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Office of Emergency and
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Washington DC 20460

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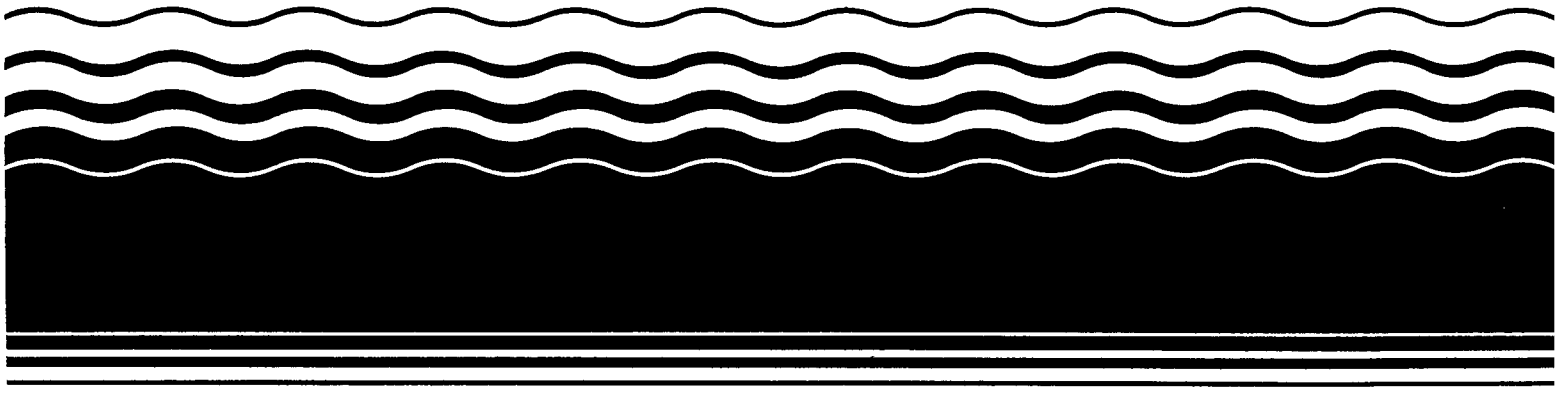
Superfund

EPA

OSWER Comparative Risk Project

Executive Summary and Overview



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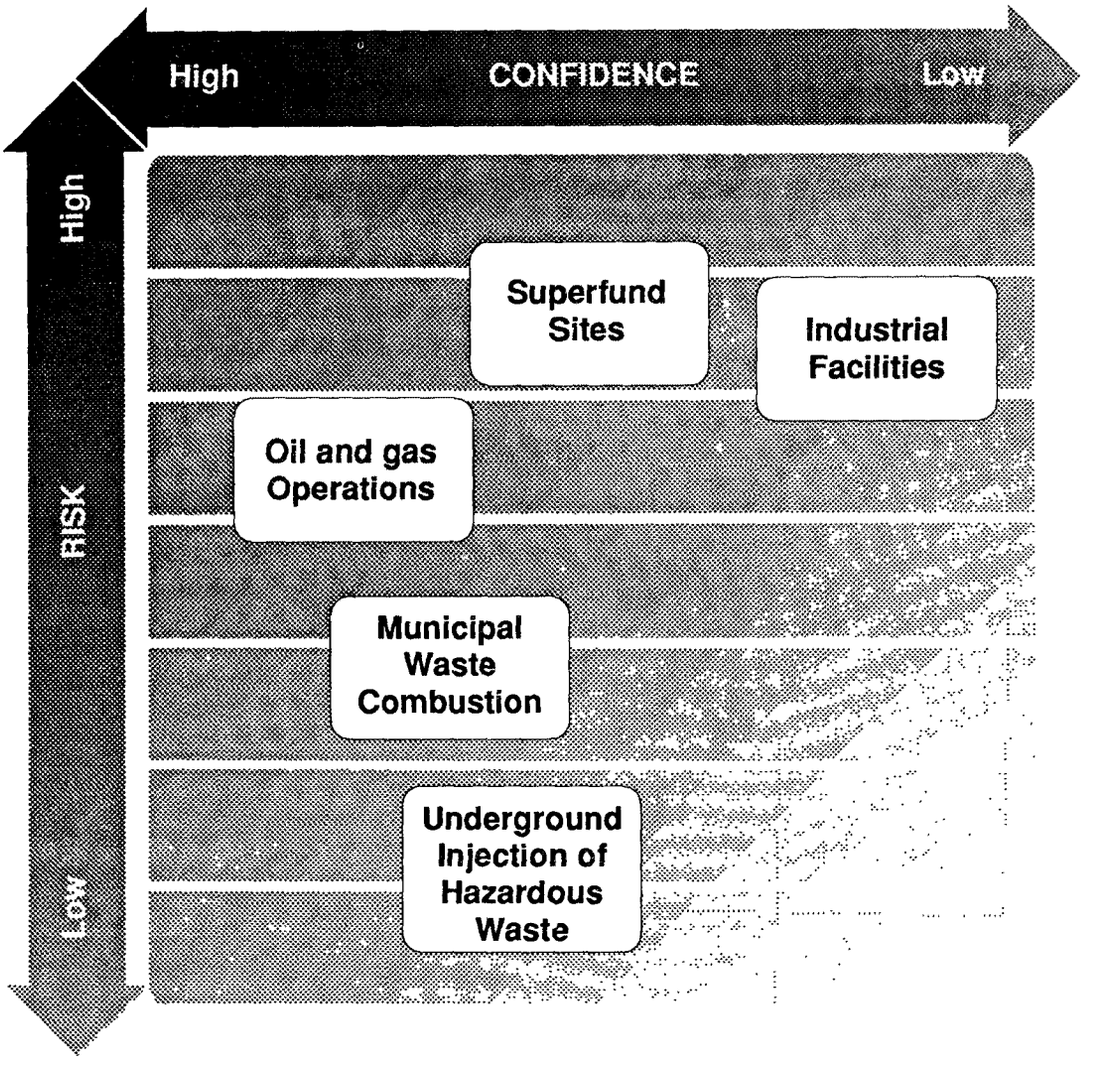

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

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EXECUTIVE SUMMARY

The Office of Solid Waste and Emergency Response (OSWER) Comparative Risk Project was initiated to serve strategic planning needs by exploring the comparative risks posed by various waste management practices regulated by and/or under OSWER purview. The study was also undertaken to gain experience in performing comparative analysis, identifying information needs, and assisting in establishing research priorities.

In evaluating study goals, a number of objectives became apparent, including:

- Identifying Data Needs: provide for more consistent evaluations of relative and absolute risks across different program areas that OSWER addresses;
- Improve on Explicit Use of Data: allow for reevaluating rankings as new information becomes available (algorithms are made explicit where possible);
- Public Perception and Risk: address the apparent disparity between the public's perception of risks and the actual risks that may require priority OSWER attention in the future; and
- Type of Decision: provide a clearer separation of risk assessment from risk management.

The outputs/products of this study are expected to serve to rank important waste management problems facing OSWER; identify public health and environmental problems for future investigation; and identify data needs and uncertainties associated with information gaps. The findings of this study are not intended as an assessment of the effectiveness of existing regulatory controls or as justification for more or less regulatory involvement.

SCOPE AND ORGANIZATION OF THE STUDY

This study was organized with a study chair and five Workgroups. The five Workgroups are: (1) Acute Events, (2) Other Health Effects, (3) Ecological Effects, (4) Welfare Effects[1], and (5) Ground Water Valuation. Each workgroup produced a separate report. The Workgroups divided the universe of public health and environmental problems into different problem areas. These problem areas generally reflected organizational structure and program priorities. The

[1]The Welfare Effects Workgroup examined impacts on welfare (which were defined as damages to economic resources that result in a reduction in the value of commercial activities or in the value of human well-being). This approach was chosen because of the lack of studies associating economic impacts with OSWER problem areas. While the supporting workgroup report is titled "Report of the Economic Effects Workgroup", the Workgroup recommended that "Welfare Effects" be used for purposes of the overview report.

Workgroups believe that the list of problem areas accounts for the principal risks associated with OSWER's programs.

FINDINGS

Table ES-1 summarizes both the relative rankings (e.g., high, medium, and low) and the level of confidence of the rankings. The workgroup rankings were developed through a process that involved the evaluation of available information and judgments to estimate the relative risks associated with each problem area.

The problem areas in Table ES-1 are ordered by decreasing severity--that is, those judged to represent the highest risks are at the top and those judged to pose the least risks are at the bottom. Because it provides a range of results associated with the individual workgroup rankings, Table ES-1 can only be used to stratify problem areas into broad groups.

For purposes of this overview report, the workgroup rankings have been stratified into three bands:

- High: Those problem areas that have at least two rankings of high and were assessed by at least four workgroups. This band includes Municipal Landfills; Industrial Facilities; Hazardous Waste Storage Treatment Tanks, Drums and Containers; and Land Disposal of Hazardous Waste.

- Medium: Those problem areas not grouped as "high" or "low" relative risk for purposes of this overview report.

- Low: Those problem areas that did not receive any "high" rankings. Problem areas grouped into as "low" were ranked by no more than four workgroups and had a minimum of at least two low rankings by the Workgroups. (While Ocean Dumping was ranked as high (with high confidence) within the Ecological Effects Workgroup, the definition of Ocean Dumping included activities OSWER programs do not address. As such, the ranking of Ocean Dumping within this matrix has been adjusted downward.)

Had Superfund activities been grouped into one single category, it appears that the ranking would have been: medium by the Acute Events workgroup and high for the other four workgroups. Given this combination, Superfund activities would be moved from the "medium" risk grouping to "high".

Because risk is a continuum, these three broad bands of problem areas reflect professional judgment, not risk thresholds. Table ES-1 suggests that those problem areas with better supporting information tended to be associated with higher confidence and also were actually ranked (as opposed to not being ranked or being combined with other problem areas).

The underlying information used to support rankings shown in Table ES-1 differs significantly both within and across Workgroups. The differences

include such factors as measures of risk used for ranking and the quality of information needed for ranking. These rankings provide risk estimates associated with current emissions that reflect in-place controls. Obviously, rankings would differ without controls. Selected highlights that may assist in interpreting Table ES-1 include:

- Industrial Facilities: All Workgroups except the Ground Water Valuation Workgroup stated that they believed that risks may be substantially higher than the data suggest and that more data should be collected.

- Superfund Sites: The Other Health Effects Workgroup considered current National Priorities List [NPL] sites (currently about 1,200 sites) and sites that are to be evaluated for NPL listing (currently over 30,000 sites). The Welfare Effects and the Other Health Effects Workgroups combined remedial and removal actions at both NPL and non-NPL sites. The other workgroups considered only removal actions at NPL or potential NPL sites.

- Chemical and Industrial Manufacturing Facilities: The Other Health Effects Workgroup called this problem area "Chemical and Industrial Manufacturing Facilities" or "Accidental Releases at Chemical Facilities." The Welfare Effects Workgroup called this problem area "Accidental Releases at Chemical Facilities." The Acute Events Workgroup addressed only risks posed to workers at chemical and industrial facilities.

- Underground Storage Tanks: This problem area was only considered by the Ground Water Valuation Workgroup. It includes: hazardous substance product storage tanks, petroleum underground storage tanks, and exempt underground storage tanks.

- Underground Injection of Hazardous Waste: The Other Health Effects Workgroup considered injection of hazardous waste into Class I injection wells. The other workgroups considered all underground injection of hazardous waste regulated under 40 CFR Part 267 Subpart G and 40 CFR Part 146.

Table ES-1 suggests that the relative rankings of problem areas are generally consistent with program priorities, and that some problem areas not necessarily perceived as high program priorities could be ranked high even though they are supported by relatively uncertain information.

PROGRAM RECOMMENDATIONS

The following long-term recommendations for the continued support of strategic planning are:

- Risk Rankings: should be reviewed periodically to incorporate new information gathered.

- Centralized Repository: should be established for the maintenance of information used to perform the rankings.

To provide a more consistent basis to support decisions on program direction, the Workgroups recommend developing better information in the following areas:

- Broader Range of Information Collection: Information was especially limited and of low quality for ecological effects, welfare effects, and ground water valuation. Consideration should be given to enhanced data collection and methodological work in these areas.

- Cross Media Analysis: It is recommended that efforts be made to better assess major risks from all pathways as opposed to those pathways easiest to evaluate.

- Low Confidence Areas: The Workgroups expressed particularly low confidence in their findings in four problem areas (i.e., Mixed Wastes, Other Treatment, Storage, and Disposal Facilities, Industrial Facilities, and Solid Waste Management Units). Future analyses should benefit from more and better data in these areas.

- Ground Water Valuation: The Ground Water Valuation Workgroup eliminated 13 problem areas from consideration, partly due to lack of information. The Ecological Effects Workgroup did not consider Removal Actions at Non-NPL Sites due to insufficient data. To improve future studies, EPA should benefit from obtaining new data sources for these problem areas.

Finally, to improve confidence of the findings of this and future studies, sensitivity analyses of the use of alternative methodologies and the corresponding impacts on final rankings would be useful.

ES-1

COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS

	Workgroup Ranking					
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-Water Valuation	
Municipal Landfills	L	M	*H*	H	*H*	High
Industrial Facilities	H	H	M	H	-	High
Hazardous Waste Storage Treatment Tanks, Drums, and Containers	*M*	H	*M*	H	-	High
Petroleum Underground Storage Tanks	H	M	*ML*	H	-	High
Land Disposal of Hazardous Waste	*M*	*M*	*H*	H	*M*	High
Superfund Sites	-	H	-	H	H	Medium
Remedial Activities	*L*	-	*H*	-	-	Medium
Transportation of Hazardous Materials	*H*	*L*	*ML*	L	-	Medium
Chemical and Industrial Manufacturing Facilities	*H*	L	*ML*	L	-	Medium
Underground Storage Tanks	-	-	-	-	H	Medium
Oil Spill Response	H	L	*ML*	L	-	Medium
Oil and Gas Operations	H	*M*	M	M	*L*	Medium
Solid Waste Management Units	M	*H*	ML	*M*	*M*	Medium
Exempt Storage Tanks	M	M	*ML*	*M*	-	Medium
Mining Wastes	L	*M*	*MH*	*M*	*M*	Medium
Other Treatment, Storage, and Disposal Facilities	*M*	M	M	M	*L*	Medium
Removal Activities	*M*	-	-	-	-	Medium
Combustion of Hazardous Waste	*M*	M	*M*	L	L	Medium
Municipal Waste Combustion	*L*	*M*	MH	L	L	Medium
Hazardous Substance/Product Underground Storage Tanks	M	M	*M*	L	-	Medium
PCB Wastes	M	L	MH	L	-	Medium
Land Treatment of Hazardous Wastes	*L*	*M*	M	L	-	Low
Underground Injection of Hazardous Waste	*M*	L	ML	L	-	Low
Mixed Wastes	L	L	M	L	-	Low
Ocean Dumping	L	L	H	L	-	Low
Ocean Incineration	L	-	*ML*	L	-	Low

Notes on the Comparison Table

Letters reflect relative risk rankings judged for problem areas:

$\mathcal{H}$	High or higher relative risk potential
$\mathcal{MH}$	Moderately high relative risk potential
$\mathcal{M}$	Medium or moderate relative risk potential
$\mathcal{ML}$	Moderately low relative risk potential
$\mathcal{L}$	Low or lower relative risk potential
—	The workgroup did not consider this problem area.

