completion Cost	.096	4	F>E>B>>C>D; A=0	
	Transported Waste	.061	5	F>C>B>A; D=E=0	
2	Short Term Public Cancer	.07		B=C=D=E=F; A=0	Changes in Ambient Condition Compared Health Impacts CAH Resources Changes in Resources Short Term Public accidents
	WHR (fatalities)	.056		F>A=B=C=D=E=0	
	WHR (routine)	.028		B=E=F.C,D; A=0	
	Long Term Public Cancer	.094		C=D≅E>>A>B; F=0	
	Contaminant Concentration (TCE)	.055	6	C=D≅A≅E>B; F=0	
	Completion Cost	.110	3	E=F>≅B>C>D; A=0	
	Implementation Cost	.037	8	F>>B; A,C,D,E=0	
Transported Waste	.015	10	A=B=C=F>>D; E=0		
3	WHR (injuries)	.0398		F>A=B=C=D=E=0	Changes in Ambient Condition Compared Health Impacts CAH Resources Changes in Resources Short Term Public Accidents
	WHR (routine)	.1194	3	B=E=F> A=C=D=0	
	Contaminant Concentration (TCE)	.266	2	C=D ≅E>>A>B; F=0	
	Implementation Cost (not discriminating)	.058	4	A=B=C=D=F; E=0	
	ER Waste (not discriminating)	.016	8	A=B=C=D=F; E=0	
4	Long Term Public Cancer Risk	.0525		C=D=E>A>B; F=0	Changes in Ambient Condition Compared Health Impacts CAH Resources <u>Contaminant Conc. (Cr)</u> Changes in Resources Short Term Public accidents
	Impact on Local Economy	.040	6	A=E=D=C>B; F=0	
	Completion Cost	.059	4	E=F=B>C≅D>>A=0	
	Implementation Cost	.037	8	F>>B; A=C=D=E=0	

<sup>1</sup> Those PMs for which the results of the impacts were such that the stakeholder had no utility for that PM across all RAAs. In other words, all the RAAs performed equally poor in regards to this measure.

<sup>2</sup> This refers to the order of the RAAs under this PM .



Stakeholder	Main Performance Measure Contributors				Zero Utilities <sup>1</sup>
	Main PM	Weight	Rank	Order of RAAs <sup>2</sup>	
5	WHR (fatalities)	.0249		F>A=B=C=D=E=0	Changes in Ambient Condition Compared Health Impacts CAH Resources Changes in Resources <u>Worker Health Risk(routine)</u> <u>Short Term Cancer Risks</u> Short Term Public accidents
	WHR (injuries)	.0049		F>>B;A=C=D=E=0	
	Long Term Public Cancer Risk	.0655		C=D≅E>A>B; F=0	
	Completion Cost	.083	5	E=F≅B>C≅D>>A	
	Implementation Cost	.017	10	F=B>A≅C≅D;E=0	
Transported Waste	.020	9	A=B=CF;D,E=0		
6	WHR (injuries)		1		Changes in Ambient Condition Compared Health Impacts CAH Resources Changes in Resources <u>Worker Health Risk(routine)</u> <u>Short Term Cancer Risks</u> Short Term Public accidents
	WHR (fatalities)		1		
	WHR (routine)		1		
	Contaminant Concentration (TCE)				
	ER Waste		6		
	Process Waste		6		
	Transported Waste		6		



## APPENDIX 2

### Deliberation Presentation Material

Pre-deliberation Material that was sent to each stakeholder:

#### **INDIVIDUAL RESULTS — STAKEHOLDER 1**

Our analysis of your input tells us that you prefer alternative F (no action) because F does not involve workers and, thus, avoids worker health risks. F does not generate wastes of any kind, although it leaves the contaminated material in the ground. F is obviously cost-free.

You appear to prefer C and E less than F. Compared to F, both C and E provide a substantial reduction in groundwater contamination risks, but C and E do not fare as well in worker health risk. Unlike F, both C and E require workers who are inevitably exposed to both transportation and contaminant risks. C also has a rather high completion cost. However, E involves a greater amount of waste transported off-site, because E's technology is based on excavation followed by off-site treatment and disposal.

