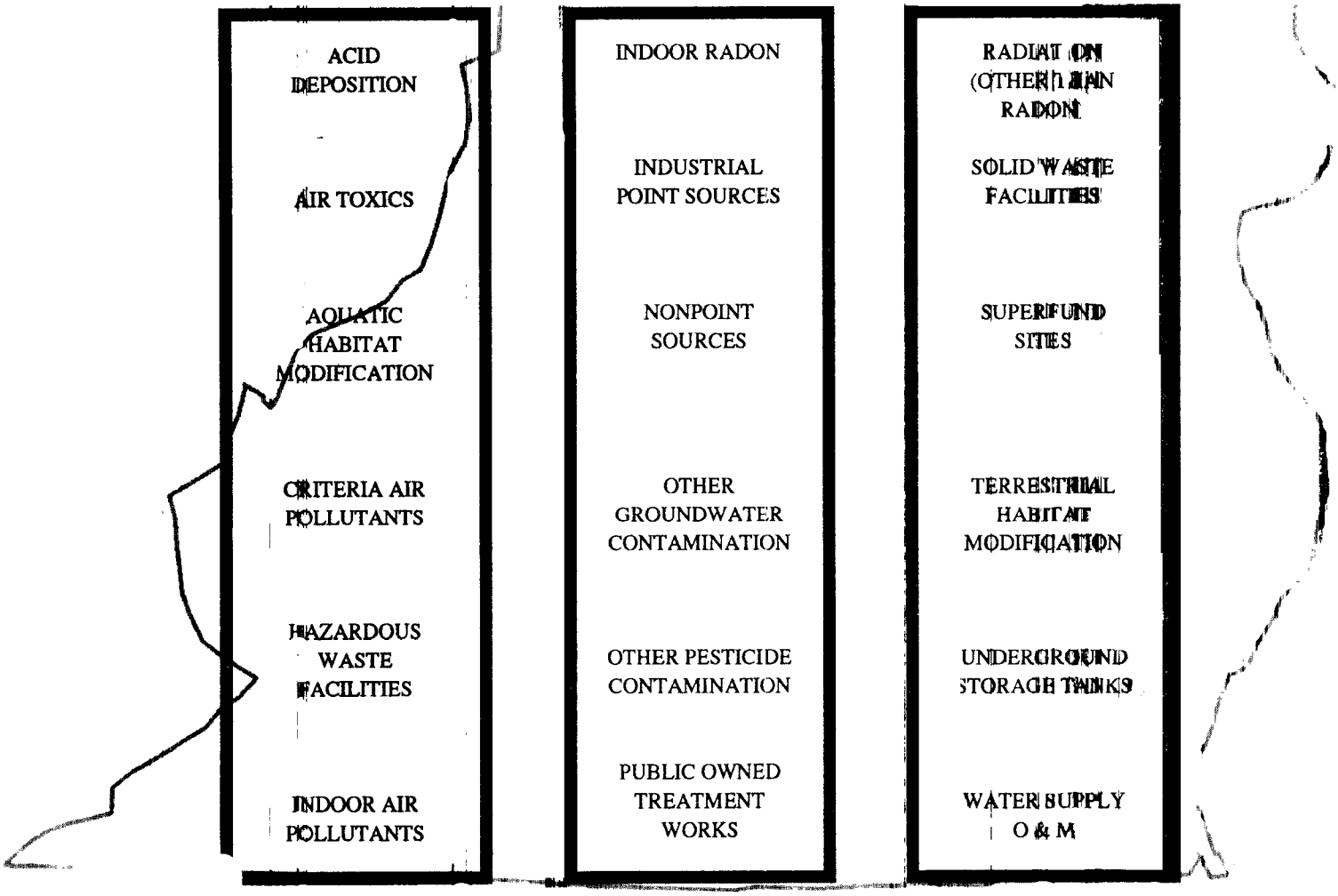
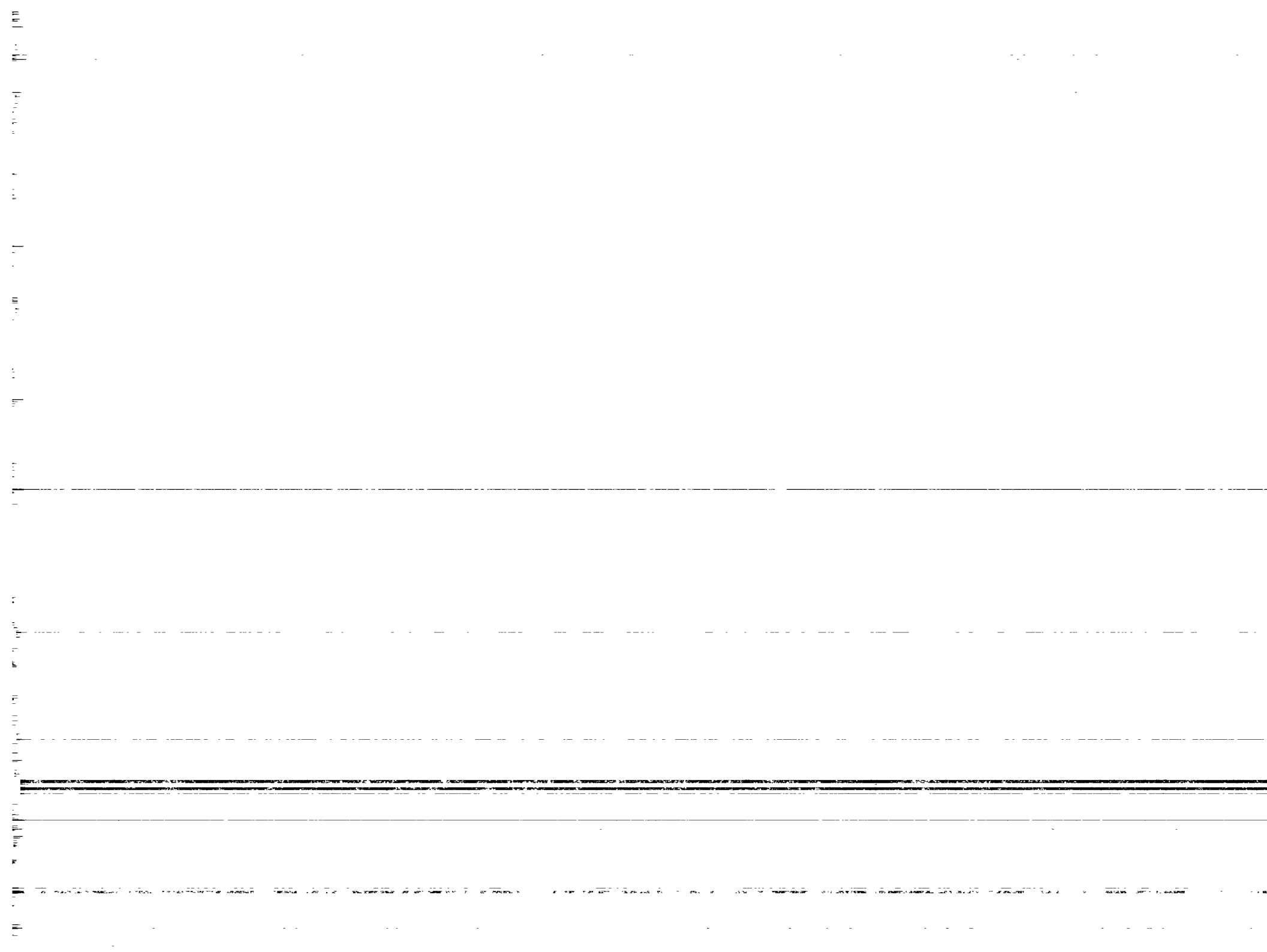
EPA Region III

COMPARATIVE RISK PROJECT

A RISK-BASED ASSESSMENT OF

ENVIRONMENTAL PROBLEMS





PREFACE
BY
EDWIN B. ERICKSON

Citizens Concerned With the Environment:

The Mid-Atlantic area that encompasses EPA's Region III has a diverse environment. In our region, we are challenged to find innovative ways to protect the public health and the environment we share with various species of flora and fauna. This is a challenge we gladly accept.

This report summarizes the current status of environmental problems within the region in terms of the relative risks that are posed by eighteen defined problem areas. This is our first attempt to use the comparative risk evaluation methodology, which is an innovative approach to ranking environmental problems.

We at EPA share everyone's concerns about the continued presence of contaminants and pollutants which threaten our health and damage our environment. Often, new problems appear before existing problems can be brought under control or eliminated. Restraints on the Federal budget require agencies like EPA to direct resources to those areas where they can do the most good, that is to achieve the greatest reduction in environmental risks.

EPA Region III Comparative Risk Project is our response to the question, "Which environmental problems pose the highest risk to public health and the environment?" We are currently working on the next step, determining how to address those highest risk problems.

Our understanding of the complexities of the environment in which we live continues to improve, but demands further examination in our approach to solving environmental problems. Government at all levels must work together to find solutions that manage environmental risks. Therefore, we are releasing this report to help identify the relative risk of our environmental problems and focus our attention to reducing those risks.

I hope this report will help us improve as environmental managers and help the public to better understand our activities. We would be pleased to have your reactions to this report.

Edwin B. Erickson
Regional Administrator

EXECUTIVE SUMMARY

Environmental problems which have only recently "come to light" or for which existing control programs have not been completely successful present high risks to human health and the environment in the area that encompasses EPA's Region III. While the technology to address these problems is generally available, the associated costs will be prohibitive. Region III does not have the necessary resources in terms of personnel, funds, or legal authority, to resolve all of these problems in the immediate future.

Region III conducted the Comparative Risk Project to determine which of the Region's environmental problems posed the greatest risks to human health, ecology, and societal welfare.

Region III's Comparative Risk Project is consistent with the national report, Unfinished Business, and with similar projects in Regions I and X. This summary discusses the major findings of the project, the methodology used to obtain those findings, and some of the additional benefits derived from undertaking this project.

FINDINGS

The findings of the project are priority rankings of eighteen environmental problem areas in terms of human health, ecology, and welfare risks. The project focused on the uncontrolled portion of an environmental problem, known as residual risk. Risks that are currently abated were not considered. The findings were as follows:

* The highest ranking human health risks are indoor air, indoor radon, pesticides in food, radiation (other than radon), nonpoint sources of pollution, and contamination associated with the operation and maintenance of public water supplies.

* The problem areas that rank highest for ecological risks are the physical modification of terrestrial and aquatic habitats and nonpoint source discharges of pollution.

* In the welfare category, the problem areas with the highest ranking are criteria air pollutants and acid deposition.

* Assisted regional management in planning and priority setting in Region III. This analytical tool may be used by the senior level managers in the decision-making process employed in establishing resource allocations.

* Determined the importance of explaining the limitations of this project. The project does not indicate trends in environmental programs, or the consequences of reducing or eliminating base programs.

* Identified the need to put more effort into developing and improving data management systems. Regional and state data bases were often inaccessible or lacking information.