Uncertainty is reflected in lettering as:

H	Low uncertainty (high confidence)
$\mathcal{H}$	Medium uncertainty (medium confidence)
$\vdash\!\!\dashv$	High uncertainty (low confidence)

No attempt was made to "add" risks across Workgroups or compare the importance of one Workgroup as more significant than another. Note that differences in problem areas addressed is due to a combination of available data and scope.

CHAPTER 1. INTRODUCTION

The Office of Solid Waste and Emergency Response (OSWER) Comparative Risk Project was initiated to serve strategic planning needs by exploring the comparative risks posed by various waste management practices regulated by and/or under OSWER purview. The study was also undertaken to gain experience in performing comparative analysis, identifying information needs, and assisting in establishing research priorities.

The statutory goals for the solid waste program direct the Agency to promote protection of health and the environment. The statutory language varies among the different programs, the emphasis is consistently on developing standards to protect the health and the environment or by adopting standards of other Agency programs.

In evaluating study goals, a number of objectives became apparent, including:

- Identifying Data Needs: provide for more consistent evaluations of relative and absolute risks across different program areas that OSWER addresses;
- Improve on Explicit Use of Data: allow for reevaluating rankings as new information becomes available (algorithms are made explicit where possible);
- Public Perception and Risk: address the apparent disparity between the public's perception of risks and the actual risks that may require priority OSWER attention in the future; and
- Type of Decision: provide a clearer separation of risk assessment from risk management.

1.1 ORGANIZATION

This report is organized as follows:

- Chapter 1: Introduction -- addresses the goal of this study, its relationship to strategic planning, and its relationship to Agency comparative risk efforts.
- Chapter 2: Study Approach -- addresses specific problem areas covered and the overall approach used.
- Chapter 3: Study Results -- addresses the confidence in the data sources and methodology used, differences among the Workgroups (including problem areas addressed and methodologies used), future data needs, and the comparison of risks.

- **Chapter 4: Information Needs** -- addresses the links between information needs based upon the rankings of problem areas and the type and quality of information available to support rankings.

- **Appendix A: Glossary** -- defines key terms.

- **Appendix B: Definition of OSWER Problem Areas** -- defines the areas addressed by the Workgroups.

- **Appendix C: Individual Workgroup Methodologies** -- addresses the different methodologies used by the Workgroups to determine the relative risk of the OSWER problem areas.

These materials constitute the project overview. The original workgroup reports that provide the foundation for this overall report should also be reviewed for detailed evaluations of information bases, assumptions, and references.

1.2 RELATIONSHIP OF STUDY TO AGENCY COMPARATIVE RISK EFFORTS

The OSWER Comparative Risk Project is a follow on to an earlier Agency effort. In 1986, the Administrator commissioned a special task force of senior EPA managers and technical experts to compare the risks associated with major environmental problems. In February 1987, the task force issued its report, *Unfinished Business: A Comparative Assessment of Environmental Problems*. The report was an Agency-wide effort that examined all environmental problems facing the nation and estimated the relative risk to public health and the environment posed by each problem area, assuming existing levels of regulatory control.

In many instances, the rankings in *Unfinished Business* did not correspond closely with EPA's current program priorities. For example, areas of substantial Agency effort identified as posing relatively low risk included hazardous waste and Superfund sites, underground storage tanks, and municipal non-hazardous waste sites. The report, however, suggested that this seemingly anomalous result was not necessarily inappropriate. Rather, some problem areas appeared to pose relatively low risks precisely because of the high levels of Agency resources were devoted to controlling them. Furthermore, *Unfinished Business* noted higher levels of effort may remain necessary to hold risks at current levels. In reviewing *Unfinished Business*, the Workgroups determined that at least one reason that OSWER problem areas did not rank high was the lack of information to support development of national chemical-specific rankings. Solid waste programs often focus on waste streams and may lack pollutant-specific information on risks. Moreover, information on Superfund risks may exist but is sometimes difficult to obtain. As such, the OSWER Comparative Risk Project was viewed as an opportunity to make fuller use of newer program-related information including information under development when *Unfinished Business* was being prepared.

Unfinished Business relied upon professional judgment (supported by background materials) to develop rankings. Thus, it is not possible to modify the rankings in *Unfinished Business* based on additional information. The OSWER

Comparative Risk Project was designed to generate rankings through a process that better documented the algorithm and rationale used to generate rankings. If the rationale for the algorithms and rankings could be documented, both algorithms and the rankings could be updated as new information becomes available.

1.3 RELATIONSHIP OF STUDY TO STRATEGIC PLANNING

In June 1985, the Administrator initiated a strategic planning process. The process was intended to assist in developing a consensus around environmental goals across all media and help establish program priorities. The resulting OSWER strategic planning initiative was based on the concept of preventing waste transfers from one location to another and one medium to another. Given the absence of a cross-media perspective on waste management issues, it is possible that a specific regulation in one media may shift waste to other media without reducing risks to human health or the environment. This study supports this larger planning process.

Comparing risks from releases to different media allows OSWER to begin to assess the consequences of regulation in different media. In the long-term, this study will support OSWER strategic planning by: identifying public health and environmental problems for future investigation; and identifying data gaps and associated uncertainties.

This study should be seen only as an early step in the larger strategic planning process. It was undertaken to gain experience in performing comparative analysis, as much as for the results of the analysis itself. This study is an opportunity to make fuller use of available information and to build upon the experience of *Unfinished Business*. While the results are expected to assist in the identification of information gaps and in establishing research priorities, no other applications of the results have been determined at this time. Thus, the findings are not intended to assess the effectiveness of existing regulatory controls or justify more or less regulation.

CHAPTER 2. STUDY APPROACH

This chapter addresses the general study approach. The overall methodology (Section 2.1) and the OSWER problem areas (Section 2.2) are also discussed.

2.1 OVERALL APPROACH

This study was organized with a study chair and five workgroup chairs. The five Workgroups are: Acute Events; Other Health Effects; Ecological Effects; Welfare Effects; and Ground Water Valuation. Each workgroup produced separate reports (which are summarized in Appendix C). Workgroup assumptions, references employed and other useful information is available in the individual reports.

To promote consistency, the Workgroups began with the same set of environmental problem areas. A centralized effort was initiated to collect information and seek review for completeness and technical accuracy. This information was used as a baseline for ranking the problem areas.

The evaluation relied primarily upon readily available information, where possible. However, in discussing possible approaches they might take, the Workgroups decided to modify the approach employed in Unfinished Business. Recognizing that direct comparisons across problem areas are difficult, the following steps were undertaken to improve the plausibility of such comparisons:

- promoted the consistent use of information across Workgroups,
- requested assumptions be explicitly stated and
- characterized uncertainties associated with the rankings.

Assessing health risks is generally easier than assessing risks associated with other measures of environmental damage (e.g., ecological risks) because of availability of information and acceptance of consistent methods to evaluate risks. The assessment process is further complicated by the difficulties in relating risks to the types of activities. For example, it is difficult to relate specific health risks (typically assessed by a single chemical) to different types of heterogenous hazardous waste.

Another difficulty in comparing health risks with other measures of environmental damage is the difficulty in comparing endpoints that must be associated with differing levels of confidence (or uncertainty). The uncertainty of a specific endpoint (economic impact) is a function of the uncertainties associated with both the inputs and algorithm employed. As previously stated, measures of environmental risk such as economic impacts may be the most relevant measures for some audiences, but are also the most uncertain and the most limited in the support of comparisons. Thus, the strength of conclusions in this report reflects consideration of the relative uncertainties of the input parameters and the algorithm employed to rank problem areas.

2.2 OSWER PROBLEM AREAS

OSWER problem areas generally reflected organizational structure and program priorities. The 24 problem areas represent the principal risks associated with OSWER's programs (as defined in Appendix B). These problem areas are not mutually exclusive; the same release may be addressed in more than one problem area (e.g., disposal of PCB wastes at a site on the National Priorities List may be reflected in both the problem areas PCB Wastes and Remedial Actions). This potential for "double counting" is noted wherever possible.

2.2.1 Problem Area Definitions

Differences in the Workgroups' definitions for some problem areas created difficulty in comparing relative risk rankings. These differences can be divided into two categories:

- those related to different types of wastes or waste management practices and
- those related to different types of events.

A number of the workgroups included different types of waste and waste management practices in the same problem area. For the Underground Injection of Hazardous Waste problem area, the Other Health Effects Workgroup considered injection of hazardous waste into Class I injection wells, while the other workgroups considered all underground injection of hazardous waste regulated under 40 CFR Part 267 Subpart G and 40 CFR Part 146. In the Ocean Dumping problem area, Workgroups diverged in their definitions of what constituted ocean dumping. The Other Health Effects and Welfare Effects Workgroups considered risks from ocean dumping of municipal waste, dredge spoil, and discharges of industrial waste into the ocean, the Ecological Effects Workgroup considered risks from ocean dumping of municipal waste and dredge spoil, and the Acute Events Workgroup only considered risks from ocean dumping of municipal waste.

As to the types of events and associated risks considered, the Acute Events Workgroup took a different approach. For example, in the Oil and Gas Operations problem area, the Acute Events Workgroup considered only the effects of blow-outs at oil wells, while other workgroups considered the effects of releases from wastes resulting from oil and gas activities.

In the Chemical and Industrial Manufacturing Facilities problem area, the Acute Events Workgroup addressed only risks posed to workers at chemical and industrial facilities, whereas other workgroups considered the impacts of releases both within and outside chemical and industrial manufacturing facilities.

2.2.2 Problem Areas Addressed

Every workgroup did not address all of the 24 OSWER problem areas. In fact, only five problem areas were addressed by all the Workgroups (Combustion of Municipal Waste, Land Disposal of Hazardous Wastes, Mining Wastes, Other Treatment, Storage, and Disposal Facilities, and Municipal Landfills). Four other problem areas (Remedial Activities, Hazardous Substance Product Storage Tanks, Petroleum Underground Storage Tanks, and Exempt Storage Tanks) also were addressed by all Workgroups, but were merged with existing/new problem areas. For the Remedial Activities, the Other Health Effects Workgroup and Welfare Effects Workgroup combined this problem area with Removal Activities to create a new problem area called Superfund Removal and Remedial Activities. Similarly, the Ground Water Valuation Workgroup combined Hazardous Substance Product Storage Tanks, Petroleum Underground Storage Tanks, and Exempt Storage Tanks, into a single problem area called Underground Storage Tanks.

Workgroups excluded problem areas from consideration for two reasons:

- insufficient data were available to properly assess the relative potential risk posed by a problem area or
- the relative risks were too small to merit analysis.

Based on these criteria, the Ground Water Valuation Workgroup eliminated 13 problem areas: Land Treatment of Hazardous Waste; Hazardous Waste Storage Treatment Tanks, Drums, and Containers; PCB Wastes; Mixed Wastes; Underground Injection of Hazardous Waste; Transportation of Hazardous Materials; Removal Activities; Industrial Facilities; Municipal Waste Combustion; Oil Spill Response; Chemical and Industrial Manufacturing Facilities; Ocean Incineration; and Ocean Dumping. The other four workgroups evaluated most of the other problem areas.

CHAPTER 3. STUDY RESULTS

This chapter addresses general results reported from each of the Workgroups; specific rankings of the Workgroups; methodological and data factors affecting the rankings; and data quality and confidence.

3.1 GENERAL RESULTS

This section draws upon the highlights of the results reported in the individual reports. While Appendix C summarizes approaches, data use and results, the individual reports contain additional information.

3.1.1 Acute Events

The Acute Events Workgroup provided recommendations in three key areas: new data collection efforts; revisiting risk rankings/estimates of relative risk over time; and greater data centralization.

- New Data Collection: Two criteria were employed to formulate recommendations:

  - data were especially poor and

  - the relative risks may be greater than the numeric score may reflect.

  With few exceptions, data needs are greatest for problem areas in the low relative risk ranking group. The Workgroups stressed that the following problem areas appeared to warrant additional work: Ocean Dumping, Combustion of Municipal Wastes, Mining Waste, Municipal Landfills, and Mixed Wastes.

- Revisiting risk rankings/estimates of relative risks over time: The Workgroup recommended that all the problem areas be assessed periodically to determine if regulatory or technological changes have affected the relative risks posed by acute events.

- Greater Data Centralization: The Workgroups concluded that considerable information is available through State agencies, Regional EPA offices, different offices within EPA, and other federal agencies. While many problems are involved in developing an accurate, reliable centralized reporting system, such a system should make a significant difference through improving confidence in rankings, providing a basis for re-visiting rankings, and providing for more reliable priority setting.

3.1.2 Other Health Effects

The Other Health Effects Workgroup provided both substantive and general recommendations. The substantive recommendations are:

- Risks associated with Mixed Wastes, Ocean Incineration, and Underground Injection, appear to be very low. Additional work based on health risks, in the absence of new information, is not recommended.

- Improve on cross media analysis, especially the evaluation of air risks. In particular, air risks associated with Land Disposal of Hazardous Wastes and Municipal Landfills are substantially higher than anticipated.

Other recommendations that addressed general risk assessment activities included:

- Continue efforts to model risk associated with waste-related problems. Such modeling offers valuable insights into health problems and is critical to informed regulatory decision-making and priority-setting.

- Develop consistent assumptions for use in assessing exposure and characterizing the quality of the information.

- Evaluate all pathways for their potential risks to public health. Air or direct contact risks could be larger than risks associated with the drinking of contaminated ground water.

- Address risks associated with noncarcinogenic health effects more critically (there appears to be a bias towards cancer risks).

- Use modeling results, not just monitoring data, to assess exposure, especially for air and drinking water.

3.1.3 Ecological Effects

The Ecological Effects Workgroup stressed that the absolute numerical rankings in its report should not be taken as absolute because of the assumptions employed to develop rankings and the data limitations. In general, data were limiting for many problem areas. The Workgroup provided several recommendations, including:

- In presenting data on ecological risks, the associated uncertainties, limited meaningful measures of pollutant-related stress, and the lack of quantitative ecological risk information, all make the assessment of ecological risks difficult. As such, it is recommended that the uncertainties of this analysis be carried forward in subsequent presentations of the data.

- Conduct a comprehensive review to identify situations with the greatest potential for significantly damaging to important bird and mammal populations. In addition to the scientific literature, information generated by the Fish and Wildlife Service, NOAA, EPA Regional Offices, and State environmental and natural resources agencies will enable EPA to better focus its efforts.

