Final Report of the New Jersey Comparative Risk Project

March 2003

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Bradley M. Campbell
401 East State Street
P.O. Box 402
Trenton, NJ 08625-0402

Dear Commissioner Campbell:

On behalf of the Steering Committee of the New Jersey Comparative Risk Project, we are very pleased to transmit our final report to you, summarizing a four-year effort to evaluate the comparative negative impacts of the state's many environmental problems.

We find that the environmental threats with the greatest impact statewide in New Jersey include land use change, indoor environmental problems, and invasive species, plus a set of more familiar pollutants already targeted by government action. Some of these threats are clearly within the domain of the New Jersey Department of Environmental Protection, and we hope that you will take appropriate management actions. Other threats, including land use change and the indoor environment, depend on coordinated action by multiple agencies of government. We encourage you to pursue such coordination vigorously.

The 178 detailed, systematic analyses of health, ecological and socioeconomic impacts of 88 environmental stressors provide unprecedented information about impacts not yet dealt with by existing environmental management efforts. While monitoring, data analysis and research can and should be used to fill in the inevitable data gaps and uncertainties, we hope that you will encourage your agency and other environmental managers in New Jersey to use these results in priority-setting and strategy development.

The New Jersey Comparative Risk Project was led by an active and broad-based Steering Committee (see attached list), supported by three expert Technical Work Groups and a project coordination team. A thorough peer review process and outreach efforts touching hundreds of citizens enhanced the project's technical credibility, transparency and legitimacy. Among the dozens of project participants, we would especially like to recognize the contributions of Martin Rosen, Branden Johnson, Gary Buchanan, Alan Stern and Suzanne Shannon of NJDEP, and Professor Clinton Andrews of Rutgers University.

Sincerely,

Daniel Rubenstein
Co-chair, Steering Committee
Professor and Chair
Department of Ecology & Evolutionary Biology
Princeton University

Sheryl Telford
Co-chair, Steering Committee
Business Team Manager
E.I. du Pont de Nemours & Co.

Steering Committee, New Jersey Comparative Risk Project

Co-Chair: Daniel I. Rubenstein, Princeton University
Co-Chair: Sheryl Telford, PSE&G (later E.I. du Pont de Nemours & Company)

Dorothy Bowers, Merck & Co. (Retired)

James Brownlee, New Jersey Department of Health & Senior Services

Joseph DellaFave, Ironbound Community Corporation

Gus Elsner, Infineum USA

Peter J. Furey, New Jersey Farm Bureau

Keith V. Hamilton, Mercer County Freeholders, and Avaya Corp.

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Michael McGuinness, New Jersey Chapter of the National Association of Industrial and Office Properties

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Randy Solomon/Tim Evans (sequential members), New Jersey Future

Nancy Wittenberg, New Jersey Builders Association

Charles Yates, Farmers & Mechanics Bank (deceased)

Carolyn Whittaker/Junfeng (Jim) Zhang (sequential members), Environmental & Occupational Health Sciences Institute (EOHSI), UMDNJ

A Guide to This Report

This report is organized to emphasize the two primary products of the New Jersey Comparative Risk Project (NJCRP): (1) the rankings of environmental issues according to their relative negative impacts on human health, ecological quality, and socioeconomic conditions, and (2) the detailed analyses of those impacts for each issue.

The report begins with an Executive Summary, which includes the overall rankings for the three kinds of impacts.

The main part of the report has three sections:

- The Rankings section begins with a very brief background section on the NJCRP's origins, mission, and process; presents the separate statewide rankings of issues based on their health, ecological and socioeconomic impacts (including uncertainty in these rankings, trends, and catastrophic potential); and ends with a discussion of caveats about the overall rankings.
- The Analyses section provides a more detailed discussion of the process of the NJCRP, particularly for the expert workgroups that separately analyzed health, ecological and socioeconomic impacts; and presents alternative perspectives for ranking environmental issues (by uncertainty, trends, catastrophic potential, areas and populations at particular risk).
- The Steering Committee for the project—a diverse group of stakeholders from across New Jersey—used the rankings and analyses produced by the experts to develop their own set of Findings and Recommendations to the New Jersey Department of Environmental Protection (DEP).

The next part of the report contains the Summaries. These are one-page distillations of the information developed for each environmental issue. They define the issue; show its overall relative ranking; discuss potential impacts overall; report the health, ecological and/or socioeconomic impacts judged most likely to occur; and briefly report on what's being done about them.

The final section of the report contains the Appendices. These include (1) a list of NJCRP participants; (2) blank versions of the templates that the expert workgroups used to standardize their analyses; (3) the Human Health analyses; (4) the Ecological Quality analyses; (5) the Socioeconomic analyses; and (6) analyses of issues that were not included in the overall rankings.

Contents

TABLES

FIGURES

ACKNOWLEDGMENTS

A project of this complexity and magnitude could not be successfully completed without the significant and dedicated efforts of a committed group of individuals. This group recognized the value and potential of the comparative risk concept for improving environmental decision-making in New Jersey with the ultimate goal being the improvement of our state's environmental quality. They worked hard, remained committed, and contributed their most valuable assets—their intelligence and time. Consequently, I would like to offer my appreciation to the following:

Dr. Daniel Rubenstein, Princeton University, and Ms. Sheryl Telford, E.I. du Pont de Nemours Corporation, the project's Steering Committee Co-Chairs, who took much time out of their busy schedules to lead and refine this project and inspire its participants. Their attention to process and content, and their sensitivity to detail and politics, kept the project on a sound footing and gave it a clear direction. Their contributions on behalf of the citizens of New Jersey are gratefully applauded.

Dr. Clinton Andrews, Rutgers University, whose insights, products and humor helped keep the project practically focused as well as intellectually challenging throughout. He is owed an additional debt of gratitude for being the mainstay of the Socioeconomic Technical Work Group and ensuring that the necessary analyses were completed. Many thanks also to Clint's graduate students, especially John Posey, Dave Hassenzahl, Jun Bi, Jason Lien and Ana Baptista.

Dr. Alan Stern and Dr. Gary Buchanan, NJDEP Division of Science, Research and Technology (DSRT), for their outstanding work as Chairs of the Human Health and Ecological Quality Technical Work Groups, respectively. I thank them for their commitment to scientific excellence and their willingness to persevere and guide the many members of their committees, especially when committee members' energy inevitably began to wane.

Ms. Suzanne Shannon, my Executive Assistant, who endured many extended meetings, short deadlines and numerous thankless assignments. Her patience, dedication and suggestions were always appreciated and her contributions vital.

Dr. Ken Jones of the Green Mountain Institute for Environmental Democracy, Montpelier, Vermont, who shared his extensive understanding of the comparative risk paradigm to help inform key project decisions, and (with Jennifer Colby) accomplished wonders of synthesis in writing stressor summaries and initial versions of this report.

Ms. Terri Tucker exhibited enormous patience and resolve in dealing with numerous revisions of the content, formatting, and organization of this report, and in ensuring that both its printed and Web versions would enhance its usefulness to environmental managers and New Jersey citizens.

Finally, Dr. Branden Johnson, DSRT, who was my left hand, my right hand, my advisor, and my colleague, and who kept this colossus moving forward throughout the numerous years it took to bring this project to fruition. The successful completion of this endeavor would not have been possible without his many, many efforts and excellent judgment.

Marty Rosen
Project Manager, New Jersey Comparative Risk Project
Director, Division of Science, Research and Technology
New Jersey Department of Environmental Protection

EXECUTIVE SUMMARY

Executive Summary

Introduction

From 1988 to 1998, the U.S. Environmental Protection Agency (EPA) partially funded and gave technical assistance to comparative risk projects. As defined by the EPA, comparative risk assessment "uses sound science, policy, economic analysis and stakeholder participation to identify and address the areas of greatest environmental risks and provide a framework for prioritizing environmental problems." By the end of 2000, 24 states had completed comparative risk projects.

In April 1998, the New Jersey Department of Environmental Protection (DEP) launched the New Jersey Comparative Risk Project (NJCRP).