METHODOLOGY

The method used to compare environmental problems is closely aligned with the procedure used for risk assessment. The Region approached the project systematically, utilizing the best professional judgment among Regional experts. The staff represented all regional environmental programs with a variety of scientific expertise. Three work groups were formed to address the problem areas based on human health, ecology, and welfare. Existing data on pollutants, exposure, effects, and costs were collected and analyzed. Where gaps existed, work groups relied heavily on professional judgment. In some areas, the project represents the Region's best opinion, given the limited knowledge, rather than quantitative analysis. The participants felt relatively confident in their final rankings.

The regional staff analyzed problem areas which generally correspond with existing EPA programs or statutes. The Region excluded certain problem areas that were beyond the influence of EPA Region III, such as global warming and ocean dumping. The final list consisted of eighteen problem areas that were analyzed for this report.

For each problem area, three types of risk were evaluated; public health risk, which included cancer and non-caner risks; ecological risks; and welfare risks, or social costs. Each type of risk was evaluated separately. No attempt was made to determine whether one category was more important than another or to combine risks across problem areas.

BENEFITS

The Region benefitted from the Comparative Risk Project in several ways:

* Identified that high-ranking public health problems have little or no ecological impacts, except for nc point source discharges of pollutants. Regional attention needs to be focused in both areas to reduce risks.

* Identified several problem areas which did not pose the high risk that were expected, including the hazardous waste and underground storage tank programs.

* Increased the level of communication among the various environmental programs. Provided a greater understanding of the relative risks among the problem areas. The work group participants were especially enlightened to the risks associated with other environmental problems.

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I. Introduction

Themes in Environmental Management

The early 1970's marked the beginning of a new national commitment to restore and protect the environment. The Environmental Protection Agency (EPA) was created to clean up the gross and highly visible pollution that choked our nation's air and fouled our rivers and streams. Using newly developed environmental laws, regulations, and technologies, EPA and state environmental agencies have made significant progress over the past two decades in controlling air pollution and restoring water quality. During this time, several major themes in environmental management have emerged to make this project timely.

Setting Priorities

One important theme in the evolution of environmental protection has been an increase in the complexity and number of issues without an accompanying increase in resources to address them. With advances in scientific knowledge and measurement techniques, previously unrecognized problems have been detected. DDT, asbestos, PCBs, dioxin, radon, indoor air pollution, the ozone layer, and many other environmental problems have come to the forefront of public concern. As scientific understanding and public awareness increase, the list of issues continues to grow.

Increased governmental responsibilities for managing these issues, particularly at the state and local levels, have not always been matched with sufficient funds. In an era of tight budgets, government environmental programs need to set priorities carefully to get the greatest possible benefit out of available resources.

Risk Analysis

Government has traditionally faced environmental challenges in a reactive mode -- setting and enforcing environmental standards. With increased understanding of the problems comes the realization that a reactive approach must be supplemented with new strategies that better anticipate and plan for future environmental concerns. A second important theme in environmental management is the development of risk analysis as a tool to help sort through environmental problems. Risk analysis can provide a common denominator across disparate environmental areas to indicate the seriousness of the problem. To avoid

reactive policy-making, government officials can use risk analysis to evaluate and compare the multitude of environmental problems.

Regional Differences

The third theme providing important background for the Region III Comparative Risk Project is the growing importance of regional differences in environmental management. National pollution control programs have effectively provided most citizens with a minimum level of environmental protection. Many of the remaining problems vary from area to area and require site-specific, tailored controls at the regional, state, or local level for effective mitigation. Nationwide requirements cannot always address unique local conditions, such as exposure patterns, hydrogeology, or meteorology, which demand unique local solutions.

These three themes underscore the need to set environmental priorities carefully. Region III believes the Comparative Risk Project will provide insight to help develop a new environmental planning process.

Origin and Focus of the Comparative Risk Project

EPA Headquarters earmarks nearly all the resources it provides to the Regions to accomplish specified levels of work output. The Regions have limited influence over national priorities or specified work levels. For several years, Region III has sought more flexibility from EPA Headquarters to address unique regional problems. Nearly all of the resources provided by EPA Headquarters to the Region are earmarked by program. Region III has attempted to improve this situation by systematically determining regional priorities, how they differ from national priorities, and how to obtain increased flexibility to address them.

Region III developed its MERITs (Measurable Environmental Results Initiatives) program to help address high-risk, high-priority regional problems. Every year the Region solicits MERITs proposals from the staff. It encourages the staff to develop proposals that address emerging high-risk environmental problems that are inadequately addressed by existing programs. A committee of regional managers and senior staff evaluates the proposals in terms of their feasibility and risk reduction benefits. The Region has completed over 50 projects that would otherwise not have occurred.

Although Region III's MERITs have been nationally recognized as an innovative method of focusing resources on high-priority environmental problems, the MERITs process has limited scope. The Region

allocates only a small fraction of its resources to MERITs projects. The Region wanted to conduct a comparative risk analysis to expand on the MERITs process by addressing the entire scope of regional programs. The analysis would produce a relative ranking of environmental programs and a starting point for developing comprehensive regional resource allocation priorities. In a narrow sense, the Region wanted to use comparative risk to allocate its own discretionary resources by identifying problems for development of MERITs proposals. In a broader sense, the Region planned to use the assessment to increase its flexibility in allocating non-discretionary resources by highlighting what is unique about Region III's environmental problems.

Region III's Comparative Risk Project is designed to improve the Region's process for setting management priorities among environmental problems. The central premise is that environmental protection priorities should be placed on reducing demonstrated risks. The project has three specific objectives:

- To develop a relative ranking of environmental problems in Region III based upon the seriousness of the risks they pose.

- To establish a set of effective initiatives to work toward mitigating these problems.

- To enhance the Region's management system using the rankings of problems and initiatives.

The Comparative Risk Project has two phases corresponding generally to the first two of these objectives: a risk assessment phase and a risk management phase. In the first phase, the regional staff analyzed and ranked the major environmental problems facing the Region. They ranked the problems in terms of the risks they pose to human health, to natural ecosystems, and to economic welfare in the Region. The project covered all of the environmental media -- air, surface water, land and ground water. In the second phase, now under way, the staff is evaluating initiatives to mitigate these problems. The Region will consider the ranking results and initiatives in the regional budget and planning processes.

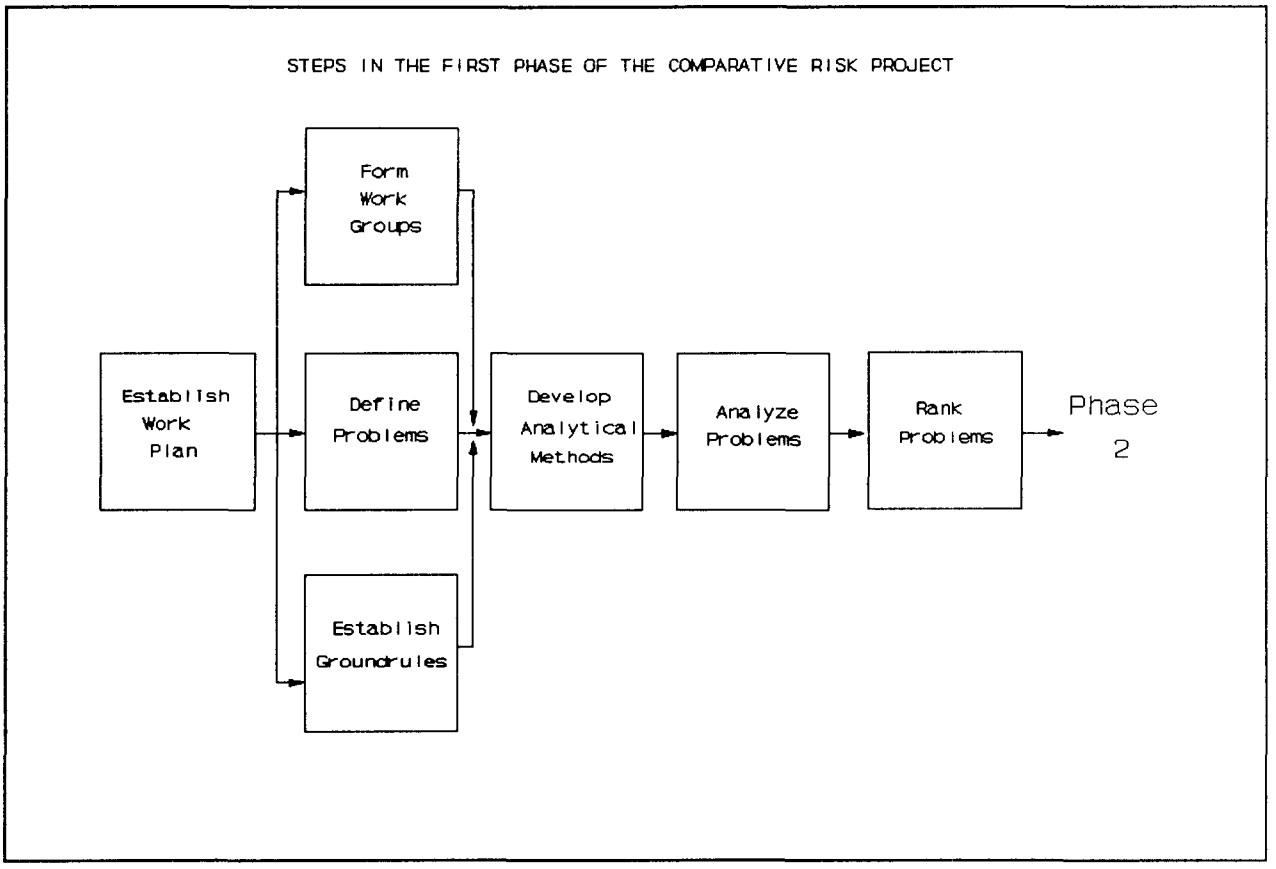
Purpose of This Report

This report focuses on the activities and results of the first phase of the project. The report briefly describes the general process the Region used in conducting the comparative risk analysis and provides details on the project's major steps. The report describes in more detail the analytical methods used to rank the environmental problems, and the ranking results.

II. Overview of the Project's First Year

The Process

The main objective in the first phase of the project was to rank the risks posed by the major environmental problems in Region III. The basic approach included defining the list of environmental problems, developing methods to analyze the risks they posed, collecting and analyzing data, and ranking the problems using the data and best professional judgment. This section briefly describes the process the Region used in the first phase of the Comparative Risk Project.



Beginning the Project

In the spring of 1987, staff in the Environmental Services Division (ESD) drafted a work plan for the Comparative Risk Project. The Environmental Management Committee (EMC), a standing multi-

media committee in Region III, and a committee of senior managers reviewed and modified the work plan. On July 9, 1987, the Regional Administrator approved the work plan and sent it to EPA Headquarters. This marked the formal beginning of the project.

Designating Roles and Responsibilities of Participants

Once the work plan had been approved, the Region organized personnel to perform specific project tasks. The Region designated project management staff, a Steering Committee to provide direction and oversight, the EMC to coordinate and resolve issues, and three work groups (one work group for each of health, ecological, and welfare risk) to perform the analysis and rankings. EPA Headquarters provided staff assistance and contractor support.

Defining the Problem Areas

The project management staff based Region III's problem list on the list from Unfinished Business. The Steering Committee made several major changes to the original list by requiring the problem areas to be mutually exclusive and by dropping problems that were national in scope and unlikely to be addressed at the regional level.