You seem to prefer B slightly less than E and C, perhaps because B yields a higher concentration of contaminant in the groundwater as a result of the on-site remediation.

D requires a greater volume of transported waste and a higher completion cost than B. This is primarily because D requires transportation off-site. For this reason, you apparently prefer D less than B.

You seem to rate alternative A (in-situ vitrification and soil vapor extraction) inferior to the other RAAs because A has high completion costs as well as worker risk. The high completion costs result from the technologies used. Furthermore, this alternative releases a greater amount of chromium particulates during the remediation process, and this exposure puts the workers at greater risk.

The actual numerical results from which the above insights were gleaned are given below. The table and graph show your numerical results and rankings for the RAAs. These rankings are based on the performance indices (PI), which are numerical measures of your overall preferences. The higher the PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. Uncertainty analyses on your performance outputs of the RAAs suggest that the preferences regarding F (your most preferred) and regarding D and A as the least preferred, are stable (relatively certain). E, C, and B only reveal small differences in mean PI values, so each of these could be second best within the uncertainties.

Stakeholder 1	F	E	C	B	D	A
Lower bound	0.2386	0.2047	0.1933	0.1755	0.1687	0.0711
Higher bound	0.2766	0.2403	0.2381	0.2335	0.1971	0.1161
Mean PI	0.2576	0.2225	0.2157	0.2045	0.1829	0.0936
Std deviation	0.019	0.0178	0.0224	0.029	0.0142	0.0225

## INDIVIDUAL RESULTS — STAKEHOLDER 2

Our analysis of your input tells us that you seem to prefer alternative F (no action). This probably is because F does not lead to short-term public health risk from accidents (in comparison to the other RAAs), and you have indicated particular concern for the health and safety of the public. In addition, F has no implementation costs.

You evidently prefer E less than F since E requires transportation of wastes. This contributes to E's lower performance with respect to implementation costs, as the number of trucks and workers involved are greater for this type of remediation. Although E is better than F in the removal of contamination, the fact that E requires waste transportation leads to a poor performance in the short-term public health risk from accidents.

Your preference for B is similar to E. B involves remediation activities on-site; this reduces the amount of transported waste and, thus, leads to significantly lower costs. On the other hand, the long-term public risk of cancer from B is significantly higher than E.

C and D appear considerably less attractive to you because C and D have higher completion costs. These higher costs can be attributed to the thermal desorption treatment and the disposal of the residuals. Furthermore, D requires

transportation of the treatment residuals off-site, which increases the total cost of completion.

You evidently have the lowest preference for A due to its poor performance under worker and public health risks, as well as completion costs. The risks for A are higher due to the fact that chromium particulates are released from the stack and volatilized (vaporized) during the process of in-situ vitrification.

The actual numerical results from which the above insights were gleaned are given below.

The table and graph show your numerical results and rankings for the RAAs. These rankings are based on the performance indices (PI), which are numerical measures of your overall preferences. The higher the PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. Uncertainty analysis on the performance output of the RAAs have shown that your preferences are quite stable (reasonably definite).

Stakeholder 2	F	E	B	C	D	A
Lower bound	0.1999	0.1773	0.1519	0.0986	0.0933	0.0379
Higher bound	0.2105	0.1931	0.1917	0.1576	0.1371	0.0571
Mean PI	0.2052	0.1852	0.1718	0.1281	0.1152	0.0475
Std deviation	0.0053	0.0079	0.0199	0.0295	0.0219	0.0096

### INDIVIDUAL RESULTS — STAKEHOLDER 3

Our analysis of your input tells us that you slightly prefer alternative F (no action). This is perhaps because F does not cause any worker injuries, although F does not solve the problem of groundwater contamination. Worker injuries have a significant impact on the performance of the other RAAs due to the number of workers involved in the remediation of the site. Transportation of the waste is the major contributor to potential injuries, specifically in C, D, and E.

You evidently regard C and D almost as well as F, primarily because C and D remove a substantial amount of the contaminants. This may balance the higher risk of worker injuries with C and D, which is inevitable higher than F's no action.