Its primary question was:

"What is the relative importance of environmental problems in New Jersey?"

The NJCRP Steering Committee, a diverse group of stakeholders, was charged with the following tasks:

- Determine how different environmental issues compare to one another in their negative impacts on human health, ecological quality, and socioeconomic conditions in New Jersey, based on current environmental management.
- Identify key gaps in existing knowledge that need filling to better compare environmental issues and develop strategies to deal with them that also account for any beneficial impacts (not included here).

To meet these objectives, the Steering Committee assembled three Technical Work Groups (TWGs). These included the Human Health (HH)TWG, the Ecological Quality (EQ) TWG and the Socioeconomic (SE) TWG, each composed of experts from government, business, academia and nonprofit organizations. The three TWGs together created impact analyses for 88 different environmental stressors (chemical, physical, or biological factors) affecting the environment. Each TWG also produced a ranking based on these analyses, designed to indicate the relative statewide risks posed by each stressor in New Jersey.

The 178 resulting analyses (not all stressors were relevant to each impact category, and some were aggregated) provide detailed information on each stressor's undesirable impacts, and are well worth additional study (see Appendices). They focused on current impacts and impacts over the next five years, which means that issues with long-term or uncertain impacts (such as climate change due to greenhouse gases) rank low. The fact that an issue ranks low does not mean that it is not worth action to reduce its impacts further. For example, it may be low due to the success of current environmental management or because it is inherently or currently low-risk; action may be warranted because easy means of additional risk reduction can be applied or because society wishes to prevent a potential problem from getting worse. <u>A low rank does not necessarily signal lack of importance</u> (see p. 20).

Findings

Based on the exhaustive analysis performed by the TWGs, the Steering Committee arrived at the following findings. Its members focused on issues ranking high for more than one TWG or that seemed relatively neglected or in need of further attention. The full rankings, which appear at the end of the Executive Summary, show that many of the high-ranking issues on individual TWG lists are already subject to major impact-reduction efforts by DEP. The fact that their high rank indicates significant impacts are not addressed by current programs may at the very least encourage state government to continue its efforts on these issues.

1. Land use change lies at the heart of many of New Jersey's environmental problems. Land use change, in the view of the experts, produced by a wide margin the largest negative ecological and socioeconomic impacts.

- Habitat loss and fragmentation are leading to species loss and permanent destruction within several of the state's ecosystems.
- An increase in the amount of impervious surfaces increases stormwater flows to New Jersey streams and rivers, leading to destruction of wetlands and increased flooding and reducing aquifer recharge.
- Sprawl skews employment patterns and affects property values, both to the detriment of older communities.
- Congestion may cause health and psychological impacts, although there is much uncertainty about the quantification of this threat.

2. Indoor pollution ranked among the highest threats in both the HH and SE rankings. This is a serious problem that deserves more attention from environmental and public health managers.

- Several stressors with high health impacts are primarily or entirely problems of indoor air: secondhand tobacco smoke, radon, indoor asthma inducers, carbon monoxide, and indoor microbial air pollution.
- Although there is insufficient evidence with which to quantify the risk associated with certain stressors, there is some evidence that indoor exposure to some chemicals may be a cause for concern. These include formaldehyde and several volatileorganic compounds.
- Indoor air quality is almost entirely unregulated, although the New Jersey Department of Health and Senior Services (DHSS) is to be commended for beginning discussions concerning an action plan.
- Other indoor pollution problems, such as skin contact with or ingestion of indoor pesticides or lead by children, also are serious and deserve more attention.

3. Invasive species pose a serious ecological threat to several New Jersey ecosystems.

- Insects such as the Asian longhorned beetle and the hemlock woolly adelgid have the potential to destroy hardwood and softwood forests. For example, over 90% of the state's hemlock forests have suffered varying degrees of defoliation.
- The zebra mussel will probably reach freshwaters in New Jersey sometime in the next five years. This thumbnail-sized mollusk has already destroyed freshwater ecosystems in more than a dozen states.
- Invasive plants such as the purple loosestrife, the Norway maple and garlic mustard threaten biodiversity and ecological integrity in several ecosystems, with wetlands a particular concern.

4. Progress has been made in the battle against outdoor air pollution. However, several air pollutants continue to pose both ecological and health risks, including ground-level ozone, sulfur oxides and nitrogen oxides.

Recommendations

These findings led the Steering Committee to offer the following recommendations:

1. The notion that land use changes can create significant environmental problems is not new to New Jersey policy-makers or citizens. But these problems continue to be large and increasing despite past efforts, and reducing negative impacts while retaining benefits of land use change will be challenging. Thus DEP should collaborate with state and local planning officials to design and implement strengthened efforts to reduce the environmental impacts of land use change. While the Steering Committee did not define the precise role of DEP in implementing the state plan, there is a consensus that DEP can contribute by bringing together people from multiple sectors.

2. It is time for DEP and other environmental managers to join DHSS to examine systematically indoor pollution's impacts and management options, and to take action against these problems. The current approach, with inconsistent (across pollutants) attempts at education and persuasion, is clearly not sufficient for the magnitude of the problem.

3. Continued vigilance should be employed against threats posed by invasive species and hazardous air pollutants.

4. A high priority should be placed on identifying and targeting sources that produce multiple stressors. Control of stressors that co-occur (i.e., come from the same sources) offers the potential for more effective environmental management. For example, many air pollutants may be jointly reduced by single actions such as more efficient energy use and use of emissions-cleaning technology.

5. State officials and the New Jersey congressional delegation should seek assistance from the federal government in dealing with sources that originate outside New Jersey borders as well as work with other states on regional problems. Criteria air pollutants (e.g., SOx, NOx) and greenhouse gases are the best known examples of this problem. Other examples include certain invasive species such as the zebra mussel.

6. Increased monitoring, data assessment and research (see Analyses section for examples) will aid in the understanding of risks and the formation of policy. Monitoring programs may help the state focus resources in geographic areas or in economic sectors that will provide the most benefit. In addition, there was a high degree of uncertainty regarding the impact of certain stressors, such as chromium, indoor microbes and pesticides. Additional research can reduce uncertainty and guide risk reduction strategies.

7. Local discussions of risks may yield important new environmental protection efforts. Local environmental planners and managers are encouraged to use the analyses created in this project to produce local comparative risk projects. A pilot local comparative risk project has begun as a collaboration between New Brunswick and Rutgers University.

8. NJCRP analyses and rankings should be used by DEP as part of its risk-based and performance-based management system.

9. The State should consider repeating NJCRP at regular intervals. Comparative risk projects are a strong and useful complement to topic-specific and program-specific analyses.

Caveats

The analyses of environmental impacts were the best possible reviews of available data and science, limited by data availability and quality. Use of identical templates for analysis within TWGs, and peer review, limited variability in analyses across authors. These analytic results are the most systematic across a wide range of stressors ever produced in New Jersey.

Consequently, the resulting rankings should be taken as reasonable reflection of the relative negative impacts imposed by these stressors. (The value of the analyses' estimates of absolute risk is less, due to data gaps, incommensurate kinds of impacts, changing conditions, and other confounding factors.)

A risk ranking is not a list of priorities. It is tempting to consider a list of higher risk issues as the priorities for action. The Steering Committee and other project participants discourage that translation, since the risk ranking does not take into account the limits of agency responsibility, the differing costs of risk reduction, or the appropriate role of public opinion in policy making. Moreover, very few stressors scored high in all three areas (human health, ecological, socioeconomic), thus underscoring the multi-dimensional nature of environmental risks. Any composite ranking would have elevated one dimension over another, which the Steering Committee felt was inappropriate.

The Steering Committee and Technical Work Groups agree that the risk rankings are only part of the product from the analysis. There is a great deal of information that supports the risk ranking. In many cases, this information is more useful than the ranking itself. For this reason, the project produced one-page summaries for each stressor which give an overview of the extent and type of risks that occur. For even more information, the Appendices include the full analyses of each stressor.