Establishing Ground Rules

To structure the ranking of environmental problems, the Region adopted several important ground rules identical to those used in Unfinished Business. The rules focus on risk as the best way of comparing the relative seriousness of environmental problems. In particular, the project examines risks that remain after assuming current levels of environmental controls as the base.

Developing Analytical Methods for Comparing and Ranking Problem Areas

Each of the three work groups developed methods to provide a structure for determining the data to collect and analysis to perform for each problem area. These methods imposed consistency within each work group across the problem areas.

Lack of standard risk assessment methods in several areas, unfamiliarity with risk analyses, and the novelty of the project posed a problem for the work groups in developing analytical risk assessment methods. Each work group with the assistance of EPA Headquarters staff and contractors basically designed its own new method of analysis after considering available options.

Analyzing the Problems

Each work group assigned a problem area to a single individual in the group. The lead individual for a problem area analyzed the problem in accordance with the work group's methodology and reported the results to the entire work group. As a first step, the lead work group member directed contractors to prepare plans that outlined the data to collect and analysis to be performed for the problem area. These plans typically relied on the results of national analyses, modified to reflect regional data sources. Contractors provided summaries of the results to the lead individuals.

Ranking the Problems

Each work group used a similar procedure to develop its final rankings. The lead work group member for a problem area reviewed the data and analysis provided by the contractors and developed a tentative ranking or score for the problem. The lead described the analysis and the proposed ranking to the entire work group. Intensive discussions followed, often involving questioning the analysis or data, developing group judgments, and directing work group members or contractors to do further analysis. The discussions continued until the group reached a consensus on the problem's rank. After the work groups discussed each problem area, they reviewed the entire list of rank-ordered problems, making adjustments as necessary. Each work group concluded by characterizing its level of confidence in the final ranking.

Reviewing and Documenting the Rankings

Representatives of the work groups presented their risk rankings to the EMC and the Steering Committee. Neither group made any changes to the rankings. After approval of the rankings by the Steering Committee, the project staff wrote this report summarizing the results of the first phase of the project.

Roles and Responsibilities of Participants

More than 50 regional employees representing all EPA's environmental programs participated in the Comparative Risk Project. They included senior professional staff and all levels of management. The participants are listed in Appendix 2. The Region organized these participants to perform the following functions:

Project Management Staff

The Region designated as the project manager an individual in ESD who was familiar with risk assessment and had managed the Region's MERITs process. The Geographic Studies Branch at EPA Headquarters provided a full-time staff person to support Region III's project. EPA Headquarters also provided other staff and contractor assistance as needed.

Steering Committee

The Steering Committee was formed to provide general guidance and oversight for the project; assign personnel; review and approve the work plan, list of problem areas, project ground rules, analytical methods, and final rankings; evaluate regional activities to address project results; and integrate the project with the Region's planning and resource allocation processes. Chaired by the Deputy Regional Administrator, the Steering Committee consists of the Region's Division Directors and Office Heads. The Committee has final approval on all significant project activities.

Environmental Management Committee (EMC)

The EMC is a standing committee that consists of mid-level managers and senior staff across all programs in the Region. The Branch Chief of the Environmental Assessment Branch in the Environmental Services Division chairs the EMC. For purposes of the Comparative Risk Project, the EMC assists with project design and implementation and provides recommendations to the Steering Committee on such issues as the list of problem areas, analytical methods, and development of the final rankings. The EMC also coordinates and resolves issues raised by the three work groups.

Work Groups

Three work groups (Health Work Group, Ecological Work Group, and Welfare Work Group) were formed to carry out the bulk of the analysis needed to rank the problem areas. Chaired by a Branch Chief, each work group consists of approximately ten individuals, ranging from technical staff to regional managers, who represent all major program areas. Although the Region does not have many individuals with methodological expertise in health, ecological, or welfare risk assessment, the project organizers attempted to assign individuals with appropriate experience to the work groups. Three toxicologists sit on the Health Work Group; two ecologists are on the Ecological Work Group; and one economist sits on the Welfare Work Group.

Problem Definitions

Region III had many options to consider in defining the problem areas. Environmental problems may be divided by pollutants (e.g., benzene, microbials, cadmium), by sources of pollution (e.g., automobiles, power plants, underground storage tanks), by media (e.g., air, surface water), by geographic region (e.g., Chesapeake Bay, the Kanawha Valley, Virginia), or by other factors. The project management staff decided to define the problem areas to correspond with areas addressed by major EPA programs, so that it would be easier to translate the results of a risk ranking into implications for program priorities. This produced a mixture of problem areas defined as pollutants, sources and media.

To allow a comparison of regional and national environmental risks, the project management staff decided to modify the list from Unfinished Business, which included 31 problem areas roughly corresponding with EPA national program areas. The Region modified the list in two ways -- by defining the problems to be mutually exclusive and by excluding problem areas outside regional control.

Defining the problems to be mutually exclusive was a major divergence from the Unfinished Business list. Where a risk might plausibly be included in any of several problem areas, the Region assigned it explicitly to one problem area, to avoid double-counting the risk. For example, if a Superfund site contaminates ground water that is used for drinking, the resulting health risk could be counted as a Superfund site problem, a ground-water problem, a drinking water problem, or all three. Multiple EPA programs may address this problem. The Region assigned this risk to the Superfund problem area. Regional staff devoted substantial effort to identifying areas of potential program overlap and assigning them uniquely to a problem area.

Although the Region wanted a comprehensive list of problems, it did not want to include environmental problems of a national or global scope which could not be solved by regional action. Consequently, the project organizers excluded problem areas that were beyond the Region's level of control, such as global warming or ozone depletion. The final list of problem areas covered all environmental risks addressed by Region III.

Exhibit 1 shows the resulting list of 18 environmental problems. Appendix 1 provides full definitions of the problems. The definitions identify what is included and excluded from each problem. The definitions play an important role in explaining the rankings.

EXHIBIT 1

List of Problem Areas

1. Criteria Air Pollutants
2. Hazardous/Toxic Air Pollutants
3. Radon - Indoor
4. Indoor Air Pollutants Other Than Radon
5. Radiation Other Than Indoor Radon
6. Industrial Point Source Discharges to Surface Water and Air
7. POTW Discharges to Surface Water and Air
8. Nonpoint Source Discharges to Surface Water and Air
9. Management of Hazardous Waste at RCRA Facilities
10. Hazardous Substances at CERCLA Sites
11. Solid Waste Management
12. Releases from Underground Storage Tanks
13. Other Ground-Water Contamination
14. Other Pesticide Contamination
15. Physical Modification of Aquatic Habitats
16. Physical Modification of Environmentally Sensitive Terrestrial Habitats
17. Acid Deposition
18. Operation and Maintenance of Water Supply Facilities

Ground Rules

Region III adopted important ground rules that affect the interpretation of the results of the comparative risk analysis.

Focus on Risks

To measure the relative seriousness of environmental problems, the project organizers focused on risks. Risk measures capture the ultimate impacts of the problems. For example, scrubbers are not installed on electric power plants to reduce emissions to meet air quality standards; rather they are installed to protect people from getting sick or lakes from acidification. Pollution control actions are designed to eliminate the ultimate impact of environmental problems on humans or the ecology of an area. Region III's comparative risk analysis focused on three basic types of risks: human health effects, ecological effects, and welfare effects.

THREE TYPES OF RISK

Health risk - Cases of human disease or injury caused by the environmental problem.

The health effects considered ranged from cancer (e.g., lung cancer from indoor radon) to learning disabilities (from airborne lead) to gastrointestinal disease (from pathogens in drinking water) to angina pain (from carbon monoxide) to numerous other non-cancer effects.

Ecological risk - Damage to the structure and function of natural ecosystems from the environmental problem.

Some examples of the effects considered include: eutrophication of water bodies from nutrients in nonpoint source runoff; loss of species' range, breeding grounds, and other effects from physical modification of habitat; and reduced growth rate of trees and increased susceptibility to pests in forests exposed to high levels of ozone.

Welfare risk - Economic losses to human activities caused by the environmental problem.

Examples include increased maintenance expenses for paints and other materials exposed to acid deposition; reduced recreational use of water bodies polluted by industrial dischargers; costs of replacing or treating drinking water supplies contaminated by hazardous waste site leachate; and costs of treatment and lost productivity for individuals suffering adverse health effects from environmental pollutants. Also included under welfare risks are intangible damages, such as the adverse effects of odors or reduced visibility associated with air pollution. Only the primary or direct welfare damages were counted. Market manifestations of welfare damages (e.g., reduced real estate prices in polluted areas) were thought to provide possible measures for welfare damages, but were not considered themselves to be damages.

Consider Only Residual Risks

The project assessed the "residual risks" associated with each problem area. Residual risks are the impacts that remain, given the current levels of controls and non-compliance with regulatory requirements. The project did not assess risks in the absence of control actions or after current requirements are met. This ground rule of considering only residual risks forced the Region to evaluate the existing environmental situation. It also affects the policy implications one might draw from the risk ranking:

- o A problem area might rank low because the risks it presents are: (a) inherently low, or (b) inherently high, but a control program has successfully reduced them.

- o The risk rankings provide guidance for allocation of new incremental resources among programs, but no guidance for reallocating existing resources. Residual risks provide a guide to problem areas most in need of further efforts. They do not provide an indication of how much risks would increase in a problem area if present programs were dismantled or reduced.

- o A problem area can appear to present high residual risks currently, even though compliance with existing laws and regulations will lower the risks considerably.

Separate Risk Assessment from Risk Management

The third project ground rule was to consider only the risks associated with the problem areas. Other attributes of the problems that are important in determining how to address them -- such as the cost or technical feasibility of dealing with them, or public opinion about them, for example -- were not considered in the ranking process and were reserved for consideration later in the project. Assessment of the seriousness of each environmental problem (risk assessment) was carefully separated from evaluation of what could be done about each problem (risk management). The risk rankings alone do not represent the Region's priorities for action. Setting priorities involves balancing the severity of each problem with judgments about how effectively it can be addressed.

Use Both Quantitative Data and Expert Judgment

The project organizers wanted the risk rankings to be as objective as possible. There had been several other instances, for other purposes, in which regional management had listed which environmental problems they considered most serious in the Region. These lists, though, were based upon opinion, judgment, and little analysis. The Comparative Risk Project was unique in that it sought to generate a risk

ranking in a systematic, objective, and data-driven way. The project participants aimed to generate and use as much quantitative data on risks as possible. But there were inevitable constraints:

- The work groups had limited time, staff, and budget for the analysis. Full risk analysis, in which data on emissions and ambient concentrations are collected, exposures are modeled, and ultimate impacts are projected, is very costly and time-consuming.

- Even if resources had been unlimited, risk analysis is an inherently uncertain process. Subjective interpretation of the results of any risk analysis is always necessary, weighing the strength of the data base used and the validity of the assumptions made.

In short, the project organizers realized that the rankings could not be completely objective. The project staff used their own expert judgment in instances when they could not obtain data or perform analyses. Their approach was to quantify results to the extent the available data and time allowed, to recognize the universal need to supplement the data with judgment, to make the judgments in an objective manner, and to address significant data gaps through future refinement of the estimates and assessments.