- Form a task force to examine inter- and intra-Agency projects that have incorporated ecological effects data and risk assessment methodologies. The task force should: (1) coordinate Federal efforts both within EPA (e.g., the Office of Pesticides and Toxic Substances) and other departments (e.g., Department of Agriculture, Department of the Interior); (2) assess available data bases and evaluate international efforts to obtain data specific to ecosystem impacts; (3) coordinate with the Agency-wide groups (specifically the eco-risk planning group on Reducing the Uncertainty in Risk Assessments (RURA); and (4) following completion of the above steps, organize an international conference.

3.1.4 Welfare Effects

The Welfare Effects Workgroup recommended that welfare damages be investigated carefully for these high risk problem areas if any new comparative risk analysis is initiated. The Workgroup further recommended that if assessing welfare impacts is a priority for future regulatory activities, then the uncertainties associated with rankings and data should be explicitly considered.

3.1.5 Ground Water Valuation

The Ground Water Valuation Workgroup focused on the approach and analysis employed to assess resource damage to drinking water supplies on the basis of replacement costs.

3.2 KEY FINDINGS

This section addresses the key findings of each workgroup analyses. Final rankings, data quality and confidence levels, and overall confidence in rankings are discussed.

3.2.1 Final Rankings

Table 1 summarizes both the relative rankings (e.g., high, medium, and low), and the level of confidence (indicated by text face) of the rankings. The workgroup rankings were developed through a process that involved the evaluation of available information and judgments to estimate the relative risks associated with each problem area.

The problem areas in Table 1 are ordered by decreasing severity--that is, those judged to represent the highest risks are at the top and those judged to pose the least risks are at the bottom. Because it provides a range of results associated with the individual workgroup rankings, Table 1 can only be used to stratify problem areas into broad groups.

For purposes of this overview report, the workgroup rankings have been stratified into three bands:

- High: Those problem areas that have at least two rankings of high and were assessed by at least four workgroups. This band includes Municipal Landfills; Industrial Facilities; Hazardous Waste Storage Treatment Tanks, Drums and Containers; and Land Disposal of Hazardous Waste.

- Medium: Those problem areas not grouped as "high" or "low" relative risk for purposes of this overview report.

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Had Superfund activities had been grouped into one single category, it appears that the ranking would have been: medium by the Acute Events workgroup and high for the other four workgroups. Given this combination, Superfund activities would be moved from the "medium" risk grouping to "high".

Given that the ordering of problem areas shown in Table 1 has been derived from the ranking efforts of the individual workgroups, the ordering of problem areas shown in Table 1 reflects the assumptions associated with the rankings of each workgroup, and then some additional assumptions. For this reason, rankings within a workgroup (e.g., high, medium high, medium, etc.) are more certain than the compilation of rankings across workgroups. Due to the limitations of the data and methods used to develop the rankings, minor differences in rankings among problem areas should not be construed to represent genuine differences in aggregate, national risks. Moreover, these three broad bands of problem areas reflect professional judgment, not risk thresholds.

The underlying information used to support rankings shown in Table 1 differ significantly both within and across workgroups. The differences include such factors as measures of risk used for ranking and the quality of information needed for ranking. These rankings provide risk estimates associated with current emissions that reflect in place controls. Obviously, rankings would differ without controls. Selected highlights that may assist in interpreting Table 1 include:

- Industrial Facilities: All workgroups except the Ground Water Valuation Workgroup stated that they believed that risks may be substantially higher than the data suggest and that more data should be collected.

- Superfund Sites: The Other Health Effects Workgroup considered current National Priorities List [NPL] sites (currently about 1,200 sites) and sites that are to be evaluated for NPL listing (currently over 30,000 sites). The Welfare Effects and the Other Health Effects Workgroups combined remedial and removal actions at both NPL

and non-NPL sites. The other workgroups considered only removal actions at NPL or potential NPL sites.

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- Underground Injection of Hazardous Waste: The Other Health Effects Workgroup considered injection of hazardous waste into Class I injection wells. The other workgroups considered all underground injection of hazardous waste regulated under 40 CFR Part 267 Subpart G and 40 CFR Part 146.

Table 1 suggests that the relative rankings of problem areas are generally consistent with program priorities, and that some problem areas not necessarily perceived as high program priorities could be ranked high even though they are supported by relatively uncertain information. Table 1 also suggests that those problem areas with better supporting information tended to be associated with higher confidence and also were actually ranked (as opposed to not being ranked or being combined with other problem areas).

The Acute Events Workgroup ranked Transportation of Hazardous Materials, Oil & Gas Operations Waste, Oil Spill Response, Accidental Releases at Chemical Facilities, Petroleum Underground Storage Tanks, and Industrial Non-Hazardous Waste Facilities highest; and ranked Ocean Dumping, Remedial Actions at NPL Sites, Municipal Waste Combustion, Land Treatment of Hazardous Waste, Mining Waste, Ocean Incineration, Mixed Waste, and Municipal Landfills lowest.

The Other Health Effects Workgroup ranked Superfund Activities, Industrial Non-Hazardous Waste Management Facilities, Solid Waste Management Units, and Hazardous Waste Storage and Treatment Tanks, Drums, and Containers at the top of their list. In contrast to the Acute Events Workgroup, Oil Spill Response was among the lower risk problem areas. It is worthwhile noting that Solid Waste Management Units received a high ranking in this workgroup, but there was a lack of data to support this ranking at the time that the rankings were developed. However, the Regulatory Impact Analysis (released after drafting of this report) for the Corrective Action rule generally supports the rankings assigned by this workgroup.

In contrast to the Acute Events Workgroup, the Ecological Effects Workgroup ranked Ocean Dumping as the highest. This ranking assumed that Ocean Dumping includes practices that are not and are not expected to be addressed by OSWER because they are addressed by other programs (e.g., air or water).

However, like the Other Health Effects Workgroup, the Ecological Effects Workgroup ranked Remedial Actions at NPL Sites in the high risk group. Other problem areas that were ranked as posing relatively high risk were: Land Disposal of Hazardous Waste, Municipal Landfills, PCB Wastes, and Mining Wastes. Problem areas that particularly low included: Underground Injection of Hazardous Waste, Oil Spill Response, Solid Waste Management Units, Transportation of Hazardous Materials, Exempt Underground Storage Tanks, and Accidental Releases at Chemical Manufacturing Facilities.

The Welfare Effects Workgroup placed problem areas into three broad relative risk categories. The Workgroup concluded that comparisons beyond this level of detail were not justified, considering the quality of data supporting individual scores. At this level of comparison, however, the Workgroup expressed reasonable confidence in its conclusions. Superfund Activities, Solid Waste Management Units, Land Disposal of Hazardous Waste, Industrial Non-Hazardous Waste Facilities, Petroleum Underground Storage Tanks (Including Used Oil), Municipal Landfills, Hazardous Waste Storage and Treatment Tanks were all ranked relatively high by the Welfare Effects Workgroup. Combustion of Hazardous Waste, Transportation, Hazardous Substance Underground Storage Tanks, Land Treatment of Hazardous Waste, Oil Spill Response, Underground Injection, Ocean Dumping, PCB Wastes, Accidental Releases at Chemical Manufacturing Facilities, Mixed Waste, Ocean Incineration were all ranked relatively low.

The Ground Water Valuation Workgroup report estimated aggregate national costs of releases or potential releases to ground water from OSWER problem areas. The principal findings were:

- Ground Water resource damage is extremely variable across problem areas. It is also extremely variable across facilities in problem areas due to site-specific differences in use patterns, pollutant releases, hydrogeological characteristics, and availability of substitute water sources.

- Nationwide, underground storage tanks produce the highest total resource damage ($15 billion) in present value terms.

- NPL sites have the highest mean resource damage (present value of $9.7 million per site).

- The size of the facilities is highly correlated with high resource damage.

Other highly ranked problem areas were: Municipal Landfills, Solid Waste Management Units, Land Disposal of Hazardous Waste, Mining Waste, Oil and Gas Operations Waste, Industrial (Subtitle D) Landfills, and Land Treatment of Hazardous Waste.

3.2.2 Data Quality and Confidence Levels

The level of confidence that Workgroups expressed in their rankings varied greatly. While they may have had confidence in broad groupings of problem areas (e.g., high vs. low), they reported considerable uncertainty in relative risk rankings for most problem areas. Thus, while it is possible to derive rankings for problem areas that subdivide the problem areas presented, the differences in the rankings would not be as robust.

The Other Health Effects Workgroup, the Ecological Effects Workgroup, and the Acute Events Workgroup all developed separate scales for assigning confidence levels to problem areas. The Other Health Effects Workgroup scale represents the confidence the Workgroup expressed in the accuracy of its assessment of the relative risk posed by a problem area. The rankings, therefore, reflect staff judgments, based upon available data, of the relative risk posed by a problem area. It should be stressed that the confidence levels are not simply data quality indicators. In many problem areas, data were lacking or of extremely poor quality, but the Workgroup expressed a high degree of confidence in its assessment of the relative potential risk posed.

The Acute Events Workgroup and the Ecological Effects Workgroup developed a confidence level scale based on the quality of the data used to develop relative risk assessments. Both used a similar method for assessing data quality. The Workgroups assigned a score to each parameter used to calculate relative potential risk. Factors such as the degree of documentation supporting reported effects, the generalization of data, and the degree to which data were based on professional judgment were used to assess the quality of data supporting each parameter. The number of parameters supported by good, moderate, or poor quality data then determined the overall data quality score a problem area received.

Confidence levels for the Welfare Effects Workgroup report were derived from two sources: problem area summary sheets and the text of the workgroup's report. These sources were reviewed by the Workgroup to determine the degree to which findings were based on comprehensive historical data, modeling data, or professional judgment. The problem area summary sheets and the text of the report then were reviewed for any indications of the degree of confidence the Workgroup expressed in the data used to estimate problem area rankings.

- Historical data existed and/or the Workgroup expressed a high degree of confidence: high.

- When little historical data existed or the Workgroup used model data and/or the Workgroup expressed only medium confidence: medium.

- When the Workgroup findings were based primarily on professional judgment (i.e., no data existed): low.

Confidence levels for the Ground Water Valuation Workgroup report were derived from Exhibit 13 of its report. This exhibit lists the sources of data for each problem area and provides a relative assessment of data quality. As

such, the characterizations of good, fair, or poor were used because they corresponded directly with rankings of confidence.

3.2.3 Overall Confidence in Rankings

Workgroups expressed particularly low confidence in four problem areas:

- Mixed Wastes;
- Other Treatment, Storage, and Disposal Facilities;
- Industrial Facilities; and
- Solid Waste Management Units.

With the exception of Other Treatment, Storage, and Disposal Facilities, all the Workgroups stated that they either had low confidence in their estimate of relative risk or did not have enough data to assess the risk posed by the problem area. For the Other Treatment, Storage, and Disposal Facilities problem area, all stated that they had low confidence in their estimate of relative potential risk, except the Acute Events Workgroup, which that its estimate was based on moderate quality data only.

All Workgroups expressed a high/moderate level of confidence that they had accurately identified the risks associated with Oil and Gas Operations Waste. Workgroups also generally reported a high to moderate level of confidence in the findings for the problem areas Petroleum Underground Storage Tanks and Exempt Storage Tanks.

3.3 METHODOLOGICAL AND DATA FACTORS AFFECTING WORKGROUP RANKINGS

The type and quality of information affect the type of method that might be appropriate for supporting the rankings of problem areas.

The methodology each workgroup ultimately used had considerable impact on the final ranking. In some cases, differences in one or two parameters in a workgroup's methodology had a substantial impact on the relative risk score a problem area received. Below, these critical parameters, or "driving factors", are identified for each workgroup. Refer to Appendix C for a more detailed summary of each workgroup methodology.

3.3.1 Acute Events

The Acute Events Workgroup's method assumed the overall relative risk posed by a problem area is comprised of four effects:

- acute exposure health risks;
- chronic health risks from acute events;
- welfare effects; and
- ecological risks.

For each effect, relative risks were assessed by summing measures of the observed frequency of occurrence of each event, the population potentially exposed, and the inherent hazard (based on the effect type).

3.3.2 Other Health Effects

The main driving force in the Other Health Effects Workgroup's methodology was cancer risks. Two scales (i.e., individual and population) were used to estimate cancer risk scores while only one scale was used to assess noncancer scores. As a result, cancer risks tended to drive the final relative risk rankings. Thus, scores used to determine ranking were primarily formulated from the application of an algorithm that used information from reports.

The potential biases associated with combining high and low estimates was mitigated by the workgroup's use of professional judgment. If relative risk scores were thought to be disproportionately influenced by a single parameter, the Workgroup would review the input parameters to ensure that reasonable factors had been considered. For example, the Workgroup acknowledged that for several problem areas (i.e., Mixed Wastes, PCB Wastes, Hazardous Materials Transportation, and Underground Injection), the relative risk scores were initially heavily influenced by the toxicities and volumes of chemicals released. The Workgroup thought this gave an inflated estimate of the relative risk associated with these problem areas and revised risk estimates downward.

3.3.3 Ecological Effects

The Ecological Effects Workgroup estimated relative risk as a function of four composite parameters:

- number of sources and releases in a problem area;
- contaminant concentration;
- receptors; and
- toxicity.

Each composite parameter was derived by taking the mean score of a series of data elements. The first three composites were then added together, and the result was multiplied by the toxicity composite. This approach made the relative risk score heavily dependent on the toxicity composite score. Furthermore, as the approach used for developing the toxicity composite scores was based on selecting the highest ranked contaminant in each toxicity category,

the effect of the toxicity composite on the relative risk score may have been multiplied even further.

3.3.4 Welfare Effects

The Welfare Effects Workgroup's methodology was, in many ways, the most flexible and least prone to being overly influenced by a single parameter. However, the methodology does seem to weight natural resource damages higher than other parameters, at least in the problem areas ranked low.

The Workgroup considered welfare effects for three general resource categories:

- residential and commercial property (four types);
- natural resources (two types); and
- surface water (two types).

Within each category, potential types of damage were identified and the Workgroup assigned a welfare damage score to each type. As a result, the total welfare score received by a problem area could be heavily influenced by the welfare damage score for natural resources (because of its four types of damage).

3.3.5 Ground Water Valuation

The number, distribution, and location of facilities within a problem area were three key factors that affected final relative risk rankings for the Ground Water Valuation Workgroup. The value users placed on ground water located in different areas was not considered, however. Thus, a problem area was likely to be highly ranked if it affected a large number of aquifers, irrespective of what value users placed on the individual aquifers. Therefore, problem areas where facilities or sources were distributed over many aquifers were much more likely to receive higher rankings than those that had a narrower distribution.

3.4 RANKINGS AND PUBLIC PERCEPTION OF RISKS

The importance of public perception and effective communication is a priority for successful program management. Program history suggests that the public wants to know that a site is "safe" before EPA or a State leaves the site. Moreover, it is likely that the judgment as to what constitutes safe varies with the site and the people surrounding that site. Given this premise, there is an increasing concern for better understanding the public, improving communication with the public, and improving methods for addressing public concerns.