Table 1. Issues Rankings (by impact type)

Human Health

High

- Lead
- Ozone (ground level)
- Particulate matter
- Polychlorinated biphenyls (PCBs)
- Radon
- Secondhand tobacco smoke

Medium-High

- Carbon monoxide (Co) -indoor
- Dioxins/furans
- Indoor asthma inducers
- Pesticides-indoor
- Radium
- Volatile organic compounds (VOCs)-carcinogenic

Medium

- 1,3-butadiene
- Acrolein
- Arsenic
- Benzene
- Chromium
- Disinfection byproducts
- Endocrine disruptors
- Formaldehyde
- Legionella
- Mercury
- Nitrogen oxides (NOx)
- Pesticides-food
- Pesticides-outdoor
- Pesticides-water
- Ultraviolet radiation
- Waterborne pathogens-recreational water

Medium-Low

- Airborne pathogens
- Carbon monoxide (CO) -outdoor
- Cryptosporidium-recreational water
- Sulfur oxides (SOx)/sulfates
- Volatile organic compounds- non-carcinogenic (VOCs)

Low

- Cadmium
- Cryptosporidium-drinking water
- Extremely low frequency/Electro magnetic radiation
- Greenhouse gases
- Hanta virus
- Indoor microbial air pollution
- Lyme disease
- Methyl tertiary butyl ether (MTBE)
- Nickel
- Nitrogen pollution (water)
- Noise
- Pfiesteria
- Polycyclic aromatic hydrocarbons (PAHs)
- Radionuclides
- Waterborne pathogens-drinking water
- West Nile virus

Ecological

High

- Habitat fragmentation
- Habitat loss

Medium-High

- Hemlock woolly adelgid
- Increase in impervious surface
- Mercury
- Pesticides-historical use
- Ultraviolet radiation

Medium

- Cadmium
- Catastrophic radioactive release
- Deer
- Endocrine disruptors
- Geese
- Inadvertent animal mortality
- Invasive plants
- Lead
- Nitrogen pollution (water)
- Overharvesting (marine)
- Petroleum spills
- Phosphorus
- Phthalates
- Polychlorinated biphenyls (PCBs)
- Starlings

Medium-Low

- Acid precipitation
- Arsenic
- Brown tide
- Chromium
- Copper
- Dioxins/furans
- Dredging
- Greenhouse gases
- Nickel
- Noise
- Off-road vehicles
- Pesticides-present use
- Polycyclic aromatic hydrocarbons (PAHs)
- Tin
- Water overuse
- West Nile virus
- Zinc

Low

- Asian longhorned beetle
- Blue-green algae
- Channelization
- Dermo parasite in oysters
- EHD virus in deer
- Extremely low frequency magnetic radiation
- Floatables
- Genetically modified organisms (GMOs)
- Green/red tides
- Light pollution
- MSX parasite in oysters
- Ozone (ground level)
- Pets as predators
- Pfiesteria
- QPX parasite in shellfish
- Road salt
- Thermal pollution
- Volatile organic compounds (VOCs)
- Zebra mussels

Socioeconomic

High

- Land use change
- Lead

Medium-High

- Arsenic
- Deer
- Indoor asthma inducers
- Particulate matter
- Pesticides
- Petroleum spills
- Phosphorus
- Polychlorinated biphenyls (PCBs)
- Secondhand tobacco smoke
- Ultraviolet radiation

Medium

- Dioxins/furans
- Endocrine disruptors
- Inadvertent animal mortality
- Indoor microbial air pollution
- Invasive plants
- Noise
- Ozone (ground level)
- Polycyclic aromatic hydrocarbons (PAHs)
- Radon
- Sulfur oxides (SOx)
- Water overuse

Medium-Low

- 1,3-butadiene
- Acid precipitation
- Acrolein
- Catastrophic radioactive release
- Chromium
- Dermo and MSX parasites in oysters
- Extremely low frequency/Electro magnetic radiation
- Floatables
- Formaldehyde
- Greenhouse gases
- Hemlock woolly adelgid
- Light pollution
- Mercury
- Methyl tertiary butyl ether (MTBE)
- Volatile organic compounds (VOCs)
- Waterborne pathogens

Low

- Asian longhorned beetle
- Benzene
- Brown tide
- Cadmium
- Carbon monoxide (CO)
- Copper
- Cryptosporidium
- Disinfection byproducts
- Dredging
- EHD virus in deer
- Geese
- Genetically modified organisms (GMOs)
- Green/red tides
- Hanta virus
- Legionella
- Nickel
- Nitrogen oxides (NOx)
- Nitrogen pollution (water)
- Off-road vehicles
- Overharvesting (marine)
- Pets as predators
- Pfiesteria
- QPX parasite in shellfish
- Radium
- Road salt
- Starlings
- Thermal pollution
- Tin
- West Nile virus
- Zebra mussels
- Zinc

RANKINGS

Rankings

Introduction

The New Jersey Comparative Risk Project represents New Jersey's effort to evaluate the relative risk facing the state's people and ecosystems. Its primary question was:

"What is the relative importance of environmental problems in New Jersey?"

It is not the first effort to describe the state's environmental conditions. It may, however, be the most comprehensive report systematically describing numerous physical, biological and chemical threats.

In 1998, then-Commissioner Robert Shinn requested that the Department of Environmental Protection (DEP) carry out a comparison of risks to New Jersey's environment. In this request, Commissioner Shinn asked for the comparative risk approach because of its ability to "provide a basis for comparing environmental issues in a balanced manner using the best possible scientific information." Commissioner Shinn's charge included:

Determine how different environmental issues compare to one another in their negative impacts on human health, ecological quality, and socioeconomic conditions in New Jersey.

Identify the key gaps in our existing knowledge that need to be filled in order to better address the comparison of environmental issues and strategies to deal with those issues.

This report is the result of that charge, and the result of thousands of hours of effort from DEP staff, volunteers, and contractors.

This report is intended as a first step in meeting the following objectives:

Develop a better understanding of New Jersey's environment;

Strengthen the basis for DEP and New Jersey citizens to make choices regarding environmental improvement;

Promote discussion in New Jersey regarding the need for additional action to continue improvement in environmental quality and to address future challenges.

Understanding our environment

DEP was established in 1970 to protect the state's environment. The Department carries out thousands of functions to implement more than a hundred programs. The citizens of New Jersey should be proud that the state has implemented these programs and has gained significant benefit in environmental protection. However, continued progress will not come easily. Continuing growth of the population and economy place increased pressures on our valuable natural resources. In addition, some of our past economic progress came at a price to our land, air, and water. To strengthen the state for its future, we need to address some of those past damages. This comparative risk project report will help New Jersey decisionmakers in that effort.

The New Jersey Department of Environmental Protection (DEP) has produced several assessments of environmental conditions over the past few years. In 1995, DEP produced an assessment as a part of its participation in the National Environmental Performance Partnership System with EPA. That project initially focused on air and water quality programs that were direct partnerships between New Jersey and EPA. New Jersey since expanded the scope of its self assessment and Performance Partnership participation to include almost all of its programs, including those that have no direct federal support. In 1998, New Jersey released its first State of the Environment Report. That report highlighted some of the improvements that have taken place during three decades of DEP action. The most important difference between this comparative risk report and previous efforts is the structure used in carrying out the assessments. The NJCRP report is designed so that different issues can be considered and compared.

Because of the maturity of many programs and the opportunities for program changes offered by DEP's own internal planning and management policies, comparative risk is particularly useful. One requirement for an optimal planning process is a solid understanding of the relative magnitude of negative impacts from different environmental issues. From this understanding, the state can work together with its federal partners to ensure that programs address the most significant environmental threats. This comparative risk project will help New Jersey develop future Performance Partnership Agreements with the EPA as well as inform internal strategic planning and management efforts.

The results of this comparative risk project should also enhance future sustainability projects. New Jersey is a national leader in the use of sustainability principles for implementing state policies. Recent examples include the New Jersey Future project ("sustainable state"), the Sustainable State Institute and New Jersey's identification of a greenhouse gas emissions reduction target.