To stretch regional resources, the project staff relied extensively on risk analyses that had already been done for other purposes prior to this project, and adjusted them to suit their needs. Unfinished Business was particularly helpful. In many cases, the project staff extrapolated from incomplete analyses.

> An example occurred in estimating the health risks associated with the toxic air pollutants problem area. A contractor modeled the health risks in Region III from 22 toxic air pollutants. But there are far more than 22 toxic air pollutants in total. The health work group had to decide whether the 22 modeled pollutants constituted a large or a small fraction of the total risks associated with the problem area. The health work group relied on the judgment of the regional air program staff and the contractor, and information in Unfinished Business (deriving from OAQPS staff judgments) to make this decision. The work group decided that although a few important air toxics were omitted from the analysis and although synergistic effects had not been considered, the risks were estimated conservatively for the 22 chemicals, and they probably did not drastically understate the risks for the entire problem area.

At times, a work group relied on analyses that had been done for other geographic areas and adjusted them to fit Region III. Health risks from industrial plants discharging to surface waters had been estimated for the State of Pennsylvania; the work group scaled them up to represent the entire Region. In other cases, a work group qualitatively adjusted estimates of different quality in order to make them more comparable (e.g., where one analysis was based on highly conservative, worst-case assumptions, while another analysis was based on more realistic assumptions). And in many cases, there were simply data gaps that a work group had no choice but to fill by using judgment.

In sum, the rankings should be viewed more as the informed judgment of the Region III professional staff, based on quantitative data to the extent possible, than as the results of a scientific risk assessment. No scientific group has peer reviewed the results or analyses, because the results are fundamentally not scientific. But they are not simply opinion either. The project participants collected large amounts of data and conducted extensive analyses. They took care to make their judgments systematically and objectively. They developed the rankings by using carefully developed methods for each of the types of risk.

III. Ranking Environmental Risks in Region III

Each work group designed analytical methods, conducted analyses, and ranked the 18 environmental problems. In many instances, the analytical method a work group chose substantially influenced the group's specific results. For example, the way in which the Health Work Group chose to weigh cancer relative to non-cancer health effects influenced the way they ranked risks from criteria air pollutants (which are not thought to be carcinogenic) relative to those from radon (which causes cancer, but few non-cancer effects). This chapter describes each work group's ranking results and the methods for developing them.

Health Risk Methods

The health work group's methodology involved estimating four categories of health effects -- risks to highly exposed individuals and aggregate risks to the entire Region III population, for cancer and for non-cancer effects -- for particular chemicals chosen to represent each problem area. The work group estimated risks in each of these categories by developing exposure scenarios typical of each problem area.

An exposure scenario summarized one instance in which humans could be exposed to pollutants from a problem area. For each exposure scenario, the key data included the concentrations of contaminants to which individuals were exposed, the duration of the exposure, the number of people exposed, and an indication of the degree to which the scenario represented the entire problem area. The representativeness of each scenario was particularly important, as the work group and contractor had to decide how to scale up from the particular exposure scenarios for which data were available to the entire problem area. The scaling up processes differed substantially from one problem area to the next. Sometimes an exposure scenario represented an average case, and most of the residents in the Region were expected to be exposed similarly to those in the scenario. Sometimes the scenario was an extreme case, and relatively few individuals in the Region were likely to be similarly

Some exposure scenarios for different problem areas included:

- The ambient concentrations of 22 toxic air pollutants in each Region III county.
- The concentrations of contaminants in drinking water intakes and fish downstream of each of 12 sampled industrial dischargers.
- The indoor concentrations of radon, chlordane, formaldehyde and other substances in residences where sampling has been conducted.
- The average concentrations of pesticide residues on foods consumed nationwide.

exposed. The work group used its judgment in making such projections.

Once the work group estimated regional exposure, it projected cancer risks (for both the regional population and the maximum exposed individual) by using standard EPA methods. The work group converted exposure to dose by making standard assumptions about such quantities as the amount of air people breathe and the amount of water they drink each day. The work group used the latest EPA potency estimates for each carcinogen, and multiplied dose by potency to estimate risk.

Because standard methods do not exist for estimating non-cancer risks, the work group developed its own approach, as follows:

- For pollutants for which appropriate data were available (for example, criteria air pollutants and lead), the work group used epidemiologically derived estimates of potency in combination with Region III data on ambient concentrations and exposed populations in order to estimate the number of cases of adverse health effects directly.

- For some other effects (illnesses from microbes, and diseases transmitted by animals such as rabies), the number of cases was estimated directly by adjusting upward or downward the number of reported cases of such effects.

- The work group estimated the number of cases of non-cancer effects from the remaining pollutants with the following equation:

  (number of people exposed at hazard index > 1) x (hazard index) x 0.01,

  where hazard index = dose/RfD[1].

  This equation was calculated for each pollutant having a hazard index greater than one for the problem area. Population risk was obtained by summing across pollutants.

- A proxy for non-cancer individual risk was calculated as the highest hazard index (dose/RfD) for the problem area.

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[1]. The RfD, or Reference Dose, for a chemical is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime.

The work group was aware that both the hazard index approach and the formula for estimating cases constituted gross oversimplifications of actual toxicological relationships. Nevertheless, the work group believed that such "short cut" proxies for non-cancer risks were necessary, given the project's time and budget constraints.

Work group members and contractors estimated risks for each problem area in this manner. The problem-leads described the results of these analyses to the other work group members. The work group debated and modified these estimates, in many cases adjusting the estimated risks for a problem area upward or downward, based upon professional judgment. The work group eventually created four separate rankings of the 18 problems: for population and individual risks, and for cancer and non-cancer effects.

The work group then employed various mathematical techniques to quantitatively combine the four risk rankings and obtain an aggregate health risk ranking. The mathematical techniques yielded different aggregate ranking results. For example, using one technique where cancer cases were weighted heavily relative to cases of non-cancer effects resulted in Indoor Air Pollution ranking as the highest risk and Criteria Air Pollutants as the fifth highest. But using a different technique where cancer and non-cancer cases were weighted equally resulted in Criteria Air Pollutants ranking as the highest risk and Indoor Air Pollution as the seventh highest.

The work group members used these various results and their judgment to reach a consensus aggregate ranking of the problem areas. The consensus ranking did not exactly match any of the rankings obtained by the various mathematical techniques.

The work group decided that cancer effects were more important than non-cancer effects because non-cancer effects have a wider range of severity than cancer. Also, the work group had more confidence in their procedures for estimating the number of cancer cases than the number of non-cancer cases. The work group members then decided to weight population risks much more heavily than individual risks because they judged population risks more important in broad, Region-wide priority-setting decisions.

The consensus ranking by the work group reflected these decisions: it most closely resembles a ranking based on cancer population risks.

Health Risk Ranking Results

Exhibit 2 below shows the work group's ranking of health risks. The highest ranked problem areas all caused substantial numbers of cancers, which were judged by the work group to be generally the most severe of all the environmentally-induced adverse health effects.

- o Indoor air pollution was ranked as the highest risk. Large numbers of excess cancers were projected from chlordane, passive smoking, and formaldehyde, as well as a substantial number of non-cancer effects. Only a few of the multitude of indoor air pollutants were explicitly considered. The other pollutants would raise the risk estimates far above what was calculated, which was already so high that there was no question about the ranking.

- o Radon was ranked second. High lung cancer risks for both populations and individuals were the primary hazard.

- o Other pesticide contamination was ranked third. This was largely due to substantial residues of carcinogenic pesticides on food and the universal human exposure to these contaminants.

- o Radiation other than radon was ranked fourth. Excess cancers caused by natural background radiation (about which little can be done) were responsible.

Problem areas involving little cancer risk but substantial non-cancer risks were ranked below these four problems with high cancer risks.

- o Acid deposition was ranked seventh. The health effects of airborne sulfates were defined to be included in this problem area. They have been linked epidemiologically to a range of adverse effects, including premature mortality.

- o Criteria air pollutants were ranked ninth. This was due to the work group's emphasis on cancer and to further discounting most of the criteria air pollutant effects by a factor of 100 to reflect their particularly low severity.

- o Problem areas with exposure primarily through contaminated ground water (Other Ground-Water, RCRA Sites, CERCLA Sites, Solid Waste, UST) were ranked low primarily because few people are exposed for long periods to high levels of contaminants in ground water from such sources. The work group estimated population risks as low, though individual risks can be high.

EXHIBIT 2

Health Risk Ranking

1. Indoor Air Pollutants Other Than Radon
2. Indoor Radon
3. Other Pesticide Contamination
4. Radiation Other Than Indoor Radon
5. Nonpoint Source Discharges to Surface Water and Air
6. Operation and Maintenance of Water Supply Facilities
7. Acid Deposition
8. POTW Discharges to Surface Water and Air
9. Criteria Air Pollutants
10. Other Ground-Water Contamination
11. Industrial Point Source Discharges to Surface Water and Air
12. Management of Hazardous Waste at RCRA Facilities
13. Hazardous Substances at CERCLA (Superfund) Sites
14. Hazardous/Toxic Air Pollutants
15. Solid Waste Management
16. Physical Modification of Environmentally Sensitive Terrestrial Habitats
17. Releases from Underground Storage Tanks (USTs)
18. Physical Modification of Aquatic Habitats

Several major uncertainties are inherent in these health risk rankings. Perhaps most important, as previously discussed, are the relative weights in the aggregate ranking given to cancer vs. non-cancer and population vs. individual risks. If the work group had chosen different weights, a different ranking would have resulted.

Another uncertainty involves the procedure chosen to estimate non-cancer risks in situations where exposures were compared with RfDs. EPA has no accepted procedure for risk estimation in such cases, and the work group developed its own mathematical formula. The work group was aware that its formula substantially oversimplified the complex nature of dose-response functions for non-cancer effects. The formula may have overestimated the number of cases of non-cancer effects for problem areas (nonpoint sources, POTWs, and industrial point sources) where nearly all the exposures were at levels only slightly above RfDs. This was because substantial safety factors are built into RfDs, and, contrary to the work group's formula, there is probably only a low risk from exposures only slightly above RfDs.

Additional uncertainties derive from the data introduced into the work group's methodology. Data on the health effects of chemicals, on potencies, and on epidemiological relationships are uncertain. The data on pollutant concentrations and exposed populations ranged from very good (e.g., a huge number of measurements of the indoor radon concentrations to which Region III residents are exposed) to poor (e.g., extremely uncertain modeling of the concentrations of pollutants to which individuals downgradient of leaking waste sites or USTs might be exposed).

Despite these uncertainties, the differences in numbers of health effects estimated for the various problems were so substantial that the work group felt confident in its relative ranking.

Ecological Risk Methods

Risk assessment was more difficult for the ecological work group than for the health work group. Whereas substantial portions of the methods for assessing health risks have been standardized, there is no consensus on how to assess ecological risks. Ecological systems consist of multiple species, each perhaps reacting differently to pollution stresses. Over time, the behavior of the entire system can be quite different from that of any single portion of it. Similarly, the data available for implementing any ecological risk assessment method are more limited than the data relating to health risks.