During the preparation of *Unfinished Business*, EPA reviewed public polling data conducted over a two-years by the Roper Organization. The survey focused on perceptions of 15 environmental problems. Because surveys did not directly match the 31 EPA problem areas; they did, however, match several problem areas. As a result, *Unfinished Business* employed professional judgment to allow comparison of Roper's results with EPA's ranking of problem areas.

As with *Unfinished Business*, the OSWER Comparative Risk Study found some difference between its rankings of problem areas and public opinion (Table 2). Discrepancies can be accounted for by a number of factors. One of the most obvious is that the public's perception of the risk a problem area poses seems to be closely linked to the visibility and number and density of sites within a problem area. The degree to which a release is noticeable or produces dramatic effects is likely to affect public perceptions of risk. This probably accounts for the fact that many problem areas that were ranked high by the Acute Events Workgroup often tended to be ranked high in the Roper poll. The comparison of the overall results of the OSWER Comparative Risk Project with the results of the Roper study suggest that the public may not place a lesser value on risks posed by a number of problem areas where the damage caused is less obvious or more long-term. This would suggest that future attempts to increase public understanding of the risks posed by various problem areas should focus on explaining the less visible risks and the mitigation of long-term or chronic effects. The more effective that EPA is in characterizing risks and what actions have been taken to reduce them, the more likely it is that the public and EPA can come into a common alignment that supports the rationale behind Agency decisions.

TABLE 1

COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS

	Workgroup Ranking					
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-water Valuation	
Municipal Landfills	L	M	*H*	H	*H*	
Industrial Facilities	H	H	M	H	-	All workgroups except the Ground-Water Valuation Workgroup stated that they believed that risks may be substantially higher than the data suggests and that further data collection activities should be undertaken. The Other Health Effects Workgroup called this problem area "Industrial Non-Hazardous Waste Facilities." The other workgroups called this problem area "Industrial Facilities (RCRA Subtitle D)."
Hazardous Waste Storage and Treatment Tanks, Drums, and Containers	*M*	H	*M*	H	-	The Economic Effects Workgroup called this problem area "Hazardous Waste Storage and Treatment Tanks".
Petroleum Underground Storage Tanks	H	M	*ML*	H	-	The Other Health Effects Workgroup called this problem area "Petroleum Underground Storage Tanks." The other workgroups called this problem area "Petroleum Underground Storage Tanks (RCRA Subtitle I)."
Land Disposal of Hazardous Waste	*M*	*M*	*H*	H	*M*	

TABLE 1

COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS (CONTINUED)

	Workgroup Ranking					
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-water Valuation	
Superfund Sites	-	H	-	H	H	The Other Health Effects Workgroup considered current NPL and potential NPL sites (over 30,000 sites). The Economic Impacts and Other Health Effects Workgroups combined remedial and removal actions at both NPL and non-NPL sites. The other workgroups considered only removal actions at NPL or potential NPL sites.
Remedial Activities	L	-	H	-	-	The Ground-water Valuation Workgroup called this problem area "NPL Sites".
Transportation of Hazardous Materials	H	L	ML	L	-	
Chemical and Industrial Manufacturing Facilities	H	L	ML	L	-	The Other Health Effects Workgroup called this problem area "Chemical and Industrial Manufacturing Facilities" or "Accidental Releases at Chemical Facilities." The Economic Effects Workgroup called this problem area "Accidental Releases at Chemical Facilities." The Acute Events Workgroup addressed only risks posed to workers at chemical and industrial facilities.
Underground Storage Tanks	-	-	-	-	H	This problem area was only considered by the Ground-water Valuation Workgroup. It includes: hazardous substance product storage tanks, petroleum underground storage tanks, and exempt underground storage tanks.
Oil Spill Response	H	L	ML	L	-	

TABLE 1

COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS (CONTINUED)

	Workgroup Ranking					
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-water Valuation	
Oil and Gas Operations	H	*M*	M	M	*L*	The Acute Events Workgroup only addressed the effects of blow-outs at oil wells. Other workgroups considered the effects of releases from wastes produced as a result of oil and gas activities.
Solid Waste Management Units	M	H	ML	*M*	*M*	
Exempt Storage Tanks	M	M	*ML*	*M*	–	The Other Health Effects Workgroup called this problem area "Exempt Tanks." The Economic Workgroup called this problem area "Exempt Storage Tanks." The other workgroups called this problem area "Unregulated (Agricultural and Residential) Underground Storage Tanks."
Mining Wastes	L	*M*	*MH*	*M*	*M*	The Acute Effects Workgroup excluded mining wastes located at NPL sites; other workgroups did not explicitly exclude mining wastes at NPL sites. In addition to wastes considered by other workgroups, the Other Health Effects Workgroup included wastes from smelting and refining along with other types of mining waste considered by the other workgroups.
Other Treatment, Storage, and Disposal Facilities	*M*	M	M	M	*L*	
Removal Activities	*M*	–	–	–	–	
Combustion of Hazardous Waste	*M*	M	*M*	L	L	

TABLE 1

COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS (CONTINUED)

	Workgroup Ranking					
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-Water Valuation	
Municipal Waste Combustion	L	M	MH	L	-	
Hazardous Substance/Product Underground Storage Tanks	M	M	M	L	-	The Other Health Effects Workgroup called this problem area "Hazardous Substance Tanks." The other workgroups called this problem area "Hazardous Product Underground Storage Tanks (RCRA Subtitle I)."
PCB Wastes	M	L	MH	L	-	
Land Treatment of Hazardous Wastes	L	M	M	L	-	
Underground Injection of Hazardous Waste	M	L	ML	L	-	The Other Health Effects Workgroup considered injection of hazardous waste into class I injection wells. The other workgroups considered all underground injection of hazardous waste regulated under 40 CFR Part 267 Subpart G and 40 CFR Part 146.
Mixed Wastes	L	L	M	L	-	
Ocean Dumping	L	L	H	L	-	The Other Health Effects and Economic Effects Workgroups considered risks from ocean dumping of municipal waste, dredge spoil, and discharges of industrial waste into the ocean. The Ecological Effects Workgroup considered risks from ocean dumping of municipal waste and dredge spoil. The Acute Events Workgroup considered risks from ocean dumping of municipal waste only. The Other Health Effects Workgroup called this problem area "Ocean Disposal." The other workgroups called this problem area "Ocean Dumping."

TABLE 1
COMPARISON OF WORKGROUP RANKINGS OF OSWER PROBLEM AREAS (CONTINUED)

	Workgroup Ranking				
	Acute Events	Other Health Effects	Ecological Effects	Welfare Effects	Ground-Water Valuation
Ocean Incineration	L	$\mathcal{L}$	$\mathcal{ML}$	L	–

Notes on the Comparison Table

Letters reflect relative risk rankings judged for problem areas:

$\mathcal{H}$	High or higher relative risk potential
$\mathcal{MH}$	Moderately high relative risk potential
$\mathcal{M}$	Medium or moderate relative risk potential
$\mathcal{ML}$	Moderately low relative risk potential
$\mathcal{L}$	Low or lower relative risk potential
—	The workgroup did not consider this problem area.

Uncertainty is reflected in lettering as:

H	Low uncertainty (high confidence)
$\mathcal{H}$	Medium uncertainty (medium confidence)
H	High uncertainty (low confidence)

No attempt was made to "add" risks across Workgroups or compare the importance of one Workgroup as more significant than another. Note that differences in problem areas addressed is due to a combination of available data and scope.

TABLE 2. ROPER SURVEY AREAS AND OSWER PROBLEM AREAS

Public Perception of Risk and Ranking	Roper Survey Area	Corresponding Problem Area (and Workgroup)
High	Chemical Waste Disposal	Land Disposal of Hazardous Waste (all Workgroups)
		Hazardous Waste Storage and Treatment Tanks, Drums, and Containers (all but Ground Water Valuation)
		Other Treatment, Storage, and Disposal Facilities (all)
	Chemical Plant Accidents	Chemical and Industrial Manufacturing Facilities (Acute Events and Ecological Effects)
		Accidental Releases at Chemical and Industrial Manufacturing Facilities (Other Health Effects and Welfare Effects)
	Combustion	Air Pollution Combustion of Non-Hazardous Waste including Non-Hazardous Municipal Waste (all but Ground Water Valuation)
		Ocean Incineration (all but Ground Water Valuation)
Moderate	Oil Tanker Spillage	Oil Spill Prevention and Response (Acute Events and Ecological Effects)
	Effects	Oil Spill Response (Other Health and Welfare Effects)
Lower	Strip Mining	Mining Wastes (all but Ground Water Valuation)
		Mining Waste Sites (Ground Water Valuation)

CHAPTER 4. INFORMATION NEEDS

In general, the composition of data often guides analysis and affects its results, just as data deficiency limits analysis. Also, the Workgroups reported that they felt that limitations in the data precluded estimating the absolute risks posed by problem areas.

4.1 GENERAL INFORMATION NEEDS

For this study, information needs have been prioritized by considering the types of information needed to support program activities and the cost of obtaining the information. The rankings in Table 1 have been developed by averaging the workgroup rankings. Thus, uncertainties associated with the rankings are reflected in the text face but were not used to array problem areas.

Table 1 suggests that OSWER has generally obtained higher confidence information in the highest ranking problem areas. The rankings of problem areas make it clear that there are significant information gaps exist.

In terms of future data needs, the Workgroups expressed low confidence in rankings for: Mixed Wastes, Other Treatment, Storage, and Disposal Facilities, Industrial Facilities, and Solid Waste Management Units. Thus, future work is recommended to improve understanding of the risks these problem areas pose. In addition, several workgroups expressed many data needs related to the individual effects they had studied. The Ground Water Valuation Workgroup eliminated 13 problem areas from consideration since adequate data were not available.

The relatively high risk rankings of problem areas that were ranked high for reasons other than risks to human health suggest that protection of human health may not be the most sensitive indicator of concern. This supports the position that OSWER programs are taking in assuming that ecological and other welfare impacts may be more sensitive to environmental stress than public health. This assumption has resulted in shifts in program activities and development of guidance materials for program assessment efforts.

As discussed later in this Chapter, OSWER has initiated efforts to collect and refine information in a number of areas to assist in better understanding risks to public health and the environment. Nevertheless, there are a number of areas where additional information is important to the development of sound strategic planning. For example, given that uncertainty is high for mixed waste, it is possible that risk estimates associated with mixed wastes could change significantly with additional information.

4.1.1 Program Recommendations

The following long-term recommendations for the continued support of strategic planning are:

- risk rankings be reviewed periodically based on information gathered and

- a centralized repository should be established for the maintenance of information used to perform the rankings.

4.1.2 Information Needs

In order to provide for a more consistent basis to support decisions on program direction, it is recommended that options for improving information in the following areas be developed:

- Information was especially limited and of low quality in the areas supporting workgroup efforts for Ecological Effects, Welfare Effects, and Ground Water Valuation. Consideration should be given to enhanced data collection/methodological work in these areas.

- Accepting the finding that some pathways for exposure have not consistently been assessed, it is recommended that efforts be made to better assess major risks from all pathways.

- For four problem areas (i.e., Mixed Wastes, Other Treatment, Storage, and Disposal Facilities, Industrial Facilities, and Solid Waste Management Units), the Workgroups seem to have expressed particularly low confidence in their findings. The extent of future analyses might improve if the Agency acquired more data in these areas.

- The Ground Water Valuation Workgroup eliminated 13 problem areas from consideration, partly due to lack of information. The Ecological Effects Workgroup did not consider Removal Actions at Non-NPL Sites since insufficient data were available to estimate the ecological effects of releases during removal actions. To improve future studies, EPA may want to address the problem of obtaining new data sources for these problem areas.

Finally, in order to improve upon the confidence of the findings of this and future studies, sensitivity analyses of the use of alternative methodologies and the corresponding impacts on final rankings would be useful.

4.1.3 Ongoing Information Collection Efforts

The need for much of this information was recognized even before this effort was initiated; OSWER has embarked on efforts to fill some of these needs. More specifically, information on chemical-specific concentrations in hazardous waste streams is being addressed through the following information collection efforts: the Treatment, Storage, Disposal and Recycling Survey; and the Generator Survey. There has also been an increasing awareness of the need for consideration of the risks associated with exposure to different media. This issue is being addressed though improved guidance in the review of the *Superfund Public Health Evaluation Manual* and the *RCRA Facility Investigation Guidance.*

Moreover, OSWER is piloting an effort to determine the reasonableness of combining information from different surveys that the Agency has collected (including the air and water programs) in order to better characterize both hazardous and non-hazardous waste streams through the OSWER Waste System Model. The development of this model requires extensive coordination across different Agency groups and should aid in presenting information in a consistent form.

Recognizing the importance of public health risk information in supporting decisions for all OSWER programs, we are undertaking studies to better understand metals movement in the environment, development of probabilistic risk estimates (along with associated uncertainties), and improvement of guidance for the implementation of existing OSWER programs.

While the limitations of information that has been used to support economic estimates of environmental impacts may be most relevant to some readers, they are also generally the product of more analyses and are subject to great uncertainties. Decisions for the collection of such information are likely to consider the need for such information to support regulatory activities, the likelihood that such information can be made credible, and the resource requirements associated with the collection of the information.

Finally, recognizing the costs associated with the cleanup of radiologically contaminated waste (especially soils), OSWER programs are working with other Agency programs and other Federal agencies to assess information on technological methods for cleanup of existing sites and assessment of risks. These efforts may lead to a unified Agency program to develop technologies for the cleanup of radiologically contaminated soils as well as support for both international and EPA decisions on ocean disposal of low level radioactive wastes.

To better understand the relationship between public and Agency assessments of risks, OSWER has initiated two studies to examine public perception of risks associated with its programs. The first of these studies is examining the relationship between different types of sites associated with chemical risk (e.g., hazardous waste treatment facilities and Superfund sites) and the influence of different socioeconomic variables on risk perception. The second study is examining public perception of the risks associated with alternatives for disposal of low-level radioactive wastes (including land and ocean disposal options) is to undertake. One outcome of these studies should address the issue of how the Agency might improve on its approach to addressing the public or different segments of the public when faced with a decision for cleanup.

These studies of public perception, should provide insight as to the types of variables that affect the public thinking on issues related to OSWER problems. In addition to the above studies, a variety of studies on risk communication are designed to improve dialogue between the Agency and the public. Taken together, these studies should provide a basis for improved communication and support of cleanup options selected.

4.2 ACUTE EVENTS

A key problem in applying the Acute Events comparative risk methodology was that data for nearly every OSWER problem area were incomplete and not focused on the event. Very little data were available on potential population exposure and the frequency of acute events. Therefore, the accuracy of parameter estimates varied greatly among problem areas.

Often the Acute Events Workgroup experienced difficulty in obtaining information on the location of a facility. Also it was difficult to identify which chemicals and what quantities were typically released during an acute event. When possible, this information was obtained from data bases or case study reports, but often no data were available. The Acute Events Workgroup expressed concern over the absence of any discussion concerning illegal or unpermitted dumping. Very little data are available in this area, and no study methods have been developed.