But where to next? There are literally hundreds of stresses to our environment occurring to varying degrees at many locations across the state. How do we choose? How do we focus our resources? How do we decide where to place our efforts? The circulation of this document represents the first opportunity to promote discussion. We look forward to receiving your feedback with regards to the analysis that we undertook to better understand New Jersey's environment. *

The next sections describe very briefly the way in which the project produced rankings (details of the process of analyzing impacts, on which rankings were ultimately based, are discussed in the "Analyses" section of the report), presents the overall rankings by each of the Technical Working Groups, and discusses caveats about the rankings.**

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** Readers should note that the authors' insights on any particular issue write-ups are theirs alone and do not necessarily reflect a consensus view of all persons involved in the Comparative Risk Project. The technical work was subjected to peer review to ensure that it reflects generally accepted knowledge. The Co-Chairs sincerely appreciate the time, effort and dedication put forth by the technical working groups in the research, writing and development of the numerous issue write-ups in the Comparative Risk Report. The results, conclusions and recommendations of this study reflect the knowledge and judgment of the project participants who were selected based on their respective expertise, interest in environmental issues and diverse perspectives.

Assessing Impacts

Both natural and human-caused factors can influence the health of human beings and the environment. These factors, referred to as *stressors*, come in three major types—biological, chemical, or physical. Stressors can affect human health, influence ecological quality, create socioeconomic impacts, or result in any combination of the three. (Stressors' benefits were not estimated in this project.) Sources of stressors can range from industrial activities to agricultural practices to personal behaviors to natural processes. Stressors are the conceptual linkage between cause and effect, between sources and the health, ecological, or socioeconomic impacts that may result.

How were the stressors evaluated and scored?

The Human Health, Ecological Quality, and Socioeconomic Technical Working Groups gathered and organized information about the stressors and their effects. The identity and nature of each stressor, the level of the stressor present in New Jersey, and the adverse effects at given amounts were described (see Appendix 2 for the templates used in these analyses; the "Analyses" section describes the impact analysis process in more detail.) All three TWGs then applied their own specific criteria for evaluating and scoring the stressors:

Human health criteria

- Severity of health impacts
- Size of population at risk
- Discrete communities affected

Ecological criteria

- Severity/irreversibility of ecological impacts
- Frequency of ecological impacts
- Magnitude of ecological impacts

Socioeconomic criteria

- Severity of socioeconomic impacts
- Duration/Irreversibility of socioeconomic impacts
- Scale of socioeconomic impacts

For each stressor, scores for each criterion were combined within each TWG to derive single scores for human health risk, ecological risk, and socioeconomic risk. In some cases where very little information exists, or the stressor was judged to present too little potential for impact to support a full scale-assessment, a "short report" was developed in lieu of a full risk characterization. The ranks assigned to each stressor reflect a relative assessment of risk (e.g., high, medium, low) rather than an absolute estimate of the inherent risk (e.g., one-in-a-million cancer risk).

Designing the risk ranking

There were many challenges encountered in developing the risk rankings. However, despite the caveats, there was a large enough range of impacts among the different stressors that the rankings were reasonable representations of *relative* risks in New Jersey. Accomplishing the ranking required each TWG to determine the most appropriate mechanism for combining and summarizing risk factors in a useful fashion. The Analyses section includes a description of the ranking details for each TWG.

This report does **not** include a single ranking of stressors that combines human health, ecological quality and socioeconomic impacts. The Steering Committee considered this possibility and decided that more information would be lost through the combination of information than would be gained by developing the single ranking. The degree of agreement and disagreement among the TWGs' rankings can be seen in Table 2. It compares rankings offered by the Health and Ecological TWGs for stressors that both groups analyzed (several stressors, such as acrolein and invasive plants, respectively, were done by only one group; stressors ranking low for both groups are not shown in the table). Since socioeconomic impacts are often secondary effects based on primary human health and ecological impacts, they tend to reinforce the patterns shown in the table, making a third dimension unnecessary. Note that only about a third of the stressors compared are within one rank across these two TWGs, which is understandable since the two groups were looking at qualitatively different impacts in most cases. But this disparity underlines the value in avoiding a single integrated ranking.

Table 2. Comparison of Human Health and Ecological Rankings

ECOLOGICAL RANKS	HUMAN HEALTH RANKS				
	High	**Medium-High**	**Medium**	**Medium-Low**	**Low**
High					
Medium-High			Mercury Ultraviolet radiation		
Medium	Lead PCBs		Endocrine disruptors		Cadmium Nitrogen pollution
Medium-Low		Dioxins/furans	Arsenic Chromium		
Low	Ozone (ground level)	VOCs (Health carcinogenic)		VOCs (Health non-carcino-genic)	

The following pages show the results of the rankings for Human Health, Ecological Quality, and Socioeconomic impacts, respectively. Each ranking table provides the following information.

- Overall ranking: This is scored in five categories, from High to Low. Stressors are listed alphabetically within each ranking category.
- Uncertainty: This represents the degree of confidence that the Working Group has about the overall ranking, from High to Low.
- Trend: This shows whether Working Groups expect the stressor's impacts in New Jersey to get worse, improve, or stay the same.
- Catastrophic Potential: This represents the possibility of a very large impact due to a single accident or some other unusual event (which may not actually occur), ranked from high to low.

Ranking Results

Human Health Impacts

Overall findings/ highlights

Six stressors are ranked as high risks to New Jersey health. These are secondhand tobacco smoke, radon, ozone, PCBs, airborne particulate matter, and lead. In the cases of secondhand tobacco smoke, radon, and PCBs, the potential for cancer is approximately one thousand additional cases each year. For many of these stressors, children are among the most "at risk" populations in the state because they are more susceptible to statewide exposure levels.

Ozone and lead do not lead to cancer, but thousands of children are at risk for neurological development problems from lead exposure, and hundreds of thousands of New Jersey residents may suffer respiratory effects from elevated atmospheric ozone. All residents of the state are potentially exposed to harmful levels of ozone. Children have the highest risk from exposure to ozone because they have developing respiratory systems, breathe greater amounts of air per body mass as compared to adults, and are active outside during the summertime when ozone levels are at their highest. Adults and children with respiratory illnesses, such as asthma, bronchitis and emphysema, can experience a reduction in lung function and increased respiratory symptoms when exposed to relatively low ozone levels. Precursor emissions should decrease as a result of the actions contained in the current State Implementation Plan for meeting the ozone National Ambient Air Quality Standard, but this will not be enough to meet either the 1-hour or the 8-hour ozone standard. The overall decrease in the number of ozone exceedance days since the 1970s can be attributed to reduced emissions from automobiles and industrial sources, and control of emissions of gasoline during refueling.

The presence of lead contamination in major environmental media (air, water, soil/ sediments), as well as its historic presence in consumer products such as paint, ceramics, plumbing supplies, and canned goods, currently results in a low, but pervasive background prevalence in the New Jersey population. Children represent sensitive subpopulations by virtue of experiencing increased exposure to contaminated soil and dust, and greater sensitivity to neurological impairment at relatively low blood lead levels. Among children, those with low socioeconomic status are at even greater risk, due to a higher probability of living in housing with peeling lead-based paint and in neighborhoods with historical soil contamination from flaking lead-based paint and heavy vehicular traffic using leaded gasoline, and to increased risk of poor nutritional status (which increases lead absorption).

For secondhand tobacco smoke and radon, the sources are indoors and largely in the home. The potential for reducing these risks hinges on the ability to change personal behaviors in the case of environmental tobacco smoke and the encouragement of home testing and modifications for radon. Tobacco smoke exposure occurs among all populations throughout New Jersey with the age group of 18-24 having the highest percentage of usage (29.6% smoking). Children's lungs are even more susceptible to harmful effects than those of adults. Several recent studies link secondhand tobacco smoke with increased incidence and prevalence of asthma and increased severity of asthmatic symptoms in children of mothers who smoke heavily. These respiratory illnesses in childhood may contribute to small, but significant lung function reductions associated with exposure to tobacco smoke in adults. In the 1970's, New Jersey was a leader in restricting the non-smoker's exposure to tobacco smoke. But current state laws only require that restaurants have a non-smoking section, do not prohibit smoking in the workplace, and do not require any separation between smoking and non-smoking areas, although smoking in publicplaces is prohibited. All New Jersey citizens are also at high risk from radon. The entire state population is exposed to radon in the outdoor air, and large regions of the state are at increased risk for significantly elevated radon levels in their homes. There are no requirements that homeowners must test their homes for radon, but it has become standard practice in real estate transactions and state law regulates radon hazards for new construction.