The ecological work group began by considering the effects of individual stressors (e.g., acids, metals, sediment) from problem areas on different types of ecosystems (e.g., coastal wetlands, forests, lakes). This

effort was abandoned because of the difficulty in isolating the effects of a single stressor in environments where multiple stressors are present simultaneously. The work group also devoted substantial effort to formulating a useful ecosystem typology, with the aim of assessing the risks from a problem area to each type of ecosystem individually, and then adding across ecosystems. However, this approach proved to be too complex.

Eventually, the ecological work group devised a qualitative risk assessment method based on the experience and opinions of the work group members. Although scored quantitatively, the method relied fundamentally on qualitative judgments about the intensity and geographic extent of ecological damages from each problem. Contractors provided data to help form many of the judgments. The method was based on developing scores for four criteria, combined through a mathematical formula:

Problem area score = (Severity score + Reversibility score) x (Source score + Target score)

- The severity score characterized the frequency with which the ecosystem was exposed to stressors at durations resulting in acute and/or chronic toxicity.

- The reversibility score characterized the length of time required for an ecosystem to recover from the impacts of the stressors.

- The source score depended on whether the sources of contamination associated with the problem area were widespread or local, and whether the loadings were predictable or not.

- The target score depended on whether impacts were local or widespread in one or several ecosystems, and whether environmentally sensitive/unique ecosystems were involved.

Prior to the ranking meeting, each ecological work group issue lead reviewed the available data and developed tentative scores for the four criteria. The entire work group discussed the data and the proposed scores for each of the four criteria, and reached a consensus on scores for each problem. The total score for a problem was the sum of its criteria scores, and the problems were ordinally ranked on the basis of their total scores. The work group members reviewed the ordinal ranking they generated by relying directly on the scores, and decided not to change it. They considered collapsing the numerical ranking of problems into risk groupings instead (putting problems into high, medium, or low ecological risk groups), but decided to leave their 1 - 18 ranking of the problem areas. Several problem areas were left tied in the ranking.

Ecological Risk Ranking Results

The resulting ecological risk ranking is shown below in Exhibit 3. Some of the highlights of the ranking follow:

- Physical modification of terrestrial habitats and physical modification of aquatic habitats were ranked as tied for causing the greatest ecological risk. They cause extremely widespread, devastating, and typically irreversible impacts. They can damage not only the specific location where they occur, but also nearby areas by changing water flow patterns, disrupting migration pathways, altering food webs, etc.

- Nonpoint source discharges to surface waters were ranked as causing the third highest risks. These discharges are extremely widespread and can render some areas virtually lifeless (as in some streams affected by abandoned mine drainage). The states' 305(b) water quality assessment reports show nonpoint sources as by far the leading cause of degradation in streams, lakes, and estuaries.

- Acid deposition was ranked as causing the fourth greatest risk. The work group based this ranking largely on aquatic effects, judging effects on forests to be unproven in Region III. Adverse impacts on lakes, headwaters streams, wetlands and even Chesapeake Bay (substantial air deposition of nitrates) were identified. Acid deposition could be ranked as even higher risk if effects studies become more conclusive, as precipitation in Region III is the most acidic in the nation.

- CERCLA sites were ranked fifth. Ecological investigations for Superfund sites revealed substantial impacts occurring off-site, frequently extending into receiving water bodies. Extrapolating from several case studies to the entire universe of potential NPL sites, the work group estimated significant ecological damage in sensitive environments.

- Criteria air pollutants and air toxics were each ranked sixth, with great uncertainty attached to this ranking. Data on the actual ecological effects associated with these problems were minimal. The problems were ranked moderately high because they involved widespread pollution and there was a presumption of adverse impacts.

- Five problem areas were ranked at the bottom as causing no or minimal ecological risks: indoor radon, indoor air pollution, other ground-water contamination, other pesticide contamination, and operation and maintenance of water supply facilities. Note that ground-water contamination and pesticides may cause significant ecological damage. However, the definitions of these problem areas adopted for the purposes of the Comparative Risk Project excluded the routes by which they cause such damage. Ecological impacts from ground-water contamination were limited by definition because the impacts of contaminated ground water on surface water were assigned to the nonpoint sources problem area. The pesticides problem was defined to include only risks through residues on food and risks to applicators. Risks to non-target species through non-food routes (e.g., surface runoff, dermal absorption) were excluded.

EXHIBIT 3

Ecological Risk Ranking

1. Physical Modification of Environmentally Sensitive Terrestrial Habitats
1. Physical Modification of Aquatic Habitats
3. Nonpoint Source Discharges to Surface Water and Air
4. Acid Deposition
5. Hazardous Substances at CERCLA (Superfund) Sites
6. Criteria Air Pollutants
6. Hazardous/Toxic Air Pollutants
8. Releases from Underground Storage Tanks
9. Industrial Point Source Discharges to Surface Water and Air
9. Radiation Other than Indoor Radon
9. POTW Discharges to Surface Water and Air
12. Management of Hazardous Waste at RCRA Facilities
13. Solid Waste Management
14. Indoor Radon
14. Indoor Air Pollutants Other than Radon
14. Other Ground-Water Contamination
14. Other Pesticide Contamination
14. Operation and Maintenance of Water Supply Facilities

Note - the final five problems were believed to cause no ecological risk and were ranked as tied for lowest risk.

The work group noted substantial uncertainty in its ranking results. Ecological risk assessment, in the absence of standard methods, was a very difficult task. The work group had particular difficulty in deciding how to weigh disparate impacts in arriving at a single judgment about ecological risk -- for example in comparing a problem causing substantial impacts in relatively few locations (e.g., CERCLA sites) with one causing moderate impacts to large areas (e.g., criteria air pollutants). Another difficulty came from the apparent need to weigh different ecosystem types against each other -- for example, to decide whether a particular impact in a wetland caused more damage than a different impact in a forest.

The work group also noted that the project's ground rules seemed to facilitate health risk analysis more than ecological risk analysis. The directive to assess current residual risks seemed to ignore the long-term, cumulative ecological impacts that many environmental problems will cause. The list of problem areas did not incorporate ecologically meaningful distinctions. Several problem areas had no ecological significance (e.g., indoor air pollution, drinking water), several were defined in an artificial way that excluded ecologically important effects (e.g., the pesticides problem area excluded the routes by which most ecological damage occurs from pesticides), and some lumped together extremely different ecological impacts (e.g., the nonpoint sources problem area included both acid mine drainage and eutrophication of lakes from excessive agricultural nutrient runoff).

In sum, the ecological work group members did not feel very confident in their results. They believed that the three highest ranked problem areas (physical modification of aquatic and terrestrial habitats, and nonpoint sources) clearly caused more damage than the other problems, and that the five problem areas ranked at the bottom caused lesser risks than the others. However, they had little confidence in the accuracy of the rankings for the other ten problems.

Welfare Risk Methods

The welfare work group had a major advantage over the other work groups: there was broad agreement on using the dollar value of damages as the common denominator for measuring welfare risks. The work group agreed to estimate the annual dollar losses caused by each environmental problem as the key factor on which they would base their ranking. The major methodological issues the work group dealt with were the definition of the boundaries of welfare risk, and secondary factors other than dollar damages that should enter into the ranking process.

The work group decided to consider nine categories of welfare effects.

CATEGORIES OF WELFARE EFFECTS AND EXAMPLES

Effect on agriculture and livestock: Reduced crop yields due to vegetation damages from ozone.

Effect on forestry: Reduced commercial forestry yields due to reduced growth in trees affected by ozone.

Effect on water suitability: The costs of treating or replacing contaminated water supplies.

Effect on commercial fishing: Reduced profits to the commercial fishing industry from decreases in finfish and shellfish populations due to environmental pollution.

Effect on re-use of land: Economic losses resulting from reduced options in use of land following environmental contamination, such as at a CERCLA site with contaminated soil.

Effect on materials (manufacturing, residential, commercial): Accelerated deterioration of outdoor masonry, statues, etc., exposed to airborne acids.

Effect on recreational opportunities: Reduced fishing, boating, and swimming opportunities in surface waters affected by pollution.

Effect on aesthetic value: Offensive odors from diesel exhaust.

Effect on health: Cost of treating lung cancer due to exposure to indoor radon.

The economic costs of environmentally induced diseases were included as welfare damages. These included both the medical costs of treating the disease, and the loss of economic productivity incurred by someone with the disease. There was debate within the work group over this approach. Some felt that health effects would be double-counted if they were considered by both the health and the welfare work groups. The results reveal that inclusion of health costs ultimately made some, but not a major, difference in the welfare rankings. Health costs contributed less to total welfare damages than did some other categories of damages. The work group estimated health costs by attaching standard "cost per case" values for different sorts of health effects to the health work group's estimates of the numbers of health effects for each problem area.

There was also some debate over including aesthetic effects as a category of welfare damages. There was agreement that effects such as reduced visibility, odors, and poor tasting water were legitimate damages, but there was great concern about how they could accurately be measured. Studies monetizing such damages were extremely rare, and often came to debatable conclusions. The work group decided to include aesthetic damage estimates, but to perform sensitivity analysis on the ranking for any problem areas where they were significant.

The work group took care to distinguish welfare damages from control costs, and to exclude control costs from the analysis. In general, the work group considered control costs to be costs incurred to prevent

generation of pollution, while welfare damages were costs that occurred subsequent to the pollution having been generated. The distinction became difficult in such areas as the costs of mitigating household radon and the costs of remediating CERCLA sites. In such cases the work group adopted another rule. To the extent a polluter was legally required to mitigate his pollution, his expenses of doing so were counted as a control cost. To the extent the mitigation expenses were incurred voluntarily by a victim of the pollution to reduce his damage, they were counted as a welfare damage. Radon mitigation expenditures were thus counted as a welfare damage (but to the extent they were assumed to occur, they reduced the medical costs due to radon's health effects). The costs of remedial action at CERCLA sites were split: source control and ground-water remediation were counted as control costs, while costs of treating or replacing contaminated drinking water supplies were counted as welfare damages.

The work group also decided to reflect in its ranking scheme several factors in addition to the total annual dollar estimate for the welfare damages. These factors were:

- o The geographic extent of the welfare damage;
- o The impact to individuals from the welfare damage (in effect, considering individual welfare risk in addition to population welfare risk); and
- o The reversibility of the welfare damage.

The work group developed a mathematical formula to combine the dollar magnitude of damages with these qualitative adjustment factors. The formula was designed to weight the dollar losses more heavily than the qualitative factors.

At the work group's ranking meeting, the problem-leads reviewed the results of contractor analyses with the work group and proposed scores for the problems. The work group then developed consensus scores for each category of welfare damage caused by each problem area (e.g., damage to materials, recreation, aesthetics). Using the formula, the group then summed the scores across damage categories to obtain a total score for each problem area.

Based upon the scores, the welfare work group ranked the 18 problems ordinally, and also grouped the 18 problems into high, medium and low risk categories. The work group members believed that there were major uncertainties in monetizing welfare damages, and that the full ordinal ranking might overstate the degree of confidence in their results. They felt more comfortable in portraying their findings in less precise terms. The scores for the problem areas fell into three sharply different ranges, and the three

ranges provided the basis for the high, medium and low risk categories. The work group felt very confident that there were substantial differences in risk between problems in different groups, but much less confident in risk differences within a group.