4.3 OTHER HEALTH EFFECTS

For the Other Health Effects Workgroup, comprehensive risk modeling studies rarely covered all of the potential exposure pathways through which health risks might occur. The available exposure data were very limited and of variable quality. There was also considerably less information on noncancer risks than on cancer risks, and far fewer national modeling studies have been conducted to assess noncancer risks. For most problem areas, the Workgroup could only synthesize existing information on non-carcinogenic chemicals and their potential effects. The availability of methods for the characterization of risks as probabilities, fuller characterization of the severity of effects, and characterization of the uncertainties is desired. Such information would not only be useful in supporting more relevant decisions within the Agency but should also improve our ability to communicate risks to the public.

4.4 ECOLOGICAL EFFECTS

Data availability for the Ecological Effects Workgroup was a major limiting factor. For many problem areas, the scores for concentration and receptor composites were based largely on professional judgment.

4.5 WELFARE EFFECTS

The Welfare Effects Workgroup's methodology relied heavily on its best professional judgment. Future analyses may also want to consider aesthetic and potential use values, where sufficient data were not available.

4.6 GROUND WATER VALUATION

Data deficiencies required the Ground Water Valuation Workgroup to make assumptions about the environmental settings of various types of facilities or

sites, hydrological parameters, exposed populations, types of waste handled, facility size, and water-use patterns. Future comparative risk analyses may want to consider the effects of ground water contamination prevention programs, which were not considered in this project.

4.7 PUBLIC PERCEPTION OF RISK

It is clear from the differences in the rankings between public opinion polls and the Agency's efforts to address environmental concerns that there is considerable work to be done in improving communication with the public. As part of the recently released *A Management Review of the Superfund Program*, also known as the "90 Day Study of the Superfund Program", the Administrator identified a goal of "encourage full participation by communities." This and other activities within the Agency signal an increased emphasis on efforts to provide effective communication with the public.

APPENDIX A

GLOSSARY

Term	Definition
absolute risk	An estimated level of risk intended as a representation of the true risk (see relative risk).
acute event	The sudden, unplanned release of hazardous substance(s) that pose a threat to public health, welfare, and/or the environment and result in either acute or chronic exposures.
aquifer	The permeable rock strata or sediment that is saturated with ground water and may allow free movement of ground water.
beneficiation (mining)	The treatment of raw materials (i.e., iron ore) to improve the material's inherent properties in preparation of smelting.
bioconcentration	The process by which organic chemicals and certain metals accumulate in tissues of exposed organisms. When the organisms are consumed by predators, some of these pollutants can increase in concentration in the predator.
bulk waste	Any waste, hazardous or nonhazardous, existing in large quantities.
cancer risk	The potential or probability of contracting cancer due to exposure to carcinogenic substances. Cancer risk often is expressed as expected number of cases (population risk) or excess lifetime probability per person (individual risk).
ecological impact	The damage to natural components of an ecosystem resulting from the contamination of environmental media, such as soil, surface water, ground water, and air.
economic effect	The loss in value of materials, property, natural resources, food supplies, or recreational resources due to damages caused by environmental problem areas.

Term	Definition
extraction (mining)	The act or process of removing natural resources.
ground water damage	The contamination of subsurface waters that result in unusable drinking water supplies and the need for an alternative source of drinking water.
health effect	The human injury, illness, or death that are the result of exposure to hazardous substances.
low-level (radioactive) waste	Radioactive wastes that consist of radionuclides, lab wastes, or transuranic nuclides at concentrations of less than 100 nanocuries/gram.
municipal waste	Non-hazardous waste, typically household waste and waste from small commercial firms, regulated under RCRA Subtitle D.
microbial degradation	The transformation of substances in aquatic or soil environments by microscopic organisms.
mixed waste	Wastes that contain both radioactive waste and RCRA hazardous waste and are regulated by EPA as hazardous waste under RCRA.
National Priority List (NPL)	EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial response.
National Response Center (NRC)	The center responsible for collecting and maintaining reports of releases of hazardous substances into the environment. Notification to the NRC marks the beginning of the response process.
noncancer risk	The potential or probability to incur a noncancer health effect (e.g., lead poisoning, neurological disorders, liver disease) due to exposure to noncarcinogenic hazardous substances. Often indicated by comparing an estimated dose to a reference dose.
welfare effects	Effects upon economic resources that affect the value of commercial activities or in the value of human well-being.

GLOSSARY (Continued)

Term	Definition
non-NPL site	An uncontrolled or abandoned hazardous waste site identified for possible long-term remedial response, but not considered a national priority.
photooxidation	The process by which materials or substances undergo oxidation as a result of radiant energy (i.e., light).
reactivity	The characteristic assigned to a material that is either explosive, reacts violently with water, or generates toxic gases when exposed to water or other liquids that are moderately acidic or alkaline.
reference dose (RfD)	The dose of a substance above which adverse health effects may occur.
relative risk	An estimated level of risk intended only for comparison to other relative risk estimates derived using the same methodology (see absolute risk).
reportable quantity (RQ)	A threshold quantity set by EPA for certain hazardous substances. RQs serve as triggers for notification when a release of that hazardous substance occurs.
RCRA Subtitle C	Regulates any material that may be characterized as hazardous waste pursuant to 40 CFR Parts 260-272.
RCRA Subtitle D	Regulates any material that may be characterized as solid, non-hazardous waste pursuant to 40 CFR Parts 240-257.
RCRA Subtitle I	Regulates petroleum products and CERCLA hazardous substances that is contained in an underground storage tank.
solid waste	Any material that is discarded, to include solids, semi-solids, liquids, or gases.
transuranic nuclides	Radioactive materials that contain alpha-emitting nuclides with an atomic number greater than 92.

APPENDIX B

DEFINITIONS OF OSWER PROBLEM AREAS

TABLE B-1

OSWER PROBLEM AREAS

Problem Areas	Definition
Combustion of Hazardous Waste	Combustion of waste material that is hazardous, including waste burned for energy recovery (e.g., industrial furnaces and industrial and utility boilers) (40 CFR Part 266, Subpart D), hazardous waste incinerators (40 CFR Part 264, Subpart O and Part 265 Subpart O), and open detonation.
Hazardous Waste Storage and Treatment Tanks, Drums, and Containers (Subtitle C)	Hazardous waste storage and treatment tanks, drums and containers, which are found both at private hazardous waste management companies and at individual industrial sites are regulated under Subtitle C of RCRA.
Land Disposal of Hazardous Waste	These land sites are hazardous waste landfills, surface impoundments, and waste piles under RCRA Subtitle C (40 CFR Parts 264, Subparts M and N).
Land Treatment of Hazardous Waste	The use of processes (e.g., photooxidation and microbial degradation) to reduce the toxicity or quantity of waste deposited at a site. These land treatment sites are subject to RCRA requirements in 40 CFR Sections 264.270-.317.
Industrial Facilities	Nonhazardous waste landfills, surface impoundments, land treatment, and incineration (not including municipal incineration) regulated under Subtitle D of RCRA (surface impoundments are regulated under 40 CFR Parts 264 and 267, Subpart K and Part 267 Subpart D).
Mining Wastes	Wastes include solid waste from the extraction, beneficiation, and processing of ores and minerals.

TABLE B-1 (continued)

Problem Areas	Definition
Mixed Waste	Mixed waste consist of radioactive wastes that are mixed with a RCRA hazardous waste component and are regulated by EPA as hazardous waste under RCRA. For the most part, these are low-level wastes consisting of naturally-occurring radionuclides and transuranic nuclides at concentrations less than 100 nanocuries/gram.
Municipal Landfills	Landfills used to dispose of household waste and waste from small commercial firms. These sites are regulated under Subtitle D of RCRA.
Municipal Waste Combustion	This area includes the incineration of municipal waste, which is not hazardous.
Oil and Gas Operations Waste	Oil and gas operations generate drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil, natural gas, or geothermal energy as described in RCRA section 3001(b)(2)(A). (Oil spills into navigable waters of the U.S are covered by section 311 of the Clean Water Act.)
Other Treatment, Storage or Disposal Facilities	Such facilities are involved in waste treatment, storage, and disposal not included in those identified above. These include: waste recycling facilities, waste transfer stations, container storage areas, or any subject to systematic and routine release.

TABLE B-1 (continued)

Problem Areas	Definition
Solid Waste Management Units	SWMUs are on-site land disposal units associated with permitted RCRA facilities. These classes of facilities are subject to requirements as established by Section 3004U and 3008H of RCRA.
Oil Spill Response	Activities linked to establishing procedures and requirements for preventing oil discharges from vessels and offshore and onshore facilities for containing such discharges, and for responding to discharges or threats of discharges to waters of the U.S., adjoining shorelines, waters of the contiguous zone, and waters of the high seas under U.S. jurisdiction CWA §311.
Removal Activities	Activities related to Superfund removal actions taken pursuant to CERCLA §104 (40 CFR Part 300) and CWA §311. Removal actions will include emergency response actions to transportation accidents involving releases of hazardous substances.
Remedial Activities	Activities related to Superfund remedial actions taken pursuant to CERCLA §104 and 40 CFR Part 300. Remedial actions will include RI/FS activities and cleanup at NPL and non-NPL sites.

TABLE B-1 (continued)

Problem Areas	Definition
Chemical Industrial Manufacturing Facilities	Chemical industrial manufacturing facilities that process/manufacture chemicals, especially those types of chemicals that manufacture, process, or store types of chemicals that could pose a threat in terms of an accidental release that could pose a public health threat. (Focus on accidental releases that would be addressed under SARA Title III.)
Ocean Dumping	Ocean dumping involves the disposal of bulk waste (usually untreated) at sea (40 CFR 227). Ocean dumping is only allowed for bulk nonhazardous wastes as no additional treatment of the waste is permitted.
Ocean Incineration	Ocean incineration involves the incineration of waste materials at sea. Given that future risks associated with ocean incineration are highly uncertain but appear to be small (ocean incineration may not be chosen as a popular mechanism to deal with hazardous waste), the principle reason for including this source category is that ocean incineration affects the capacity question.
PCB Wastes	Polychlorinated biphenyls (PCBs) and PCB wastes primarily found in electrical transformers and capacitors. They are regulated under the Toxic Substances Control Act 40 CFR Part 761.

TABLE B-1 (continued)

Problem Areas	Definition
Transportation	Trucks, railroads and barges used to transport hazardous substances. Most hazardous substances are transported by truck and are regulated by the Department of Transportation.
Underground Injection	Underground injection is defined as disposal of liquid waste material into isolated geologic strata, placing the wastes in portions of the earth's crust that are free from the usual effects of the hydrologic cycle (regulated under 40 CFR Part 267, Subpart G and Part 146).
Exempt Storage Tanks	Heating oil, farm, and residential tanks that are exempted from regulation under Subtitle I.
Hazardous Substance Storage Tanks (RCRA Subtitle I)	Underground storage of substances designated as hazardous (under CERCLA).
Petroleum Storage Tanks (RCRA Subtitle I)	Tanks that store petroleum products in underground storage tanks such as gasoline stations (includes used oil).

APPENDIX C
INDIVIDUAL WORKGROUP SUMMARIES

This appendix addresses the scope of effort, methodology, data sources and uncertainty levels, and results of each of the five Workgroups (i.e., Acute Events, Other Health Effects, Ecological Impacts, Welfare Effects, and Ground Water Valuation). A short discussion on caveats and other issues is also provided for each Workgroup.

C.1 ACUTE EVENTS

Scope of Effort. The Acute Events Workgroup assessed and compared risks arising from acute events in 24 OSWER problem areas. Acute events were defined as sudden, unplanned releases of hazardous substances that pose a threat to public health, welfare, and the environment. These events represent a qualitatively different kind of threat to human health and the environment as compared to long-term or chronic environmental contamination. Acute events have the potential to cause immediate injury, long-term health problems, significant environmental contamination, and extensive property damage.

Methodology. The methodology used (see Figure C-1) was based on the assumption that the overall relative risk a problem area poses is comprised of four different effects:

(1) effects associated with acute exposures;
(2) effects associated with chronic exposures;
(3) welfare effects; and
(4) ecological effects.

For each effect type, relative risks were assessed by combining the observed frequency of occurrence of an acute event with its inherent hazard (based on the effect type) and the size of the population potentially exposed. A series of indices were developed to represent exposure, frequency, and severity (inherent hazard). The three indices were summed for each effect type to get an effect type score. Then, the four effect type scores were summed to get an overall acute events score for a problem area.

Frequency indices are based on historical records of the annual occurrence of acute events. Exposure indices are derived from 1980 Census-based estimates of the number of people within one mile of a facility at which acute events may occur. Severity indices were estimated as a function of the quantity of a chemical released and the primary criteria reportable quantity (RQ) for that chemical (i.e., an indicator of inherent toxicity). The RQ provides the minimum quantity of a chemical spilled or released at which a report must be made to the National Response Center and is based on five primary criteria: mammalian toxicity, chronic toxicity, carcinogenic toxicity, aquatic toxicity, and ignitability or reactivity. The severity indices, therefore, are based on the typical quantity released during an acute event, and the inherent toxicity (represented by the RQ) of typical releases in each OSWER problem area.

Data Sources and Uncertainty Levels. The Acute Events Workgroup used various data sources to estimate index scores. A key problem in applying the acute events comparative risk methodology, however, was that data for nearly every OSWER problem area was incomplete and not focused on acute events. Therefore, the data sources and the procedures used to calculate parameter estimates varied from problem area to problem area. Where data proved to be unobtainable or nonexistent, the Workgroup primarily relied on the Acute Events Survey. This survey was conducted specifically for the OSWER Comparative Risk Project on EPA personnel in program offices responsible for regulating or monitoring facilities in individual OSWER problem areas.

Population exposure estimates were obtained primarily from two sources: U.S. EPA Graphic Exposure Modeling System (GEMS) and U.S. Bureau of the Census, 1980 County Population estimates. If a specific facility or source location was known, then exposure estimates were developed from GEMS. If only the general distribution of facility or source locations were known, then exposure estimates based on U.S. Bureau of the Census data were developed to estimate the potential population exposure.

Frequency estimates were obtained, when possible, from either case studies (such as Emergency Response Division Weekly Pollution Reports) or data base estimates (such as the Department of Transportation's Hazardous Material Transport Incident Reporting System). When case studies were used, it was assumed that they accurately reflected the number of events that occurred in each problem area. Frequency estimates derived from case study data were all extrapolated to one year. In most cases, this was done by either dividing by the total number of years reported in the data or by extrapolating from monthly data to one year. Annual frequency estimates for some problem areas were derived from existing data bases. In each case, annual frequency estimates were based on the mean multi-year data.

Severity estimates, such as the Human Injuries Acute Effects Index, were also obtained, when possible, from either case study reports (such as EPA's *Summary of State Reports on Releases from Underground Storage Tanks*) or data bases (such as the Acute Health Effects Data Base). However, there was less information on human injuries and deaths associated with acute events than for any other parameter. In cases where no information was available, no attempt was made to estimate this parameter and the Human Injuries Acute Health Effects Index was dropped from consideration altogether.