B can be considered as average; you regard B basically as well as C and D in all categories except contaminant removal. C and D both involve excavation, while B is based on in-situ stabilization for the metals and bioremediation for the organics. B's technologies result in a lower removal efficiency for both contaminants. On the other hand, B has a lower completion cost.

You apparently have a lower preference for E because the implementation cost is greatest among all RAAs. Additionally, E results in a significant amount of environmental restoration waste and transported waste as compared to C and D. This is because E requires off-site treatment and disposal of the contaminants. All of the contaminated soil is excavated and sent off-site for disposal; there is no attempt in E to separate or isolate the actual contaminant. This leads to higher volumes of waste, which need a greater and more expensive transportation capacity.

A is evidently your least preferred alternative. This RAA involves in-situ vitrification which causes chromium particulates to be released from the stack and volatized (vaporized) during the remediation process. This exposure puts the workers at substantially greater risk.

The actual numerical results from which the above insights were gleaned are given below.

The table and graph show your numerical results and rankings for the RAAs. These rankings are based on the performance indexes (PI), which are numerical measures of your overall preferences. The higher the PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. Uncertainty analyses on the performance output of the RAAs suggest that your preferences are rather stable (relatively certain). They also suggest that your preferences for C, D, and F are not markedly different.

Stakeholder 3	F	D	C	B	E	A
Lower bound	0.1659	0.1697	0.1633	0.1387	0.1239	0.052
Higher bound	0.1957	0.1875	0.1909	0.1699	0.1409	0.0902
Mean PI	0.1808	0.1786	0.1771	0.1543	0.1324	0.0711
Std deviation	0.0149	0.0089	0.0138	0.0156	0.0085	0.0191

## INDIVIDUAL RESULTS — STAKEHOLDER 4

Our analysis of your input tells us that your most preferred alternative is E (excavation followed by off-site treatment and disposal). The main reason appears to be that, as with F (no action), E has a low completion cost. At the same time, E has a more substantial impact on the local economy. The local economy benefits from the revenue generated by jobs, taxes, and the purchase of goods and services. Moreover, E performs better than F in terms of long-term public cancer risk. Indeed, E removes a significant amount of the contaminant from the soil and, therefore, results in a lower long-term cancer risk.

You appear to like F (no action) nearly as well as E, except that F has no impact on the local economy and has a higher risk of long-term cancer due to the remaining contamination. An important positive aspect of F is that it has a lower risk of worker injuries than all other RAAs. Other less significant discriminators between F and the other RAAs are the absences of implementation costs and transported or generated wastes.

You show lower preferences for C and D, which have significantly higher completion costs than E. The higher completion costs are due to the type of technology employed. Although C and D perform better on the performance measures regarding environmental restoration waste and transported waste, E does significantly better on the amount of process waste generated.

Your results indicate that B is slightly less preferable than C and D to you. RAA B costs less but results in a lower impact on the local economy. B performs well in terms of worker injuries, yet gives rise to the second highest long-term public cancer risk. As transportation is the primary contributor to worker injuries, this tradeoff is a result of the fact that B does not transport any of the contaminated media off-site. On the other hand, since the contaminant remains on-site, it poses a long-term threat of cancer risk.

You appear to prefer A much less than all other RAAs. A has a lower implementation cost and completion cost. But, due to the fact that chromium particulates are released during the in-situ remediation process, the risk to individual worker health is significantly larger than that of other RAAs.

The actual numerical results from which the above insights were gleaned are given below.

The table and graph show your numerical results and rankings for the RAAs. These rankings are based on the performance indices (PI), which are numerical measures of your overall preferences. The higher your PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. The uncertainty analyses on your performance output for the RAAs show that your rankings are rather stable (relatively certain).

Stakeholder 4	E	F	C	D	B	A
Lower bound	0.1291	0.1193	0.1136	0.114	0.101	0.0403
Higher bound	0.1415	0.1359	0.1298	0.126	0.1212	0.0655
Mean PI	0.1353	0.1276	0.1217	0.12	0.1111	0.0529
Std deviation	0.0062	0.0083	0.0081	0.006	0.0101	0.0126

#### INDIVIDUAL RESULTS — STAKEHOLDER 5

Our analysis of your input tells us that you have a slight preference for alternative E (excavation followed by off-site treatment and disposal). Your primary reasons seem to be the low completion costs for this alternative and the lower long-term public risk of cancer.