After developing the two rankings, the work group considered modifying them. They performed several rough sensitivity analyses, investigating what would happen if they:

- o Discounted some of the more speculative damage estimates for air pollution effects (for example, visibility damages, and acid deposition damages to forests); and

- o Combined the damages from all problem areas affecting ground water into a single problem covering all ground-water contamination.

Welfare Risk Ranking Results

Exhibit 4 shows the resulting welfare risk ranking. The following are some of the welfare risk ranking highlights.

Criteria air pollutants and acid deposition comprised the high welfare risk category.

- o Criteria air pollutants were ranked as the highest welfare risk. The estimated annual damages were about $700 million to materials, about $200 million to crops, and about $100 million to forests.

- o Acid deposition was ranked as the second highest welfare risk. Annually it caused health care costs of $220 million $190 million in damage to materials. Speculative estimates of annual visibility losses and forestry damage were put at $550 million and $105 million, respectively. Acid deposition ranked solidly as the second-highest welfare risk, even if visibility and forestry damages were completely discounted.

Each of seven problems appeared to cause moderately high welfare damages; clearly lower than those caused by the first two ranked problems but still substantial. The work group placed these problems in the medium welfare risk category.

- o Nonpoint source discharges ranked third. Total annual damages were estimated at $265 million, consisting largely of recreational losses ($150 million), aesthetic damages ($70 million) and effects on water suitability ($30 million).

- o Operation and maintenance of water supply facilities ranked fourth, with annual damages of $150 million from the effects of corrosive water on materials, and $65 million from the health effects of lead leached from pipes and trihalomethanes from the process of disinfecting drinking water.

- o Indoor air pollutants other than radon ranked fifth. Annual damages were estimated at $130 million from health effects, and $20 million in mitigation costs. Assumptions were made about how many households would be likely to mitigate indoor air pollution, thereby reducing health costs but incurring mitigation costs.

- o Radon was ranked sixth. It was analyzed similarly as indoor air pollutants, and similar results were obtained: annual health damages of $130 million and mitigation costs of $20 million. It was ranked lower than indoor air pollution because of the qualitative factors used by the work group to adjust the dollar damage estimates.

- o Other problem areas with moderately high annual welfare damages included other pesticide contamination ($96 million annually in health costs), POTW discharges ($88 million annually, mostly in recreational damages), and radiation other than radon ($77 million annually in health costs, nearly all from natural background radiation).

The remaining problem areas were ranked as causing low welfare risks. Each was estimated to cause annual damages of $40 million or less.

Five problem areas (USTs, RCRA sites, CERCLA sites, solid waste management and other ground-water contamination) caused damages primarily through ground water, primarily involving contamination of current and potential future water supplies. The work group believed that splitting ground-water contamination into five smaller pieces biased its ranking downward. If all the ground-water damages were combined into a single ground-water contamination problem area, it would have ranked about seventh in terms of welfare risk, with annual damages of $116 million. USTs would have been the largest single contributor. Damages via private wells would substantially exceed those in public water supplies. In addition, damages to currently used ground-water supplies would slightly exceed the estimated value of damages to currently unused supplies that might be needed in the future (option demand).

EXHIBIT 4

Welfare Risk Ranking

HIGHER RISK PROBLEMS:

1. Criteria Air Pollutants
2. Acid Deposition

MEDIUM RISK PROBLEMS:

3. Nonpoint Source Discharges to Surface Water and Air
4. Operation and Maintenance of Water Supply Facilities
5. Indoor Air Pollutants Other Than Radon
6. Indoor Radon
7. Other Pesticide Contamination
8. POTW Discharges to Surface Water and Air
9. Radiation Other Than Indoor Radon

LOWER RISK PROBLEMS:

10. Releases From Underground Storage Tanks
11. Industrial Point Source Discharges to Surface Water and Air
12. Other Ground-Water Contamination
13. Management of Hazardous Waste at RCRA Facilities
14. Physical Modification of Environmentally Sensitive Terrestrial Habitats
15. Solid Waste Management
16. Physical Modification of Aquatic Habitats
17. Hazardous Substances at CERCLA (Superfund) Sites
17. Hazardous/Toxic Air Pollutants

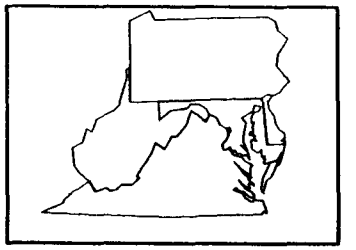
The welfare work group members felt that they were on solid ground with their ranking methodology. However, they were uncertain about estimating the dollar magnitude of the different welfare effects because of the limited data and studies available. Monetization of environmental damages is a specialized field of economics. The work group and the supporting contractors were very dependent on the few existing studies in this area. In many instances, the work group had to base its estimate of a particular welfare damage on a single study that had only limited applicability. In sum, the major uncertainty in the welfare work group's ranking derived primarily from the lack of data, rather than from assumptions made in the methodology.

Comparison of Rankings Across Types of Risk

Exhibit 5 compares the three work groups' rankings. Exhibit 6 displays the same information slightly differently; it shows for each problem area the rankings given to it by the three work groups.

EXHIBIT 5

Health, Ecological and Welfare Rankings



HIGHER RISK

LOWER RISK

Health

- o Indoor Air Pollution
- o Indoor Radon
- o Other Pesticide Contamination
- o Radiation Other Than Radon
- o Nonpoint Source Discharges
- o O&M of Water Supply Facilities
- o Acid Deposition
- o POTW Discharges
- o Criteria Air Pollutants
- o Other Ground-Water Contamination
- o Industrial Point Source Discharges
- o RCRA Sites
- o CERCLA Sites
- o Toxic Air Pollutants
- o Solid Waste Management
- o Terrestrial Habitat Modification
- o USTs
- o Aquatic Habitat Modification

Ecological

- o Terrestrial Habitat Modification
- o Aquatic Habitat Modification
- o Nonpoint Source Discharges
- o Acid Deposition
- o CERCLA Sites
- o Criteria Air Pollutants
- o Toxic Air Pollutants
- o USTs
- o Industrial Point Source Discharges
- o Radiation Other Than Radon
- o POTW Discharges
- o RCRA Sites
- o Solid Waste Management
- o Indoor Radon
- o Indoor Air Pollution
- o Other Ground-Water Contamination
- o Other Pesticide Contamination
- o O&M of Water Supply Facilities

Welfare

- o Criteria Air Pollutants
- o Acid Deposition
- o Nonpoint Source Discharges
- o O&M of Water Supply Facilities
- o Indoor Air Pollution
- o Indoor Radon
- o Other Pesticide Contamination
- o POTW Discharges
- o Radiation Other Than Radon
- o USTs
- o Industrial Point Source Discharges
- o Other Ground-Water Contamination
- o RCRA Sites
- o Terrestrial Habitat Modification
- o Solid Waste Management
- o Aquatic Habitat Modification
- o CERCLA Sites
- o Toxic Air Pollutants

EXHIBIT 6

Ranks for Each Problem Area

Problem Areas	Health Rank	Ecological Rank	Welfare Rank
1. Criteria Air Pollutants	9	6	1
2. Air Toxics	14	6	17
3. Indoor Radon	2	14	6
4. Indoor Air	1	14	5
5. Radiation	4	9	9
6. Industrial Point Sources	11	9	11
7. POTWs	8	9	8
8. Nonpoint Sources	5	3	3
9. RCRA Sites	12	12	13
10. CERCLA Sites	13	5	17
11. Solid Waste Management	15	13	15
12. USTs	17	8	10
13. Other Ground-Water Contamination	10	14	12
14. Other Pesticide Contamination	3	14	7
15. Aquatic Habitat Modification	18	1	16
16. Terrestrial Habitat Modification	16	1	14
17. Acid Deposition	7	7	2
18. O&M of Water Supply Facilities	6	14	4

The Steering Committee decided not to combine these rankings to produce an overall ranking aggregating the three types of risk. Nevertheless, looking across the three separate rankings, several conclusions are evident.

The degree of risk posed by an environmental problem seems to depend critically on the type of risk. None of the problem areas ranked first or second by one of the three work groups is ranked first or second by another work group. None of the problems ranked last or next-to-last by one of the work groups is ranked similarly by another work group.

However, some problem areas do rank consistently above or below the median across the three types of risk. The **consistently higher-risk** problems include:

- **Nonpoint source discharges** (ranked #5, #3 and #3 for health, ecological and welfare risks);
- **Acid deposition** (ranked #7, #4 and #2); and
- **Criteria air pollutants** (ranked #9, #6 and #1).

Problem areas that rank **consistently below the median** for each type of risk include:

- **Solid waste management** (ranked #15, #13 and #15);
- **RCRA sites** (ranked #12, #12 and #13); and
- **Other ground-water contamination** (ranked #10, #14 and #12).

Several problem areas rank **very high in health risks, but very low in ecological risks.** These include **indoor air pollutants other than radon, indoor radon, other pesticide contamination, and operation and maintenance of water supply facilities.** (But note that the low ecological risk ranking for other pesticide contamination is a function of its restricted definition.) Other problem areas rank **very high in ecological risks, but very low in health risks.** They include **aquatic and terrestrial habitat modification, CERCLA sites, and air toxics.**

The ranking disparities between welfare risks and health or ecological risks do not seem as extreme as between health and ecological risks. Thirteen of the 18 problem areas received welfare risk rankings that were tied with or between their health and ecological risk rankings. In effect, welfare risk seems to be

combining or mediating between health and ecological risks. This should not be surprising, since welfare damages include monetized estimates of both human health and ecological effects.

The Effect of Problem Definitions on the Rankings

Several of the problem areas received rankings that differ from what might be expected. This was at least partly because the Region defined these problems in a mutually exclusive fashion, which contrasts with the popular conception of what their titles imply. However, EPA programs are not mutually exclusive. They overlap; several of them can address the same risk. Particular attention should be paid to the definitions of the following problem areas.

1. **Criteria Air Pollutants.** Criteria Air Pollutants were defined to exclude ambient sulfates, which were included instead in Acid Deposition. Because sulfates cause substantial health and welfare (visibility) damages, Criteria Air Pollutants would rank higher if they were included.

2. **Acid Deposition.** The health and visibility effects of airborne sulfates were responsible for all of Acid Deposition's health ranking. Excluding visibility from Acid Deposition would still leave it ranked as very high for welfare damages.

3. **Other Radiation.** Natural background radiation was virtually completely responsible for this problem's health and welfare rankings. Presumably, the Region can do nothing about natural background radiation.

4. **Nonpoint Sources.** The Region defined this problem to include releases from contaminated in-place sediments. It thus included health risks from eating fish that have bioaccumulated PCBs and heavy metals. The Region might instead have attributed these risks to the problem areas that contaminated the sediments in the first place -- generally either industrial or municipal point sources. But the Region judged that most of the current sediment contamination is due to point source discharges long ago, and that defining risks from sediments as within the scope of the point source problem areas would thus be inconsistent with the objective of assessing the risks associated with current levels of pollution from each problem area. Releases from sediments were probably responsible for roughly half of the estimated health risks from Nonpoint Source Discharges.

5. **Industrial Point Source and POTW Discharges.** Health risks from these problems were correspondingly lower because sediment releases were included in Nonpoint Sources.