Polychlorinated biphenyls (PCBs) exposures (as for lead exposures) are largely the result of historical use of the chemicals; in these cases, current exposures are significant but decreasing. The health effects associated with exposure to PCBs include breast cancer, non-Hodgkin's lymphomas, liver and gall bladder cancers, pancreatic cancer, decreased thyroid hormone, and prenatal effects that influence postnatal neurodevelopment. The populations most at risk are fish consumers, and infants breast-fed by women who consumed contaminated fish while pregnant. The decreasing use of products containing PCBs along with fish consumption advisories will lead to an improving trend.

The sources of particulate matter (PM) are both natural and human-made. Particulate matter that is smaller than 2.5 micrometers in diameter is most likely to affect human health. Health effects include exacerbation of preexisting cardiopulmonary disease like asthma and other forms of airway obstructive disease, reduced lung function, alterations in the body's defense system against inhaled material, and damage to lung tissue. Susceptible populations include those with preexisting cardiopulmonary disease, the young, the elderly and smokers. Researchers have found associations between increased PM and increased mortality and morbidity. The entire population of New Jersey is exposed to levels that are estimated to cause adverse health effects. Since a significant portion of PM comes from coal burning power plants, and the U.S. Environmental Protection Agency is not supporting the Clean Air Act New Source Performance Standards (NSPS), it is unlikely that there will be any appreciable decline in levels of PM in the near future. Lack of control of motor vehicle particulate emissions and the increase in vehicle miles driven contribute to levels of PM in New Jersey.

One biological and four chemical stressors fall in the "Medium-High" risk category. Four of the five (radium, carbon monoxide in indoor air, indoor microbial asthma inducers, and carcinogenic VOCs) are airborne contaminants. For the remaining stressor, dioxins and furans, food is the primary means of exposure. Most of the impacts from the airborne stressors are the result of indoor exposure. The biological stressor, indoor microbial asthma inducers, reflects the fact that many asthma inducers are found in the home. Increasing awareness of the links between respiratory problems and these relatively high-risk environmental stressors has led to increasing concerns for public health.

The "Medium" ranked issues include many chemical pollutants that are currently released into the environment. For most of these, there have been reductions in the exposures, but their continued releases are the result of dispersed sources that are difficult to manage. Some of the medium ranked chemicals (1,3-butadiene, mercury and NOx) result from vehicle and utility combustion of fossil fuels.

Some stressors are ranked as having relatively low impacts because of successful regulation and significant public investment. Some chemical stressors, such as SOx, are found in much lower concentrations than in the past as a result of restrictions on the emissions from large industrial sources. MTBE contaminates ground water because of its recent introduction as a gasoline additive, but currently poses a low risk.

Table 3. Statewide Human Health Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Lead	High	Low	Better	Low
Ozone (ground level)	High	Medium	Better	Low
Particulate matter	High	Medium	Same	Low
Polychlorinated biphenyls (PCBs)	High	Medium	Better	Low
Radon	High	Low	Better	Low
Secondhand tobacco smoke	High	Medium	Better	Low
Carbon monoxide (CO) - indoor	Medium-High	Medium	Better	Low
Dioxins/Furans	Medium-High	Medium	Better	Low
Indoor asthma inducers	Medium-High	High	Worse	Low
Pesticides-Indoor	Medium-High	High	Same	High
Radium	Medium-High	Medium-High	Same	Low
Volatile Organic Compounds (VOCs)-carcinogenic	Medium-High	Medium	Better	Low
1,3-butadiene	Medium	Medium-High	Better	Low
Acrolein	Medium	Medium-High	Same	Low
Arsenic	Medium	Medium	Better	Low
Benzene	Medium	Medium	Better	Low
Chromium	Medium	High	Better	Low
Disinfection byproducts	Medium	Medium	Better	Low
Endocrine Disruptors	Medium	High	Worse	Medium
Formaldehyde	Medium	Medium	Same	Low
Legionella	Medium	High	Same	Low
Mercury	Medium	High	Better	Low
Nitrogen oxides (NOx)	Medium	Medium-Low	Same	Low
Pesticides-food	Medium	High	Better	Low
Pesticides-outdoor	Medium	High	Better	Medium-High
Pesticides-water	Medium	High	Better	Low
Ultraviolet radiation	Medium	Low	Worse	Low
Waterborne pathogens - recreational water	Medium	Medium	Same	Low
Airborne pathogens	Medium-Low	High	Same	Low
Carbon monoxide (CO) outdoor	Medium-Low	Medium	Better	Low
Cryptosporidium- recreational water	Medium-Low	High	Same	Low
Sulfur oxides (SOx)/Sulfates	Medium-Low	Medium-Low	Better	Low
Volatile Organic Compounds (VOCs) non-carcinogenic	Medium-Low	Medium-Low	Better	Low
Cadmium	Low	Medium	Same	Low
Cryptosporidium-drinking water	Low	High	Better	Low
Extremely low frequency/Electromagenetic fields	Low	High	Better	Low
Greenhouse gases	Low	High	Same	High
Hanta virus	Low	Low	Same	Low
Indoor microbial air pollution	Low	High	Same	Low
Lyme disease	Low	Medium	Better	Low
Methyl tertiary butyl ether (MTBE)	Low	High	Better	Low
Nickel	Low	Medium	Same	Low
Nitrogen pollution (water)	Low	Medium	Better	Low
Noise	Low	High	Better	Low
Pfiesteria	Low	Low	Same	Low
Polycyclic Aromatic Hydrocarbons (PAHs)	Low	High	Same	Low
Radionuclides	Low	Low	Same	Low
Waterborne pathogens-drinking water	Low	Medium-High	Same	Low
West Nile virus	Low	Medium-High	Better	Low

Ecological Quality Impacts

Overall findings

Physical alteration of habitat stands out in the ranking as the most compelling ecological problem in New Jersey. Virtually the entire state is at risk from ongoing fragmentation and loss of habitat, which received significantly higher scores than other highly ranked issues. Birds and other species that require large expanses of intact habitat are especially at risk. Roads and other developments force changes in wildlife mobility patterns, promote the dominance of more disturbance-tolerant nuisance species, and increase the proportion of impervious (e.g., pavement) surface. The rate of increase in impervious surface area alone represents a significant risk to ecosystems. The resulting change in the quantity and quality of storm runoff alters natural stream flow patterns, increases erosion, and further degrades habitat. A continuing cycle of habitat degradation compounded by a proliferation of additional, related stressors (e.g., invasive species, inadvertent mortality, noise, nutrients, etc.), leading to further degradation, represents a serious and overarching threat to New Jersey ecosystems.

Ultraviolet (UV) radiation from the sun, which can be increased by human-caused depletion of stratospheric ozone, ranked medium-high. Like people, plants and wildlife can suffer adverse effects as a result of exposure to UV-B radiation, and all species in all parts of the state are susceptible. Of particular concern are the effects of UV radiation on the lowest levels of the food chain. Observed effects on marine plankton, for example, may carry significant repercussions, potentially affecting many species in a myriad of ways. While human health effects from UV radiation can be somewhat controlled via avoidance and treatment, terrestrial and aquatic ecosystems cannot be protected.

Our historic use of chemicals continues to threaten ecological communities. Though banned many years ago, chlorinated pesticides such as DDT and chlordane continue to cause adverse effects in wildlife. The ability of these chemicals to persist for decades in the soils and sediments ensures that ecological exposures will continue for years to come. Levels are declining, however, and bird populations have increased in the years since DDT and chlordane were banned in 1972 and 1988, respectively. For other chemical stressors, notably mercury and lead, emissions to the environment continue. As with UV radiation, human health risk can be reduced with successful education and avoidance efforts, but ecological communities remain at risk. As long as these metals continue to be discharged (even under increasingly stringent regulations), environmental exposure will continue to cause developmental and other abnormalities in animals.