A key part of the methodology was the identification of chemicals and the quantities of those chemicals that were typically released during an acute event. When possible, this information was obtained from data bases or case study reports. However, estimates from the Acute Events Survey were used more widely in this part than in any other.

Results. The efforts of the acute events workgroup culminated in a set of rankings that reflects the relative risks from acute events for the twenty-four OSWER problem areas (Table C-1). The problem areas are divided into three relative risk groups on the basis of their overall rank. The high risk group includes the OSWER problem areas that received scores of 45 to 54; the medium

risk group includes OSWER problem areas that received scores of 36 to 43; and the low risk group includes those OSWER problem areas that received scores of 25 to 34.

Discussion. Several assumptions were made in determining the relative risks of acute events associated with the 24 OSWER problem areas. Some typical assumptions made by the Workgroup include the following.

- An acute event observed in the past was used to predict an acute event in the future.
- Annual numbers of events are assumed to be constant.
- The frequency of acute events occurring in one area was extrapolated to determine the frequency of acute events for the nation as a whole.
- The location of sensitive ecosystems (as reflected in the exposure index for ecological risks) was assumed to be more likely in areas with low human population density.
- The potential loss in property value (as reflected in the welfare effects severity index) was assumed to be associated with the ignitability of the substance released.

Data for nearly every OSWER problem area was incomplete in the area of acute events. As such, the workgroup made a series of assumptions about missing data. Therefore, caution should be exercised in interpreting the study findings.

FIGURE C-1
ACUTE EVENTS METHODOLOGY

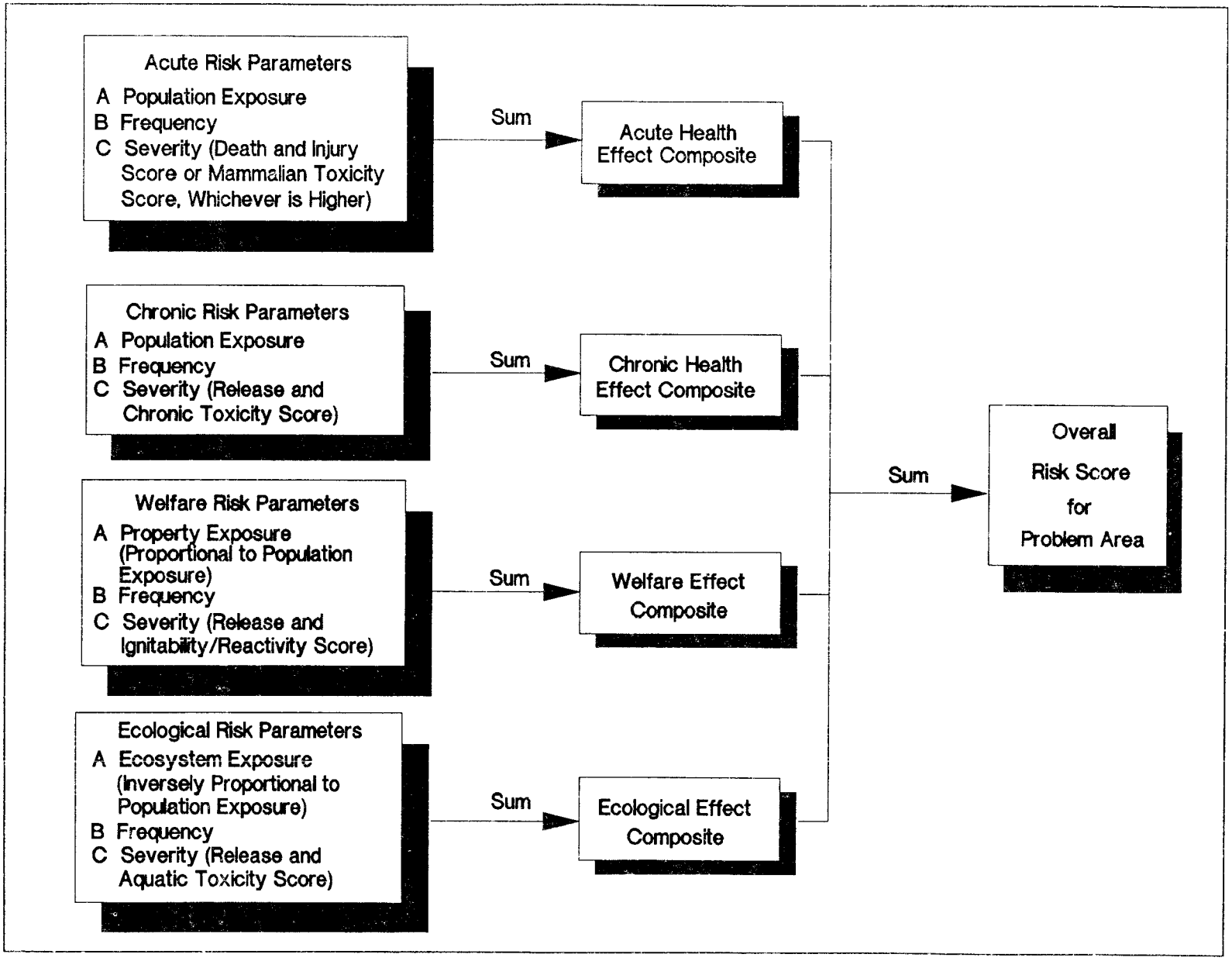

TABLE C-1

ACUTE EVENTS RANKINGS

PROGRAM AREA/SOURCE	Health				
	Acute Exposure	Chronic Exposure	Welfare	Ecological	Total Score
HIGH					
Transportation of Hazardous Materials	16	14	13	11	54
Oil & Gas Operations Waste	12	13	13	13	51
Oil Spill Response	14	13	13	11	51
Accidental Releases at Chemical Facilities	14	12	11	11	48
Petroleum Underground Storage Tanks	12	12	12	10	46
Industrial Non-Haz. Waste Facilities	12	11	12	10	45
MEDIUM					
Solid Waste Management Units	11	11	11	10	43
Hazardous waste storage and treatment tanks	10	11	10	10	41
Land disposal of hazardous waste	10	9	10	12	41
Other TSDFs	9	11	10	10	40
Removal Activities/Other Emergency Response	10	11	10	9	40
UST Hazardous Substance Tanks	11	12	9	7	39
Exempt Storage Tanks	9	11	9	10	39
PCB Wastes	9	10	9	9	37
Underground Injection of Hazardous Waste	10	9	9	9	37
Hazardous Waste Combustion	8	10	9	9	36
LOW					
Ocean Dumping	8	7	8	11	34
Remedial Actions at NPL Sites	8	9	8	9	34
Municipal Waste Combustion	8	9	7	8	32
Land Treatment of Hazardous Waste	7	9	6	8	30
Mining Waste	8	8	6	7	29
Ocean Incineration	7	8	7	7	29
Mixed Waste	7	7	7	5	26
Municipal Landfills	5	7	5	8	25

C.2 OTHER HEALTH EFFECTS

Scope of Effort. The Other Health Effects Workgroup addressed both noncancer and cancer risks associated with exposures that were not addressed in acute events. This constitutes the majority of the types of risks that are addressed by OSWER program offices in the support of various regulations. Twenty-two problem areas were addressed.

Methodology. The Other Health Effects Workgroup (see Figure C-2) sought to (1) build upon readily available information and (2) draw from the experience of *Unfinished Business*. The Workgroup examined both cancer and noncancer risks. The analysis of noncancer risks was limited to those risks not addressed in the Acute Events Workgroup. The approach to developing a ranking of problem areas involved (1) collecting information for each of the problem areas, (2) assembling that information to support the rankings, (3) developing an algorithm for the assignment of points associated with risk factors for problem areas, and (4) convening a meeting to exercise the methodology. The development of the algorithm involved considerable professional judgment on technical risk and value judgments on the relative importance of differing types of risks (e.g., cancer risks and noncancer risks were both used to develop one score).

Data Sources and Uncertainty Levels. Comprehensive risk modeling studies were not available for many of the problem areas. For areas with available studies, all of the potential exposure pathways through which health risks might occur were rarely covered. Therefore, after all available comprehensive risk information was reviewed, additional data for the problem areas on the individual parameters affecting risk were collected. These data included types of wastes and waste management units, chemicals or constituents of concern, types and numbers of releases, exposure pathways, concentrations of constituents at exposure points, potentially exposed populations, and numbers and distributions of sources.

The percent of the potential cancer risks covered by the models and the uncertainties associated with the modeling effort were assessed. For some problem areas, several sources of risk estimates provided conflicting results. Potential reasons for these conflicts were identified by analyzing the modeling approaches used. The estimates obtained with the model having the greatest technical accuracy were adopted by the Workgroup.

Generally, there was considerably less information on noncancer effects than on cancer risks, and far fewer of these effects have been studied through national modeling efforts. Where data were available on individual chemicals for which noncarcinogenic health risks have been associated, a method similar to that used in *Unfinished Business* was used. Sufficient information was available to implement this scoring approach for very few problem areas, however. Therefore, for most problem areas, the existing information on chemicals associated with noncarcinogenic health risks was summarized, and a qualitative assessment of the likelihood that the problem areas would result in exposures exceeding RfDs was based on the findings of previous investigators and professional judgment.

Results. The results of Workgroup deliberations for this effort are presented in Table C-2. As explained in the Workgroup report, the extent and quality of data had little influence on the relative ranking of problem areas. Moreover, a comparison of the rankings of OSWER rankings with those of the Unfinished Business report suggest that there are at least some similarities among the reports.

The results of the Other Health Effects Workgroup placed Superfund Activities, Industrial Nonhazardous Waste Management Facilities, Solid Waste Management Units, and Hazardous Waste Storage and Treatment Tanks, Drums, and Containers at the top of the ranked list. In contrast to the Acute Events Workgroup, Oil Spill Response was among the lower risk problem areas. It is worthwhile noting that Solid Waste Management Units received a high ranking in this Workgroup but there was a lack of data to support this ranking at the time that the rankings were developed. Recently, however, the Regulatory Impact Analysis for the Corrective Action rule has been released, which generally supports the rankings assigned by this workgroup.

Discussion. A number of assumptions were made or limitations existed for the assessment of other health effects.

- Hazard (e.g., toxicity, potency) information is not available for most substances.
- Where hazard information exists, it is based largely on animal data at high doses, resulting in uncertainty when extrapolation to humans and low doses occurs.
- Information on interactive effects (e.g., synergism, antagonism) is not available for most substances.
- Data limitations and general nonacceptance of a quantitative noncancer risk assessment methodology led the Workgroup to employ a highly qualitative noncancer methodology.
- When modeling was conducted for a representative facility or site for a problem area, it was often difficult to then scale the results up to the entire problem area.
- Assumptions regarding corrective action or averting action vary widely.
- Assumptions regarding exposed populations vary widely.
- Data on concentrations of contaminants actually monitored at exposure points did not exist or was not used for the most part.

FIGURE C-2

OTHER HEALTH EFFECTS METHODOLOGY

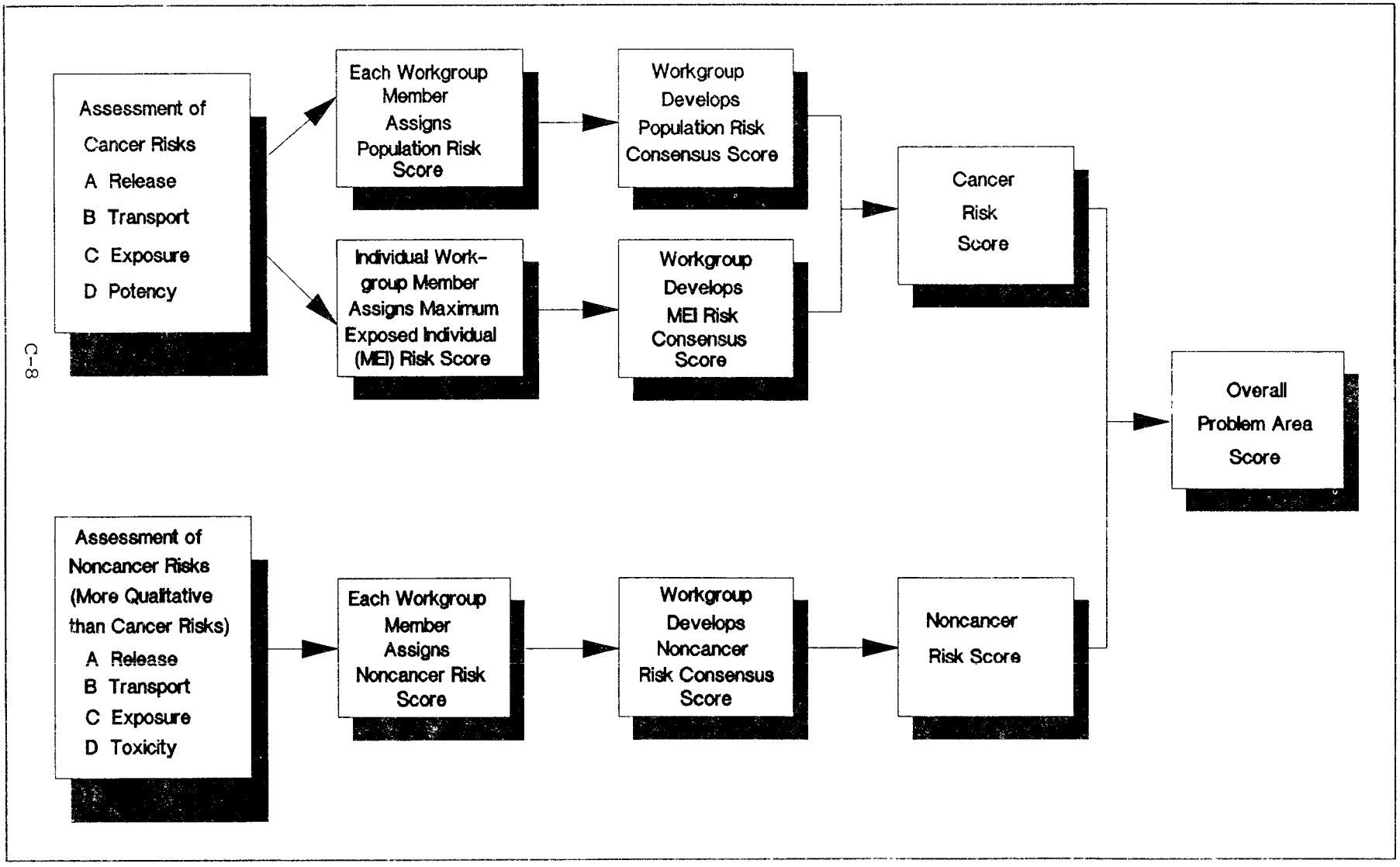

TABLE C-2

RANKINGS FROM THE OTHER HEALTH EFFECTS WORKGROUP

PROGRAM AREA/SOURCE	Cancer Risk Population	Cancer Risk MEI	Non-Cancer Risk	Score
Superfund Remedial and Removal Activities	4	5	4	13
Industrial Non-Hazardous Waste Facilities	4	5	3	12
Hazardous Waste Storage and Treatment Tanks	2	5	3	10
Land Disposal of Hazardous Waste	2	4	3	9
Mining Waste	1	5	3	9
Hazardous Waste Combustion	3	3	2	8
Municipal Landfills	2	5	1	8
Municipal Waste Combustion	3	4	1	8
Land Treatment of Hazardous Waste	2	3	1	6
Oil & Gas Operations Waste	2	3	1	6
UST Hazardous Substance Tanks	1	4	1	6
Other TSDFs	2	2	1	5
Petroleum Underground Storage Tanks	1	3	1	5
Exempt Storage Tanks	1	3	1	5
Mixed Waste	1	2	1	4
Oil Spill Response	1	2	1	4
Accidental Releases at Chemical Facilities	1	2	1	4
PCB Wastes	1	1	1	3
Ocean Dumping	1	1	1	3
Ocean Incineration	1	1	1	3
Transportation of Hazardousaterials	1	1	1	3
Underground Injection of Hazardous Waste	1	1	1	3

C.3 ECOLOGICAL IMPACTS

Scope of Effort. The Ecological Impacts Workgroup addressed the relative ecological risk potential and ecosystem impacts associated with 23 of the OSWER problem areas. Because the OSWER worksheets providing the requisite data were not available, no evaluation of removal actions at non-NPL sites was attempted. The Workgroup used a semi-quantitative risk characterization approach that relied both on available data and professional judgment.