You appear to prefer B, C and F slightly less than E. Although they perform better with respect to the programmatic objectives for waste minimization and have lower implementation costs, they pose a significant risk of long-term cancer since the contaminated matter is left on-site. B and F have completion costs similar to those of E; however, B and F perform worse when it comes to long-term public cancer risk. On the other hand, C is more expensive than B and F, yet C performs comparably to E in long-term cancer risk.



D results in greater transported waste since, unlike C, it requires the off-site disposal of the treatment residuals.

You apparently rank A (in-situ vitrification and soil vapor extraction) inferior to the other RAAs because A has higher completion costs as well as a greater long-term public cancer risk. Furthermore, this alternative releases a greater amount of chromium particulates during the in-situ vitrification process, and this exposure puts the workers at greater risk.

The actual numerical results from which the above insights were gleaned are given below.

The table and graph show your numerical results and rankings for the RAAs. These rankings are based on the performance indices (PI), which are numerical measures of your overall preferences. The higher your PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. The uncertainty analyses on your performance output of the RAAs suggest that your rankings of alternatives F, B, and C are not markedly different. The small differences among the mean PI values are largely overshadowed by the uncertainties. Alternatives F and B show a somewhat lower uncertainty than C. Your preferences for E and A are sufficiently stable (relatively certain).

Stakeholder 5	E	B	C	F	D	A
Lower bound	0.0968	0.0759	0.0661	0.0748	0.0623	0.0288
Higher bound	0.1162	0.1061	0.1155	0.1028	0.1017	0.0714
Mean PI	0.1065	0.091	0.0908	0.0888	0.082	0.0501
Std deviation	0.0097	0.0151	0.0247	0.014	0.0197	0.0213

### INDIVIDUAL RESULTS — STAKEHOLDER 6

Our analysis of your input tells us that you seem to prefer alternative F (no action) because F does not generate waste of any kind, although it leaves the contaminated material in the ground. F is obviously cost-free, and F does not involve workers, so there are no worker health risks.

You appear to prefer B and C less than F because B and C produce significantly more process waste than F. B and C perform similarly to F with respect to transported waste and environmental restoration waste generated (negligible amounts in both cases). B and C do, however, perform better than F with respect to groundwater contamination, due to the fact that F does not remove or treat any of the contaminated environmental media. On the other hand, in the remediation process, both B and C produce significant worker risks.

You seem to prefer D less than B and C because the treatment of the residuals occurs off-site and, thus, D requires greater transportation activity. Transportation of the waste contributes significantly to worker risks. Thus, D does not perform as well with respect to either transported waste or worker injury risks.

You appear to regard A as similar to B in most regards. However, the individual worker health risk is greater in A due to the fact that chromium particulates are released from the stack and vaporized during the treatment process.

E is your least preferred alternative, evidently because of the large amounts of transported waste and waste generated by environmental restoration, which also give rise to more significant worker health risks. This is primarily a result of the excavation which is part of the remediation process. Although RAA E removes the contaminants, transportation has a risk of fatalities which is two times higher than other activities.

The actual numerical results from which the above insights were gleaned are given below. The table and graph show your numerical results and rankings for the

RAAs. These rankings are based on the performance indices (PI), which are numerical measures of your overall preferences. The higher the PI value, the more preferable the RAA is to you.

Uncertainties in the PI values are indicated by the standard deviations in the table, as well as by the spread between low and high bounds. Uncertainty analyses on the performance outputs of the RAAs suggest that your preferences are stable (relatively certain).

Stakeholder 6	F	B	C	D	A	E
Lower bound	0.1766	0.1526	0.1424	0.1348	0.1251	0.1135
Higher bound	0.2122	0.1662	0.167	0.1422	0.1343	0.1135
Mean PI	0.1944	0.1594	0.1547	0.1385	0.1297	0.1135
Std deviation	0.0178	0.0068	0.0123	0.0037	0.0046	0



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