Much more difficult to control than chemicals, a number of biological stressors pose medium to high risks for New Jersey ecosystems. A number of these are considered pests due to their overabundance. White-tailed deer, Canada geese, and starlings—species which flourish in disturbed or urbanized landscapes—edge out other species or disrupt natural ecosystem processes, exacerbating the effects of habitat loss and other stressors. Invasive plants, such as the multiflora rose and purple loosestrife, have similarly spread to nuisance proportions in many areas of the state. Most of these plants are non-natives, and some continue to be sold as ornamentals. Like the animals, they tend to adapt to a wide range of conditions, outcompeting other plants and consequently altering the abundance and diversity of natural plant communities and the wildlife that depend on them.

The hemlock woolly adelgid, an aphid-like insect pest, poses a potentially catastrophic risk to New Jersey hemlock forests. All hemlock forests in the state are at risk from the non-native adelgid and more than 90% have already been infested to some extent. Once trees have become defoliated, they rarely recover. Unless the adelgid can be controlled (introduction of exotic predators offers some hope), the current infestation will undoubtedly lead to a total loss of hemlock trees, along with serious ecological consequences.

In the past, the recognition of the relationship between stressors and negative ecological impacts has resulted in actions to reduce risk. The rate of chemical releases to the environment has been substantially reduced, and environmental concentrations are showing improvement. In time, ecological effects will be reduced as a result. The connections between physical and biological stressors and ecosystem health are not as broadly recognized, nor do they arouse similar levels of public concern. This general lack of awareness combined with ongoing rates of physical and biological stress compounds the risks associated with widespread land use change. A number of moderate to high ranking physical or biological stressors are directly or indirectly linked to the rate and magnitude of habitat disturbance in New Jersey. A focus on this broad issue represents a useful starting point for reducing ecological risk statewide.

Table 4. Statewide Ecological Quality Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Habitat fragmentation	High	Low	Same	Low
Habitat loss	High	Medium	Same	Low
Hemlock woolly adelgid	Medium-High	Low	Better	High
Increase in impervious surface	Medium-High	Low	Same	Medium-High
Mercury	Medium-High	Medium	Same	Low
Pesticides-historic use	Medium-High	High	Better	Low
Ultraviolet radiation	Medium-High	Medium	Worse	Low
Cadmium	Medium	Medium	Same	Low
Catastrophic radioactive release	Medium	Low	Same	Low
Deer	Medium	Medium-Low	Same	Low
Endocrine disruptors	Medium	Medium	Same	Low
Geese	Medium	Medium	Worse	Low
Inadvertent animal mortality	Medium	Medium	Better	High
Invasive plants *	Medium	Medium	Worse	Low
Lead	Medium	Medium	Worse	Low
Nitrogen pollution (water)	Medium	Medium	Same	Low
Overharvesting (marine)	Medium	Medium	Better	Medium
Petroleum spills	Medium	Medium	Same	High
Phosphorus	Medium	Low	Worse	Low
Phthalates	Medium	High	Same	Low
Polychlorinated biphenyls(PCB)	Medium	Medium	Better	Low
Starlings	Medium	Medium	Same	Low
Acid precipitation	Medium-Low	Medium	Better	Low
Arsenic	Medium-Low	High	Same	Low
Brown tide	Medium-Low	Low	Worse	High
Chromium	Medium-Low	Medium-High	Same	Low
Copper	Medium-Low	High	Worse	Low
Dioxins/Furans	Medium-Low	Medium	Better	Low
Dredging	Medium-Low	Medium	Same	Low
Greenhouse gases	Medium-Low	High	Worse	Low
Nickel	Medium-Low	High	Same	Low
Noise	Medium-Low	High	Worse	Low
Off-road vehicles	Medium-Low	Medium	Same	Low
Pesticides-present use	Medium-Low	High	Better	Low
Polycyclic aromatic hydrocarbons (PAHs)	Medium-Low	Medium-High	Same	Low
Tin	Medium-Low	Medium	Better	Low
Water overuse	Medium-Low	Medium	Worse	Low
West Nile virus	Medium-Low	Medium	Worse	Low
Zinc	Medium-Low	Medium	Same	Low
Asian longhorned beetle	Low	Medium	Better	Medium-Low
Blue-green algae	Low	Low	Same	Low
Channelization	Low	Medium-Low	Better	Low
Dermo parasite in oysters	Low	Low	Worse	Low
EHD virus in deer	Low	Low	Same	Low
Extremely low frequency/Electromagnetic fields	Low	Medium-High	Better	Low
Floatables	Low	Medium	Better	Low
Genetically modified organisms (GMOs)	Low	High	Worse	Low
Green/red tides	Low	Medium-Low	Same	Low
Light pollution	Low	High	Worse	Low
MSX parasite in oysters	Low	Medium-Low	Same	Medium
Ozone (ground level)	Low	Low	Better	Low
Pets as predators	Low	High	Same	Low
Pfiesteria	Low	Low	Same	Low
QPX parasite in shellfish	Low	High	Same	Medium-Low
Road Salt	Low	High	Better	Low
Thermal pollution	Low	Low	Same	Low
Volatile Organic Compounds (VOCs)	Low	Medium-Low	Same	Low
Zebra Mussels	Low	Medium	Worse	Medium

* Summary of separate analyses of impacts of ten plant species.

Socioeconomic Impacts

Overall Findings

Given the criteria defined for this analysis, land use change has by far the most extensive socioeconomic implications. As the wealth and workforce migrate out of city centers, remaining urban residents are subject to increasing poverty rates and neighborhood deterioration. Meanwhile, suburban dwellers experience disproportionate transportation and infrastructure costs as a result of their vehicle-centered communities. Statewide, urban property value losses total in the billions. Employment is also affected as suburban development takes jobs out of downtown areas where lower-income city residents cannot travel to them. Other impacts are more difficult to quantify, but land use change is also associated with negative aesthetic and psychological impacts, including a weakened sense of community and increased stress levels. Benefits of land use change, though not estimated in this project, are undoubtedly substantial, but associated negative impacts may not be inevitable.

The risks of lead are even better documented. Virtually all of the state is potentially at risk via lead levels in soils and in the paint used in older structures. Medical costs related to lead in New Jersey may reach $774 million annually, according to national estimates. Costs for the removal of lead paint in homes and other buildings add to the economic burden. There is also a significant psychological component to the risks from lead. The risks of lead poisoning are well publicized and families living in older homes may experience high levels of concern, particularly when they are financially or otherwise unable to remediate their homes.

Common to the stressors judged "medium-high risk" is the ability to assign a relatively high dollar figure to the damages associated with the stressor. Generally speaking, high medical costs attributable to the stressor are a primary risk factor, along with an associated psychological (worry) component. Examples include excess cancers due to environmental tobacco smoke and ultraviolet radiation. Medical and damage costs associated with indoor microbial concentrations—including costs to address "sick building syndrome"—are in the hundreds of millions. In a few cases, property damage drives risk rather than medical costs. Damages associated with white-tailed deer, for example, may be as much as $160 million annually, and include crop and garden damage, and vehicle collisions. A number of specific chemical stressors, such as arsenic and PCBs, can depress both property values and employment. The socioeconomic impacts of phosphorus center on the significant loss of aesthetics associated with the eutrophication of New Jersey lakes.

The threshold values established at the outset of the analysis played a key role in the ultimate determination of stressors that pose "high" socioeconomic risks. In order for a stressor to achieve a rating other than "low" it had to exceed the specific benchmarks established for impacts on property values, employment, or damage costs (see Analyses section). It is important to note that these benchmarks were set based on significance at a statewide level. In the case of damage costs, for example, a stressor would have to have documented or predictable impacts exceeding $16 million to rate above a "low." Consequently, stressors judged to be low risk may have significant localized impacts, or a statewide impact for which there is insufficient evidence for making a determination about dollar costs. Information to help flesh out these types of subtleties in the ranking can be found in the full analyses for each stressor.