6. **Operation and Maintenance of Water Supply Facilities.** Because this problem area included only drinking water risks attributable to contaminants not covered under other problem areas, it differed substantially from the purview of the drinking water program. It effectively included only risks from trihalomethanes from disinfection of water supplies and lead leached from water distribution systems. Perhaps surprisingly, though, these pollutants were found to cause the bulk of the health risks from contaminants in drinking water. An expanded definition of the problem area to cover the entire drinking water area would not increase its health or welfare rankings very much.

7. **Other Ground-Water Contamination.** Like the above problem area, this problem included only ground-water risks attributable to contaminants not covered under other problem areas. It, too, differed substantially from the purview of the ground-water program. This problem effectively included only risks from nitrates and pesticides (both from agricultural leaching) and microbial contaminants in private wells (from septic tanks). Several aspects of this definition are notable:

- The contaminants included in this problem area were responsible for a moderate fraction -- probably more than half -- of all health risks arising from contaminated ground water.

- In the ecological risk area, surface discharge of contaminated ground water was counted under Nonpoint Sources. While this did not significantly raise the Nonpoint Sources ecological risk ranking, it did exclude from the definition of Other Ground-Water Contamination the only significant means by which ground-water contamination could result in ecological damage.

- The welfare work group did a separate analysis, placing the annual damages from all ground-water contamination at $116 million. This would probably rank about seventh in terms of welfare risk if it were defined as an entire problem area. As it was defined, Other Ground-Water Contamination accounted for only $30 million of this total.

- When estimating risks from Other Ground-Water Contamination, both the health and the welfare work groups made efforts to include damages occurring in private wells in addition to those in public water supplies.

8. **Other Pesticide Contamination.** This problem area included only risks to pesticide applicators, farm workers, and humans from residues on food. It thus did not cover all varieties of pesticide risks. Most important, its ecological risks were minimal, because most pesticide risks to plant and animal life, which are probably quite substantial, were covered under Nonpoint Sources and Air Toxics. Health risks

via consumption of fish that have bioaccumulated pesticides were covered under Nonpoint Sources, and those via consumption of drinking water were covered also under Nonpoint Sources or under Other Ground-Water Contamination.

IV. Observations

Comparison with Unfinished Business Findings

The problem areas that were ranked in the Region III Comparative Risk Project and the methods for and results of doing so were generally similar to those in the EPA Headquarters Unfinished Business project. Comparing the results is straightforward, with the exception of two items: the Region III project used slightly different definitions for some problem areas than did Unfinished Business, and Unfinished Business did not combine their separate health rankings for cancer and non-cancer effects.

Health Risk

Both projects rated radon, indoor air pollution, and pesticides among the highest health risks. Unfinished Business also ranked worker exposures and exposures to consumer products as causing very high health risks, but the Region III project did not consider these problem areas. Drinking water contamination ranked quite high in health risks for both studies.

At the low end of the health risk ranking, both projects listed USTs, non-hazardous waste, RCRA sites, and, somewhat higher in Unfinished Business, CERCLA sites. It is evident that the important factor causing these problem areas to be ranked as low risk in both studies was the limited population exposures typically associated with contaminated ground water. Ground water as a medium differs from air or surface water. Pollution of ground water tends to be slow-moving and localized, and exposure to contaminated ground water can usually be avoided at modest cost by obtaining alternate or treated water supplies. Although the health risk for a person exposed to contaminated ground water may be as high as that for someone exposed to polluted air or surface water, far fewer people are exposed to contaminated ground water. The health ranking methods used in both the Region III project and Unfinished Business tended to weight population risk far more than they did individual risk.

A few health risk rankings differed between the Region III project and Unfinished Business:

- Region III ranked the three surface water problem areas (nonpoint source discharges, industrial point sources, and POTWs) all as somewhat higher risk than did Unfinished Business. The discrepancy was particularly great for nonpoint sources, which the Region ranked as #5 for

health risk. Headquarters ranked nonpoint sources as #20 of 31 for cancer risks and as medium for non-cancer risks.

This difference in ranking may represent a real difference in risk between Region III and the entire nation. Region III is more densely populated, and has a large concentration of older industrial and POTW dischargers, and a unique abandoned mine drainage problem. Or, the ranking difference may be because the Region III health work group obtained data on toxic chemicals in edible fish tissue, and performed several modeling analyses to project human exposures to contaminants in surface water via fish consumption and drinking water. Unfinished Business used professional judgment, with little data. However, the Region III work group's analyses in this area used highly conservative assumptions, and may thus have overstated risks.

- The air toxics ranking in Unfinished Business showed substantially higher health risks than the Region III ranking. The disparity turns on different judgments about the degree to which the specific air toxics analyzed represent the entire universe of air toxics, and the extent to which air toxics cause non-cancer effects.

Ecological Risk

The ecological rankings were also quite similar across the studies. Physical modification of habitats, nonpoint sources, and criteria air pollutants/acid deposition were ranked as posing high risks. Unfinished Business ranked as even higher risks global warming and ozone depletion, but the Region did not consider them. Both studies found radon, indoor air pollution, drinking water, solid waste disposal, other ground-water contamination, and RCRA sites to present the lowest ecological risks. Several differences in the ecological rankings included the following:

- Unfinished Business found the risks posed by point sources (both industrial and POTW) and nonpoint sources to be similar. In contrast, the Region ranked nonpoint sources clearly higher and industrial point sources and POTWs medium to low. The ecological work group used data that Unfinished Business paid less attention to on the number of stream miles and lake acres degraded by the different sources of water pollution. The data showed nonpoint sources to be by far the greatest source of degradation.

- The Region ranked CERCLA sites as high risk, while Unfinished Business ranked them as low risk. The Region ranked USTs and other radiation as medium risk while Unfinished Business found them to be low risk. These ranking differences probably reflect the high density of

CERCLA sites and USTs in Region III, and differences in ecological scoring methods between the two projects. The Region III method tended to attribute higher risks to source types that are particularly widespread, and that release highly toxic substances unpredictably. In effect, there was a large element of evaluating potential risks in the Region's approach. Unfinished Business, by contrast, based its ecological rankings more on the actual record of observed ecological damages attributable to each problem. In any case, such differences in judgment might be expected on problems like these for which data on ecological effects are extremely limited.

Welfare Risk

At first glance, Region III's welfare risk rankings match those from Unfinished Business less well than do the health and ecological risk rankings. Several problem areas that the Region ranks high in terms of welfare risks (indoor air pollution, indoor radon, other pesticide contamination, and radiation) are ranked very low by Unfinished Business. This is because Region III counted health care costs in its welfare risk estimation and Unfinished Business did not, and each of these problems causes high health care costs. Otherwise, the welfare rankings are generally similar. In both studies the greatest damages were attributed to criteria air pollutants, with the next highest damages caused by nonpoint sources. The rankings diverge somewhat in two respects:

- As in the ecological rankings, Unfinished Business places industrial point sources and POTWs in the high risk category, while the Region categorizes them as medium. Again, the probable reason is that the Region attributed a lower share of the damages occurring via surface water to point sources (a higher share to nonpoint sources) than did Unfinished Business based on Regional 305(b) report data.

- The Region's relative ranking of the ground-water and waste problem areas was exactly opposite to that of Unfinished Business. The Region ranked USTs and other ground-water contamination as medium risks, with RCRA sites, solid waste disposal, and CERCLA sites as low risks. Unfinished Business ranked them in an inverse order. The Region III welfare work group's data and procedures for considering ground-water damages were substantially more sophisticated than those of Unfinished Business. The work group quantitatively considered impacts on private wells and impacts to currently unused ground water, and used a large regional data base to allocate damages among categories of sources responsibie for the damages. Unfinished Business did not use such data.

Reasons For Similarities To National Risk Rankings

There is a substantial similarity between the Region III results and those from Unfinished Business. The rankings agree far more often than they disagree, and many of the divergences seem explainable by definitional or methodological variations. Ranking differences that reflect real risk differences -- where a problem is substantially more or less risky in Region III than in the nation as a whole -- seem rare.

There are several cautions against drawing such conclusions, however. The first is that the Region III and Unfinished Business projects used substantially similar analytical methods and data. Some individuals from Headquarters and among the consultants participated in both projects. It is possible that the similar rankings resulted from the common methods, assumptions, and judgments, and not necessarily from the similarity of environmental risks.

Another point to note is that the Region and Headquarters both ranked risks over large geographical areas that are each large aggregations of disparate elements of risk. If the Region III project and Unfinished Business were to have ranked finer elements, the projects might have found much more extensive evidence of geographic differences in risk. Following are two examples of this point:

- The nation as a whole and Region III both encompass diverse land uses. Each has major cities, industrial areas, agricultural areas, forest lands, etc.. If such studies were to analyze problems in smaller and more homogeneously defined geographic areas, they would undoubtedly uncover larger distinctions in risk. A ranking of environmental risks in an agricultural area (e.g., Sussex County, DE) would be much different from one for an urbanized area (e.g., Philadelphia).

- Similarly, risk rankings would begin to diverge if the problem areas were more finely defined. For example, while nonpoint sources may cause similarly high ecological risks in Region III and the entire nation, the rankings would differ if the component portions of nonpoint sources were ranked individually. Nonpoint source impacts from mining (e.g., abandoned mine drainage) would rank very high in Region III, but would not be very important in New England. Similar differences across Regions might begin to emerge if other problem areas were subdivided -- perhaps by splitting criteria air pollutants into those from stationary vs. mobile sources, or by splitting non-hazardous waste sites into landfills vs. incinerators.

The Region's conclusion is that a risk ranking of environmental problems, when conducted at a broad level, will show little geographic variation. What is true for one Region will be generally true for another. There is a level of risk associated with each environmental problem that does not vary much

geographically. This supports national priority-setting when very broad questions are at issue. But as the ranking or priority-setting becomes finer, focusing on smaller geographic areas or smaller portions of programs, geographic distinctions become much more important.

Level of Confidence in Ranking Results

How accurate are the rankings produced in the Region III Comparative Risk Project? This question is difficult to answer. Very little of the analysis underlying the rankings is sufficiently quantitative to be subjected to traditional sensitivity analysis. Most of the conclusions rely on a mixture of facts and judgments, and there is very little basis for knowing how much the judgments might be in error.

Arguing against the accuracy of the rankings are several factors: the limited resources for analysis and data acquisition, the unavailability of data on many key questions, and the novelty of the risk analysis methods used for some areas. On the other hand, the project participants who made the necessary judgments formed a very high quality group. They were experienced Regional professional staff, representing all program areas, and Headquarters staff familiar with Unfinished Business and other Headquarters comparative risk analyses. The contractors had national reputations for expertise in risk analysis in their particular subject areas.

The best way to judge the quality of the ranking results is to rely on the assessment of the individuals who generated them. For the most part, the participants feel comfortable with their relative rankings of the problem areas. They believe that there are very substantial differences in risk between problem areas that have been captured accurately in the rankings, despite missing data and unproven methods.

When work group participants were asked whether they would recommend redoing the ranking using better data and methods, they argued against doing so for at least several years. This was primarily because they did not believe the rankings would change much.

This belief is supported by noting the similarity in the risk rankings with the Unfinished Business project. The similar results for the two projects, arrived at generally independently, suggest either that both projects are generally capturing the truth, or that both have made some consistent methodological error.