Methodology. For each problem area, the Ecological Impacts Workgroup characterized the actual impacts and potential risks associated with each problem area (see Figure C-3). These data elements were grouped into the following four data composites: (1) number of sources and releases in a problem area; (2) contaminant concentration; and (3) receptors.

For each data element, direct information or estimates from the appropriate OSWER Comparative Risk Project work sheet were recorded with the resulting quantitative score. Where there was a range of values or the available data were limited, a best estimate was made. Where data were lacking, professional judgment was used, if appropriate. Otherwise the category was left blank. When available, a list of the most common constituents associated with each problem area was provided. For each problem area, data elements within the toxicity composite were scored according to the specific contaminant associated with that problem area that resulted in the maximum score for that data element (i.e., the bioconcentration score was obtained from the constituent with the highest bioconcentration factor, and the aquatic toxicity score was obtained from the constituent that was most toxic to freshwater organisms).

The score for each composite was obtained by taking the average score for the data elements within that composite for which data were available (missing values did not affect the score). For each problem area, an indication of the availability of data also was provided.

Data Sources and Uncertainty Levels. For most ecological problem areas, the sources/releases composite and the toxicity composite reflected high levels of quantitative information. The concentration composite scores and receptor scores were generally based on more subjective information.

Information for each of the respective parameters for the sources/releases composite was compiled from the appropriate worksheet for each problem area, and, where necessary, from other information sources. For each of the six ecological data categories, the direct information from the OSWER worksheet was recorded with the appropriate quantitative rankings. Where there was a range of values or the available data were limited, a best estimate of the midpoint for the range was made for the category. Where data were lacking, professional judgement was used, if appropriate.

Of the four catagories of toxicity values (i.e., toxicities to freshwater, marine, and terrestrial organisms, and bioconcentration), toxicity to terrestrial organisms was the most available. Toxicity values for mice were used when available and toxicity to rabbits was used secondarily. In compiling freshwater and marine toxicity values, a hierarchy of data was created to use the best

validated data when EPA ambient chronic water quality criteria values were not available. In general, the data for freshwater organisms was more abundant than data for marine organisms. Bioconcentration values were less available than other toxicity values.

Results. The results of the ranking procedure are shown in Table C-3. In general, the final ranking did not depend on the availability of data, although several problem areas in the moderate risk potential category (problem areas 3, 7, 8, 13, and 20) might have received a higher relative ranking if more data were available. The final rankings were dependent largely on the scores for two data composites: (1) toxicity; and (2) number of sources and releases. A ranking based on the product of these two scores (not shown) correlated well with the ranking shown in Table C-3 ($r = 0.89$, $p < 0.01$), and the groupings of problem areas into high, medium, and low risk categories was largely identical. As described earlier in Section 3.2.2, the Workgroup employed a broader definition for ocean dumping and showed a striking difference (higher risks) as compared with most workgroups.

Discussion. The ideal approach to a ranking procedure of this nature would be to use a quantitative risk assessment methodology to characterize risks to certain species or ecosystems. In this project, such an approach was limited by theoretical, data, and resource limitations. Because of these limitations, a qualitative risk characterization approach that relied heavily on professional judgment was used. Data availability was a major limiting factor. For many problem areas, the score for several data elements (particularly those within the concentration and receptor composites) were based largely on professional judgment.

FIGURE C-3
ECOLOGICAL EFFECTS METHODOLOGY

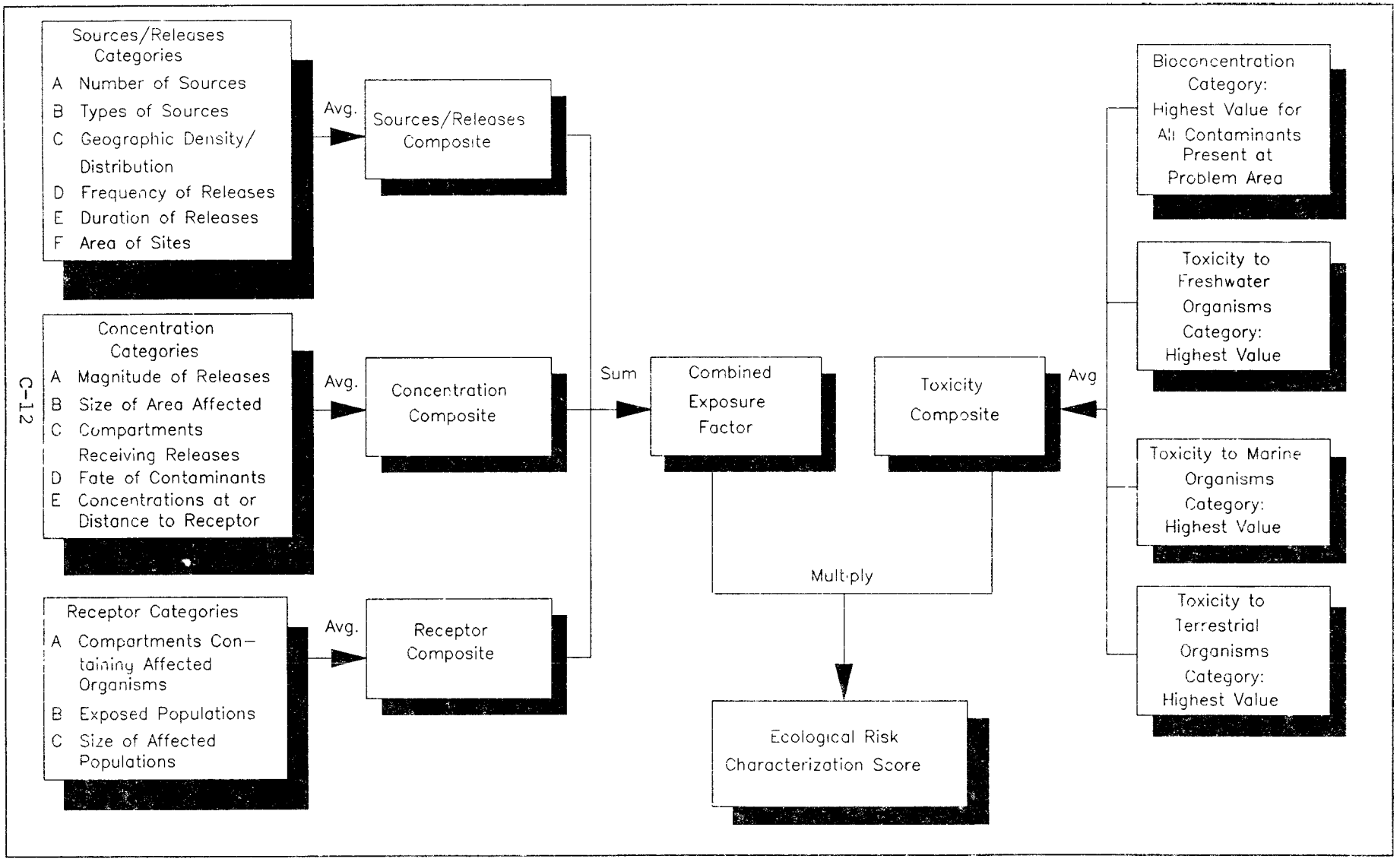

TABLE C-3

ECOLOGICAL IMPACTS

PROGRAM AREA/SOURCE	SCORE
Ocean Dumping	53.4
Remedial Actions at NPL Sites	53.1
Land Disposal of Hazardous Waste	52.0
Municipal Landfills	50.0
PCB Wastes	43.4
Mining Waste	42.5
Municipal Waste Combustion	40.2
Mixed Waste	38.3
Hazardous Waste Storage and Treatment Tanks	36.2
Hazardous Waste Combustion	35.8
Oil and Gas Operations	33.2
Land Treatment of Hazardous Waste	31.1
Other TSDFs	30.7
Industrial Non-Hazardous Waste Facilities	30.6
UST Hazardous Substance Tanks	30.6
Ocean Incineration	28.7
Petroleum Storage Tanks	27.8
Underground Injection of Hazardous Waste	24.8
Oil Spill Response	24.7
Solid Waste Management Units	23.0
Transportation of Hazardous Materials	22.2
Exempt Underground Storage Tanks	21.4
Accidental Releases at Chemical Facilities	19.8

C.4 WELFARE EFFECTS

Scope of Effort. The Welare Effects workgroup examined welfare effects (which were defined as damages to economic resources that result in a reduction in the value of commercial activities or in the value of human well-being). This approach was chosen because of the lack of studies associating economic impacts with OSWER problem areas. While the supporting workgroup report is titled "Report of the Economic Effects Workgroup", the workgroup recommended that the welfare effects be used for purposes of the overview report.The objective of the Welfare Effects Workgroup was to rank OSWER problem areas according to their potential relative negative welfare impacts. Negative welfare damages were defined as the loss in value placed upon an economic resource when environmental contamination associated with releases from OSWER problem areas occurs.

Data on the dollar value of welfare damages for each problem area were often unavailable. Consequently, the Workgroup did not attempt to estimate the absolute dollar value of welfare losses for each problem area. As such, the Workgroup decided only to estimate relative welfare damages associated with different problem areas. The limitations available information also required that the Workgroup had to rely extensively on best professional judgment when assessing the relative damages. Furthermore, the absence of rigorous, quantitative data meant that the Workgroup was unable to estimate damages with a high level of precision and instead used ordinal scales (i.e., high, medium, and low) to assess welfare damages.

Methodology. The Welfare Effects Workgroup's methodology relied heavily on the Workgroup's own best professional judgment (see Figure C-4). The Workgroup considered welfare effects for each problem area for three general categories of resources:

- residential and commercial property;
- natural resources; and
- surface water.

Damage to residential or commercial property was defined as material or structural damages to either residential or commercial properties and loss of commercial land for business activities. Damage to natural resources was defined as damages to agricultural crops, livestock, timber resources, and fisheries. Damage to surface water was defined as damages to surface waters used for drinking purposes or for recreation. For each problem area, the Workgroup assigned a Welfare Damage Score for each type of damage based on their estimate of the degree of welfare damage likely to be associated with releases in that problem area. Thus, for each problem area, the Workgroup assigned a Welfare Damage Score for damages to residential property, commercial property, timber resources, crops, livestock, fisheries, recreational use of surface water, and surface water used as drinking water. The Workgroup summed all eight scores to devise an index of total welfare damage associated with a problem area (overall scoring range 8 to 80).

The Welfare Damage Scores assigned to each type of damage ranged between 1 and 10. A score of 1 was assigned when welfare damages were estimated to be relative low, a score of 5 was assigned when welfare damages were estimated to

be moderate, and a score of 10 was assigned when welfare damages were estimated to be high.

In assigning Welfare Damages Scores, the Workgroup agreed on a series of assumptions or guidelines to estimate the magnitude of welfare damages. The Workgroup assumed that welfare damages would be greater when one or more of the following was true:

- a large volume of waste is released;
- substances released have a high toxicity;
- the concentration of constituents of concern in substances released is high;
- the degree of regulation in a problem area is relatively low;
- the number of sites or facilities in a problem area is relatively high;
- population density surrounding typical sites or facilities is relatively high; and
- there is a high density of natural resources close to the problem area.

Whenever possible, quantitative data were used as the basis for estimates of welfare damages. When no quantitative data were available, the Workgroup used its best professional judgment to estimate values for these parameters.

Data Sources and Uncertainty Levels. The key data source relied on to develop welfare damage estimates were problem area fact sheets prepared by the Office of Program Management and Technology. The fact sheets contained data on most parameters considered in the analysis. When data were not available from the fact sheets, attempts were made to identify other data sources. If no other data could be identified, the Workgroup relied on its own best professional judgment to estimate welfare damages.

Results. The final ranking of the Welfare Effects Workgroup is presented in Table C-4. The Workgroup divided the problem areas into three groups.

(1) High: problem areas with total welfare damage scores of 25 or greater.

(2) Medium: problem areas scoring between 15 and 25.

(3) Low: problem areas scoring below 15.

The Workgroup concluded that comparisons beyond this level of detail were not justified considering the quality of data supporting individual scores. At this level of comparison, however, the Workgroup expressed reasonable confidence in its conclusions.

Discussion. The Welfare Effects Workgroup chose not to consider four other potential welfare effects:

- aesthetic values;
- potential use values;
- secondary or indirect effects; and
- economic effects arising from ground water contamination.

Aesthetic and potential use values were not considered because the Workgroup judged that sufficient data were not available to realistically assess these effects. Secondary or indirect effects were not considered because the Economic Effects Workgroup wished to avoid overlap with other Workgroups. For example, the Welfare Effects Workgroup did not consider costs from medical expenses of exposed individuals because it was felt that this should be dealt with by the Other Health Effects Workgroup. Similarly, it was felt that potential welfare loss resulting from ecological damages should be addressed by the Ecological Effects Workgroup. By the same rationale, welfare effects arising from ground water contamination was not considered as this was to be addressed by the Ground Water Valuation Workgroup.