Table 5. Statewide Socioeconomic Impact Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Land use change	High	High	Worse	Medium
Lead	High	High	Better	Low
Arsenic	Medium-High	Medium-High	Better	Low
Deer	Medium-High	Medium-High	Better	Low
Indoor asthma inducers	Medium-High	Medium-High	Same	Low
Particulate matter	Medium-High	Medium-High	Same	Low
Pesticides	Medium-High	Medium-High	Better	Medium
Petroleum spills	Medium-High	Medium-High	Better	Medium
Phosphorus	Medium-High	Medium-High	Same	Low
Polychlorinated biphenyls (PCBs)	Medium-High	Medium-High	Better	Low
Secondhand tobacco smoke	Medium-High	Medium-High	Better	Low
Ultraviolet radiation	Medium-High	Medium-High	Worse	Low
Dioxins/Furans	Medium	Medium	Better	Low
Endocrine disruptors	Medium	Medium-High	Worse	Medium
Inadvertent animal mortality	Medium	Medium	Same	Low
Indoor microbial air pollution	Medium	High	Same	Low
Invasive plants	Medium	Medium	Worse	Low
Noise	Medium	Medium	Worse	Low
Ozone (ground level)	Medium	Medium	Better	Low
Polycyclic aromatic hydrocarbons (PAHs)	Medium	Medium	Same	Low
Radon	Medium	Medium	Better	Low
Sulfur oxides (SOx)	Medium	Medium	Better	Low
Water overuse	Medium	Medium	Worse	Low
1,3-butadiene	Medium-Low	Medium-Low	Better	Low
Acid precipitation	Medium-Low	Medium	Better	Low
Acrolein	Medium-Low	Medium-Low	Same	Low
Catastrophic radioactive release	Medium-Low	Medium-Low	Same	Medium
Chromium	Medium-Low	Medium-Low	Better	Low
Dermo and MSX parasites in oysters	Medium-Low	Medium-Low	Better	Low
ELF/EMF	Medium-Low	Medium-Low	Same	Low
Floatables	Medium-Low	Medium-Low	Better	Low
Formaldehyde	Medium-Low	Medium-Low	Same	Low
Greenhouse gases	Medium-Low	Medium-Low	Worse	Low
Hemlock woolly adelgid	Medium-Low	Medium-Low	Worse	Low
Light pollution	Medium-Low	Medium-Low	Worse	Low
Mercury	Medium-Low	Medium-Low	Better	Low
Methyl tertiary butyl ether (MTBE)	Medium-Low	Medium-Low	Better	Low
Volatile organic compounds (VOCs)	Medium-Low	Medium-Low	Better	Low
Waterborne pathogens	Medium-Low	Medium-Low	Worse	Low

Continued on next page

Table 5. Statewide Socioeconomic Impact Rankings (continued)

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Asian longhorned beetle	Low	Low	Worse	Medium
Benzene	Low	Low	Better	Low
Brown tide	Low	Low	Worse	Low
Cadmium	Low	Medium-Low	Same	Low
Carbon monoxide (CO)	Low	Low	Better	Low
Copper	Low	Low	Worse	Low
Cryptosporidium	Low	Low	Same	Medium
Disinfection byproducts	Low	Low	Better	Low
Dredging	Low	Low	Same	Low
EHD virus in deer	Low	Low	Same	Low
Geese	Low	Low	Worse	Low
Genetically modified organisms (GMOs)	Low	Medium	Worse	Medium
Green/red tides	Low	Low	Same	Low
Hanta virus	Low	Low	Same	Low
Legionella	Low	Low	Same	Low
Nickel	Low	Low	Same	Low
Nitrogen Oxides (NOx)	Low	Low	Same	Low
Nitrogen pollution (water)	Low	Low	Same	Low
Off-road vehicles	Low	Low	Worse	Low
Overharvesting (marine)	Low	Low	Better	Low
Pets as predators	Low	Low	Worse	Low
Pfiesteria	Low	Low	Same	Low
QPX parasite in shellfish	Low	Low	Same	Low
Radium	Low	Medium	Same	Low
Road salt	Low	Low	Better	Low
Starlings	Low	Low	Worse	Low
Thermal pollution	Low	Low	Same	Low
Tin	Low	Low	Better	Low
West Nile virus	Low	Low	Better	Low
Zebra mussels	Low	Low	Worse	Low
Zinc	Low	Low	Same	Low

Understanding Risk Rankings

The Comparative Risk Approach

Historical Perspective

In 1987, the United States Environmental Protection Agency (EPA) released a report ranking the relative risks from 31 environmental problems. The report, titled *Unfinished Business,* attempted to systematically describe the risks associated with these issues so that senior leadership could better focus its efforts to protect human health and the environment. Since that initial project, dozens of states and localities have adapted EPA's approach in order to develop a better understanding of their own environmental problems.

The *Unfinished Business* project and others that followed were innovative in their comparison of threats across program areas. The premise was that a comparison of relative risk would allow federal and state environmental agencies to focus attention and resources where they were needed most. This does not necessarily mean that these projects were simple priority-setting exercises. Multiple factors determine budget and management priorities, and the magnitude of risk is just one of those factors. The 1987 effort, in its systematic evaluation of relative risk, helped fill an important void. Then-EPA administrator Lee Thomas and other policy makers were provided a more thorough understanding of relative risks to human health and ecosystems: where they occurred geographically, how many people were potentially affected, and if any special populations were particularly susceptible.

The comparative risk tool has continued to evolve. State, regional, and local organizations agreed that reporting on relative risks would provide a sounder basis for their environmental management decisions. As a result, 24 states and more than a dozen localities have completed comparative risk projects during the late 1980s and 1990s. Projects have varied in their structure, scope of analysis, and the manner in which results have been used. Project sponsors have ranged from regional and state agencies to local nonprofit groups. Some projects relied on rigorous technical data to arrive at their rankings; other rankings were more discussion-driven. While every project has been unique, all of them expanded the discussion of environmental risk.

New Jersey's Comparative Risk Project was inspired by these other projects. In several ways, the sophistication of the comparative risk tool has grown, and its role in policy making today is better understood than when the EPA *Unfinished Business* report appeared. By facilitating a systematic evaluation of risks across problem areas, comparative risk provides a useful first step toward improving the use of risk information in environmental decision making.

Comparative Risk Is...

...An analytic exercise for estimating the relative harm from different environmental problems

...A structure for evaluating issues in a manner that reflects public values

...A useful mechanism for bringing risk information into the overall priority setting process

Caveats About Rankings

Comparing Apples and Oranges

Comparative risk is a highly structured **analytic exercise for estimating the relative harm from different environmental problems**. Traditional risk assessment methods characterize the degree of risk associated with a given "pollutant" at a known concentration, usually expressed as a probability. Comparative risk methods use the information from such assessments, along with other available information, to arrive at a relative score for each pollutant, and enabling them to be compared or ranked.

Comparing the risks of secondhand tobacco smoke with those of mercury is very much like comparing apples to oranges. Shoppers do this every day when deciding what fruit would be best for their purposes, if with some uncertainty and different people reaching different conclusions. Comparative risk relies on the selection of scoring and ranking criteria for making these types of comparisons. Project analysts review available data in a structured format that elicits key pieces of information for scoring. Examples of commonly used criteria for evaluating human health impacts include:

- Number of people exposed
- Severity of health effects
- Frequency of exposure

The consistent use of these kinds of criteria enables analysts to organize the information they obtain in a way that facilitates comparisons across issues.

A number of key decisions strongly influence the outcome of the analysis. Project participants determine the scope of the analysis and how it will be conducted. After the assessment is complete, decisions must be made regarding the ranking results and how to use them.

Decisions prior to the assessment:

- Who participates?
- How much do we spend?
- Which issues do we evaluate?
- What criteria should we use to evaluate impacts?

Decisions after the assessment:

- What are the relative risks?
- How do we report our findings?
- What are our next steps?