In sum, the participants in the Comparative Risk Project appreciate the imperfections in what they have done, but believe that the rankings of the problem areas reflect their relative risks reasonably accurately.

Information Gaps That Might Be Filled in the Future

The participants in the project noted several areas where their conclusions were particularly uncertain. These areas were not necessarily those for which data were the most limited or of the poorest quality. In several cases, the work groups noted problem areas for which data were poor but to which a ranking could nevertheless be assigned confidently. For some other problems, much high-quality data were available, but the problem area still could not be ranked confidently because of the absence of a single key piece of information. The work groups noted several areas where additional information and analysis could do much to improve the confidence of the rankings, and where the gaps in information and analysis could probably be filled at reasonable cost. These areas may be the focus of some future efforts to improve the reliability of the ranking results.

The following data elements were available at the time the comparative risk analysis was performed, but were not obtained for the project. In some cases the reason was that limited project resources explicitly prevented staff from acquiring further data on certain topics; in other cases the need for the data did not become apparent until too late in the process.

- A better understanding of the health effects of lead, adapted in a manner to fit the work group's scoring approach.

- A critical review of the epidemiological evidence for health effects from airborne sulfates.

- A full compilation of typical concentrations of indoor air pollutants.

- An exhaustive search for studies relating to the ecological effects of toxic air pollutants.

- Data on concentrations at which toxic air pollutants are found in the Region, relative to the toxicological thresholds at which they may begin to cause non-cancer human health effects.

- Data on actual, as opposed to modeled, concentrations of pesticide residues on foods as they are consumed.

- o A study of the 305(b) reports from the Region III states, including: an assessment of the validity of aggregating data across the states, developing some judgment about conditions in the unassessed stream miles, and extracting from them data about the relative effects of waste problem areas (e.g., solid waste, UST, CERCLA sites) vs. water problem areas.

- o A canvas for new studies monetizing welfare damages from environmental problems.

In addition, some other data elements were not available at the time of the Comparative Risk Project analysis because they are only now being generated. The following new pieces of data should be available within the next year or so.

- o Results of acid deposition research from Pennsylvania State University, especially on terrestrial effects.

- o Better data on toxic chemicals in the effluents from point sources, particularly for sources discharging to priority water bodies.

- o Greatly expanded data on chemical contaminants in larger public water systems, as they meet the new monitoring requirements.

- o Information from the national survey of pesticides in ground water.

- o Improved techniques for ecological risk assessment, as a result of the efforts of EPA's Office of Research and Development.

- o Ambient air quality data for 1988, for which meteorological conditions were probably worse than in other recent years.

Benefits of the Project

The Comparative Risk Project is not completed. Eventually it will contribute to better resource allocation in the Region, with efforts targeted where they can provide the greatest environmental benefits. The risk assessment findings of the first year of the project provide a clear and useful description of the environmental problems remaining in the Region. The primary benefits of the project will come when these

problems are addressed. In the meantime, though, before the risk management portions of the project are completed, the project has already provided some important benefits.

- The Region has an understanding of not only the relative risks from the environmental problems, but also the causes or "anatomy" of risk for each problem. The more detailed understanding of which pollutants, pathways, source types, or geographic areas ("hot spots") cause most of the risk in each problem area makes it easier to design efficient, targeted programs to reduce risks in each area.

- The Regional staff participating in the project have received practical training in risk assessment, and have developed a better cross-program perspective. Many project participants say they have profited from the opportunity to learn from their colleagues about environmental problems and programs other than their own. As EPA continues to move toward a cross-media approach to environmental management, this broader view by the staff will become more important.

- Senior Regional managers have gained a vision of environmental problems and directions. The comprehensive purview of the analysis and rankings gives managers a good perspective for strategic planning.

- The project has focused all Regional participants on reduction of health, ecological, and welfare risks as the ultimate reason for environmental protection.

V. Next Steps

In its next phase, the Region III Comparative Risk Project will move generally from risk assessment into risk management. The Region will use the rankings to allocate its resources more efficiently and better manage the risks that have been studied. The Region's senior managers feel comfortable with the risk rankings and are developing specific plans for how to use them. The Region's major objectives will be to:

- **Work toward systemic changes.** The Region will work to foster management processes in EPA and states that reconcile the priorities suggested by the comparative risk rankings and those mandated by other concerns. The Region will pursue two themes: greater attention in resource allocation to risks and the opportunity to reduce them, and greater flexibility to respond to unique local and regional conditions. The Region will pursue the themes at three levels: it will participate in Headquarters initiatives to institutionalize risk-based decision-making; it will develop and discuss options for addressing high-priority problems more effectively within the Region; and it will work with the states to promote the use of the Comparative Risk Project in upcoming grants negotiations.

- **Initiate MERITs projects.** The Region will seek to implement MERITs for problems identified as particularly high risk. MERITs will be targeted at the particular elements of high-risk issues that contribute to their high ranking.

- **Involve the Region III states.** The Region will develop a strategy to increase its involvement with the states so that both can participate effectively in each other's planning and management processes.

- **Analyze and strengthen the project's results.** The Region will document and further analyze the results of the first phase of the project. This will include comparing the results with those from other comparative risk projects.

- **Communicate the project's results.** The Region will develop and implement a strategy to communicate the project results to the public and relevant government agencies in Region III.

- **Evaluate Regional resource allocation relative to residual risks.** An initial look suggests that the Regional Office may not be directing its resources where the highest risks lie. The five

highest health risk problem areas are each the subject of small Regional programs -- indoor air pollution, radon, pesticides, radiation, and nonpoint source discharges. The same is true of the four highest ecological risk areas -- modification of terrestrial and aquatic habitats, nonpoint sources, and acid deposition. The same is true again of two of the three highest welfare risk areas -- acid deposition and nonpoint sources. At the other extreme, the Region devotes substantial resources to problems that rank much lower in terms of residual risks: CERCLA and RCRA sites, USTs, air toxics, industrial point sources, and POTWs. There are several reasons why resource allocation should not necessarily match residual risks, but the Region will evaluate this issue.

The ultimate test of the utility of the Region III Comparative Risk Project is whether it contributes to improved allocation of the Region's resources for protecting the environment. The first phase of the project has provided a comprehensive picture of the relative seriousness of the environmental problems facing the Region. The task of building on these findings lies ahead.

APPENDIX 1 – DEFINITIONS OF REGION III PROBLEM AREAS

ISSUE	INCLUDES	EXCLUDES
1. Criteria Air Pollutants	Ambient Sulfur Dioxide, PM 10 (TSP prior to approved PM 10 SIP), CO, NOx, ozone & related VOCs, and lead.	Acid deposition.
2. Hazardous/Toxic Air Pollutants	NESHAPs substances (approved and pending), Acutely Toxic Chemicals List, pesticides, routine & accidental releases.	Toxics from wastewater treatment plants, CERCLA sites, radionuclides NESHAPs, solid waste disposal, RCRA TSD, air deposition impacts.
3. Radon - Indoor	Indoor radon exposures from any source.	Occupational exposure, outdoor exposure.
4. Indoor Air Pollutants Other Than Radon	All indoor exposures to air pollutants for example: asbestos, formaldehyde, tobacco, CO, NOx, and pesticides.	Occupational exposure
5. Radiation Other Than Indoor Radon	Naturally occurring, manufacturing, radioactive waste disposal, indoor radiation other than radon, non-ionized activities (microwaves, high-tension lines, etc.).	Medical x-rays, CERCLA sites, cosmic rays exposure in aircraft, exposure from ozone depletion, occupational exposure, nuclear power plant accidents.
6. Impacts of Industrial Point Source Direct Discharge of Wastewater on Surface Waters and Air	Pollutants in wastewater generated by all privately-owned sources that are directly discharged to surface waters (including wetlands) through discrete conveyances or volatilized to air.	Discharges to or from publicly owned treatment facilities, treatment sludges, ground-water impacts from wastewater treatment, and physical impacts from discharges of dredge and fill material.

ISSUE	INCLUDES	EXCLUDES
7. Impacts of POTW Discharges on Surface Water and Air	Pollutants in wastewater generated by all publicly owned sources that are directly discharged to surface waters (including wetlands) through discrete conveyances or volatilized to air, indirect industrial discharges, and combined sewer overflows.	Discharges to or from privately owned treatment facilities, treatment sludges, groundwater impacts from wastewater treatment, and physical impacts from discharges of dredge and fill material.
8. Non-point Source Discharges to Surface Waters	Discharges from non-discrete conveyances including agricultural runoff, industrial runoff, silvicultural runoff, pesticide runoff, surface discharge of septic tanks, stormwater runoff, mine drainage, contaminated in-place sediments, air deposition, oil and gas operations, and chemical discharges from disposal of dredge and fill materials.	Acid deposition impacts, discrete discharges of contaminated ground water, solid waste disposal, hazardous waste sites (RCRA & CERCLA), and physical impacts from discharges of dredge and fill material.
9. Management of Hazardous Waste at RCRA Facilities	All discharges to air, soil, surface water and ground water from active and closed RCRA facilities, waste transportation, and illegal disposal/lack of capacity.	Discharges to wastewater treatment plants and criteria air pollutants.
10. Hazardous Substances at CERCLA Sites	NPL sites and potential NPL sites. Illegal disposal/lack of capacity.	Discharges to wastewater treatment plants and criteria air pollutants.
11. Solid Waste Management	Multi-media discharges to air, soil, surface water, and ground water from all household, municipal, and industrial waste not regulated by RCRA as a hazardous waste, treatment sludges, waste transportation, and illegal disposal/lack of capacity.	Discharges to wastewater treatment plants and criteria air pollutants.
12. Releases from Underground Storage Tanks	All substances released from underground storage tanks, such as gasoline, pesticides, solvents, and oil.	RCRA-regulated tanks and CERCLA sites.

ISSUE	INCLUDES	EXCLUDES
13. Other Ground-Water Contamination	Pollutants contaminating ground water from such sources as agriculture; industry; municipal activities; silviculture; oil, gas & mining operations; pesticides; UIC-related discharges; road salt; urban runoff; underground discharges from septic tanks; saltwater intrusion; and naturally occurring fluorides.	CERCLA - and RCRA - regulated sites, underground storage tanks, and solid waste disposal.
14. Other Pesticide Contamination	Residues on and in food and applicator exposure.	Surface water runoff, aerial drift, ground-water contamination, manufacturing, disposal, non-commercial and non-agricultural applicators.
15. Physical Modification of Aquatic Habitats	All physical changes to aquatic habitats such as dredging and filling of wetlands, dams, and channelization.	Chemical impacts from disposal of dredge and fill materials.
16. Physical Modification of Environmentally Sensitive Terrestrial Habitats	All physical changes to sensitive terrestrial habitats such as dam building, strip mining, and highway construction.	Chemical impacts from disposal of dredge and fill materials.
17. Acid Deposition	All damages caused by wet or dry deposition of acidic compounds from the atmosphere.	Primary impacts of sulfur oxides, NOx, and VOCs.
18. Operation and Maintenance of Water Supply Facilities	All water treatment facilities and distribution networks.	Contamination in the raw water.

APPENDIX 2 – LIST OF PROJECT PARTICIPANTS

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