FIGURE C-4
ECONOMIC EFFECTS METHODOLOGY

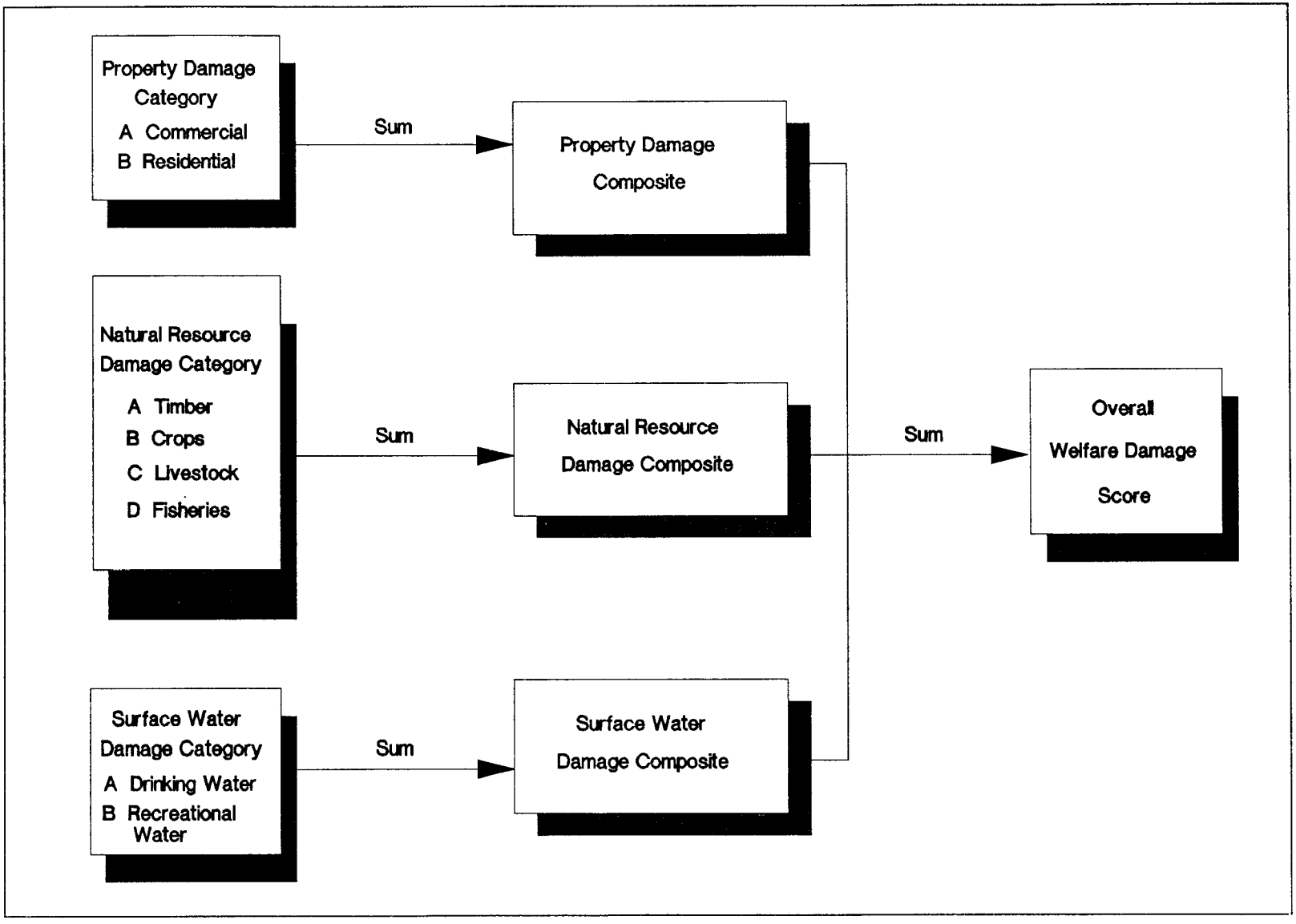

TABLE C-4

WELFARE EFFECTS WORKGROUP RESULTS

PROGRAM AREA/SOURCE	Surface Water		Natural Resources				Property		Overall Score
	Recreational	Drinking Water	Timber	Crops	Livestock	Fisheries	Commercial	Residential	
Superfund Activities	10	10	1	5	1	5	5	5	42
Solid Waste Mgmt Units (SWMUs)	10	5	1	5	5	5	5	5	41
Land Disposal of Hazardous Waste	5	5	1	5	5	5	5	5	36
Industrial Non-Hazardous Waste Facilities	5	5	1	1	1	1	10	10	34
Petroleum USTs (Including Used Oil)	5	5	0	1	1	1	10	10	33
Municipal Landfills	5	5	1	1	1	1	10	5	29
Haz. Waste Storage & Treatment Tanks	5	5	1	1	1	1	10	5	29
Mining Wastes	5	1	5	5	1	1	1	1	20
Exempt Storage Tanks	1	5	0	1	0	1	5	5	18
Oil & Gas Operations Waste	1	1	1	5	5	1	1	1	16
Other TSDFs	1	1	1	1	1	1	5	5	16
Municipal Waste Combustion	1	1	1	1	1	1	1	5	12
Combustion of Hazardous Waste	1	1	1	1	1	1	1	1	8
Transportation	1	1	1	1	1	1	1	1	8
Hazardous Substance USTs	1	1	0	1	1	1	1	1	7
Land Treatment of Hazardous Waste	1	1	1	0	0	1	1	1	6
Oil Spill Response	1	1	0	0	0	1	0	0	2
Underground Injection	0	1	0	0	0	0	0	0	1
Ocean Dumping	1	0	0	0	0	1	0	0	2
PCB Wastes	0	0	0	0	0	1	0	0	1
Accidental Releases @ Chem. Manufacturing Fac.	0	0	0	0	0	0	0	0	0
Mixed Waste	0	0	0	0	0	0	0	0	0
Ocean Incineration	0	0	0	0	0	0	0	0	0

Scale:
0 = No, or insignificant, level of economic impacts
1 = Relatively low level of economic impact
5 = An Average (or medium) level of economic impacts
10 = Relatively high level of economic impacts

C.5 GROUND WATER VALUATION

Scope of Effort. The objectives of the Ground Water Valuation Workgroup were to assess and compare the extent to which OSWER problem areas contribute to ground water resources damage. The Workgroup analyzed nine problem areas. Nine other problem areas considered by other OSWER Comparative Risk Workgroups were not analyzed since either presented only a minimal threat to ground water or because no reliable data were available on the potential of these problem areas to contribute to ground water contamination.

Methodology. The methodology used by the Ground Water Valuation Workgroup was based on a methodology developed by the Office of Solid Waste's (OSW) Economic Analysis Staff for quantifying resource damage associated with ground water contamination (see Figure C-5). This methodology is based on the concept of resource damage and replacement costs. In this approach it is assumed that ground water used as drinking water is generally a free resource. When such a resource becomes unusable due to contamination, there is a cost associated with its replacement. This cost is taken to represent the "value" users place on a contaminated resource, or how much they would be willing to pay for the least expensive substitute resource.

For each problem area, the Ground Water Valuation Workgroup developed a series of scenarios representing the range of potential contamination likely to occur from releases in that problem area. Each scenario was based on different runs of a series of problem area-specific ground water contamination models. These models simulated pollutant release from a facility or waste management unit and predicted concentrations of pollutants at various distances downgradient from sources of contamination. The models also predicted plume size, duration of contamination, and assumed well density. Based on the results of these model runs, the Ground Water Valuation Workgroup then developed engineering specifications for replacement water supply (based on a new system's design capacity, available water sources, and period of operation) for each scenario. A series of engineering cost algorithms were then applied to predict capital and operating costs for the replacement supply. These costs (expressed in present value terms) were assumed to be an approximation of the resource value of the ground water under that scenario. Aggregate national costs were then calculated by extrapolating estimated costs to the universe of facilities or sites in a problem area based on the estimated distribution of scenarios in each problem area.

Data Sources and Uncertainty Levels. No single data source was used to base model estimates on. Generally, cost, distribution, failure potential, and types of contamination were taken from data in regulatory impact analyses (RIAs) or similar reports on impacts of various waste management practices. In most cases these data were based on samples of sites or facilities. Generally, data deficiencies required that the Workgroup had to make assumptions about environmental settings of various types of facility or site, hydrological parameters, exposed populations, types of waste handled, facility size, and water use patterns.

Current and future ground water use was estimated on the basis of U.S. Geological Survey water supply data covering the 1975-1980 period. The

probability of future use was estimated based on the assumption of an increased rate of use of 1.4 percent per year.

Results. The Ground Water Valuation final ranking is presented in Table C-5. Aggregate national costs (not shown) ranged from $0 for Combustion of Hazardous Wastes to $15 billion for USTs. Other significant findings included:

- NPL sites have the highest mean resource damage per site (present value costs of $9.7 million per site).
- The number of facilities in each problem area plays a significant role in determining aggregate national resource damage cost estimates.
- The size of facilities within a problem area is highly correlated with high resource damage cost estimates.

Discussion. A number of important caveats or limitations should be noted about the results of the Ground Water Valuation Report:

- The Ground Water Valuation Workgroup did not consider the effects of ground water contamination prevention programs, although such regulations are already in place in a number of problem areas. The effect of this assumption is to probably overestimate resource damage in some problem areas. If regulatory environments were considered, it is likely that the ranking of the problem areas would change.
- The Workgroup assumed that no ground water clean-up activities were performed for any problem area except NPL sites. The effect of this assumption is that contamination spreads more widely (i.e., plumes are modeled to grow larger and last longer) than they actually do given current regulations. As a result, replacement water supplies are assumed to have larger design capacity and operate for longer periods than they probably actually have or do. This has the overall effect of increasing resource damage cost estimates.
- In many cases the final resource damage estimates were based on poor data and numerous assumptions. Generally, the weakest aspects of the data were related to plume size and water use patterns.
- The Workgroup considered using only a nearby aquifer as a substitute source for contaminated drinking water. Other alternatives (e.g., temporary use of bottle water or point of use treatments) were not considered as alternatives.
- The Workgroup did not consider regional differences in resource damage. As such, regional variation in the cost of replacing contaminated water systems was not considered. Such variations

might have considerable impacts on the overall ranking of problem areas.

- Resource damage models focused entirely on human use. Other forms of potentially significant damage from contaminated ground water (e.g., the loss of ground water for irrigation) were not considered. Including other economic losses might change overall rankings.

- The models used to calculate the impacts of contamination are not sensitive to the magnitude of contamination beyond identified thresholds. Resource damage is held to occur the moment a threshold is passed. At that point it is assumed that users will stop drinking contaminated water and seek alternative supply the moment the threshold is exceeded. Including magnitude in the analysis might alter the overall ranking of the problem areas.

FIGURE C-5
GROUND-WATER VALUATION METHODOLOGY

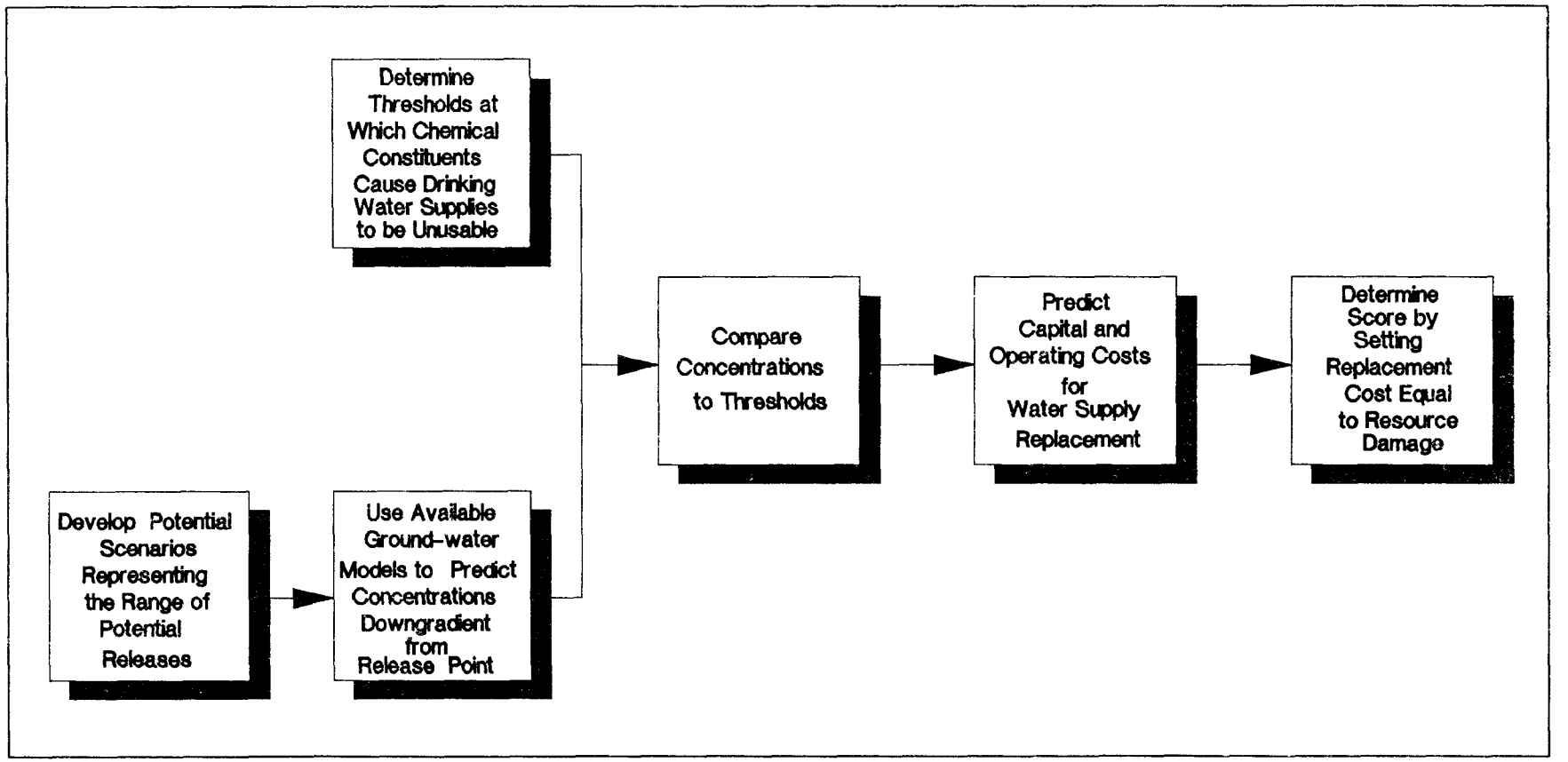

TABLE C-5

GROUND WATER VALUATION

Problem Area	Natural Resource Damage*	Mean Resource Damage**
Underground Storage Tanks	15000	11
NPL Sites	8600	9700
Municipal Landfills	2580	420
Solid Waste Management Units	1750	310
Land Disposal of Hazardous Waste	190	365
Mining Waste	178	360
Oil and Gas Waste	173	0.8
Other Treatment, Storage and Disposal Facilities	69	26
Hazardous Waste Combustion	0	0

The following problem areas were not evaluated but judged to rank between other treatment, storage and disposal facilities and hazardous waste combustion:

Industrial (D) Landfills
Land Treatment of Hazardous Waste
Underground Injection
Non-NPL Sites
Transportation

Similarly, the following problem areas were not modeled but judged to rank after hazardous waste combustion:

Municipal Trash Incineration
Hazardous Waste Cleanup
Ocean Incineration

*Natural Resource Damage is reported as water supply replacement costs by problem area in millions of dollars.
**Mean Resource Damage is reported as water supply replacement costs by problem area in thousands of dollars.

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