Public Values Guide Scientific Judgment

Common to all comparative risk projects has been the commitment to **evaluate issues in a manner that reflects acknowledged public values**. Risks cannot always be compared in a purely objective fashion, and projects have consistently attempted to develop scoring criteria in accordance with the relative importance of different factors held by members of the public.

While scientific evidence may be able to demonstrate that Problem A causes developmental effects in children and problem B accelerates deaths due to respiratory illness, it does not provide an answer for which problem is "worse." Comparative risk provides the structure for organizing the science (number of children with delayed neurological development, number of increased deaths among respiratory patients). The application of scoring criteria clarifies the value judgments being made in determining relative risks (total number of people affected, special populations affected). Project decisions regarding where the lines are drawn between lower versus higher risk scores reflect project and public values and ultimately determine relative risk within the context of the project (which should be ranked higher, Problem A or Problem B?).

Reflecting the values of the public is not the same as reflecting the perceptions of the public. A motivation for many comparative risk projects is to overcome misconceptions about the relative magnitude of risks posed by different environmental problems. A history of media coverage and political statements can distort the image that some people have about the frequency or severity

Comparative Risk Is Not...

...A simple formula for shifting resources from lower to higher ranked problems

...Scientists' personal opinions about relative risk or policy direction

of environmental problems. Comparative risk projects often uncover and organize information about environmental conditions that builds a stronger factual foundation for public discourse.

Relative Risk and Priority Setting

Many sponsors and participants in early comparative risk projects expected the process to redirect resources to higher risk areas. Confusion has sometimes occurred regarding the relationship between ranked risks and environmental management priorities. Comparative risk exercises serve to enhance understanding of the relative risks resulting from different human activities. **Most comparative risk project participants reject the use of their projects as a formula for shifting resources from lower to higher ranked problems**. Even though this was sometimes a desired outcome of early projects, the direct influence a single project can have on a complex system of environmental management priorities is limited.

There is a certain logic behind allocating agency resources to address higher risks. But a few factors make such conclusions practical in only rare cases. These include the limits of agency responsibility, differing costs of risk reduction, and the appropriate role of public opinion in policy making.

1. Agency responsibility is limited.
Environmental management agencies do not have statutory authority to eliminate the risk from all environmental threats. Natural sources of contaminants and indoor pollutants are examples where the public may be subject to relatively high levels of risk, but exposure is not regulated (and regulation may require legislative mandates). But environmental management priorities are shaped over long periods of time and driven by many factors besides risk. Comparative risk does, however, provide **a useful mechanism for bringing risk information into the overall priority setting process**. Risk rankings have also had some influence over where new resources are targeted, and have in some cases contributed to changes within program areas—how monitoring resources are allocated, for example.

2. Cost effectiveness of risk reduction varies.
Some environmental threats will require more money to address than will others. The allocation of public resources for risk management includes the consideration of cost factors in addition to the magnitude of risk. These resources may be spent on risks that can be significantly reduced, even if of lower threat.

3. Public opinion influences policy choices.
Environmental problems are often elevated to the policy arena as a result of public concern. Without a mechanism for evaluating and reporting relative risk, issues that generate more media or political attention may receive higher priority for policy making.

Opinion Versus Analysis

Comparative risk is not scientists' personal opinions about relative risk. While it would be easier to simply poll a group of scientists and report their opinions regarding the relative risks of different environmental issues, the resulting rankings would lack the analytic transparency of a comparative risk framework. Regardless of the outcome, the organizing framework and criteria chosen to establish relative risk provide the rationale for the resulting ranking. Of course, it is impossible to eliminate all subjective factors, but the characteristic consistency in the way problems are evaluated in comparative risk helps control the introduction of opinion into the analysis.

Relative Risk Versus Policy Analysis

Comparative risk does not provide a mechanism for evaluating the effects of past policies and programs to reduce risk. While ranking results may stimulate discussion about the effectiveness of the current policy mix, these results reflect residual risk—the risk that remains despite over thirty years of environmental management programs. This need not suggest a misdirection of resources; not all programs are established in response to a perceived need for risk reduction. Most environmental programs have been established as a result of federal or state legislative action, generally without considerations of risk relative to other types of threats. In many cases these efforts have reduced risks, while in others significant challenges remain.

The identification of priorities is not a straightforward task. The results of a single comparative risk exercise do not lead to a simple proclamation of environmental management priorities. However, the consideration of the range of impacts associated with different threats can serve to focus attention on a more comprehensive set of environmental issues and provide a stronger foundation for collaborative solutions.

Understanding the New Jersey Rankings

Comparative risk is a tool for using the best available science to answer the question, "What is the relative importance of recognized environmental problems?" By applying a consistent set of criteria to different stressors, comparative risk analysis enables a ranking of relative risk that can help inform one dimension of environmental management discussions.

Each of the Technical Working Groups applied its own criteria for analysis. Impacts were scaled according to the selected criteria, resulting in a structured evaluation of the relative magnitude of risks. The outcome of each TWG ranking was a direct reflection of the criteria and scales used in the analysis. Stressors that ranked highly were those that warranted higher scores based on these particular scales. Had different criteria been chosen by the Steering Committee, which oversaw the TWGs' work or different scales used, the ranking results may have looked different from those which appeared here. The comparative risk rankings were limited by other factors as well; a few of the major influences are described below.

Project boundaries

A thorough treatment of the universe of possible environmental risks in New Jersey would be a monumental task. In order to define a more manageable project, the Steering Committee agreed on some boundaries for the analysis. The resulting rankings reflect these boundaries, and it is important to keep in mind that some risks might not have been identified or might not have been considered appropriate to address in the context of this project.

Several stressors were excluded from analysis by any TWG, including such examples as:

- Occupational health stressors: Unless these were also important in environmental health, these chemicals were excluded as not affecting the general environment.
- Medical X-rays: Although these are regulated by DEP, they do not have an effect on the general environment (see Appendix 6 for an analysis completed before this decision).
- Natural hazards (flooding, drought, etc.): These were deemed too unpredictable in severity and frequency to estimate adequately, and their health and ecological effects were covered to some degree by analyses of more specific stressors (e.g., microbial pathogens, greenhouse gases).
- Non-point source pollution, and Erosion: These two stressors were addressed as appropriate for particular stressors (e.g., nitrogen, phosphorus, pesticides), but not as separate categories.
- Invasive plants: Ten of the "worst" species in New Jersey as suggested by a group of

ecologists were the focus of analysis; resources did not allow separate analyses for the hundreds of species that fall into this category (this grouping did not differ from the plants' individual rankings).

• Gypsy moths: They occur in New Jersey, but were not a current threat when stressors were selected. As this report was being completed, an upswing in gypsy moth populations suggested they would pose a low but chronic cyclical problem.

• Tourism/recreation: Although these activities can have ecological impacts (e.g., personal watercraft on eelgrass; hiking on trails and associated areas), data were not available to estimate the degree of impact for any except off-road vehicles (ORVs).

• Tentatively identified compounds (TICs): By definition, too little is known about the identity, occurrence, or impact of these water-borne substances to evaluate their risks.

• Brownfields: The effects of these contaminated locations within urban areas were incorporated into discussions of land use change and specific contaminants, as appropriate. "Brownfields" are not themselves stressors as defined in this project (but see Appendix 6 for an analysis of their socioeconomic impacts, written before this decision).

The time frame selected for the analyses represents another boundary. The Steering Committee, agreed to include impacts that could occur within the next five years. This avoided uncertainty in longer-range forecasts, and the clearly defined time period provided consistency in the analyses. However, the resulting rankings may not reflect longer-term risks, such as those involving climate change due to greenhouse gases.

The human factor

Individuals may weigh complex factors of risk in different ways. The reporting templates used by the TWGs were designed to minimize these differences, but individual analysts were responsible for evaluating available data and applying the criteria. Different analysts may have had different interpretations of the data or drawn different conclusions regarding risk. Peer review within the TWGs and the Steering Committee, plus some external reviews, served to make the rankings more objective and consistent. In addition, extensive review by TWG chairs resulted in the rewriting of some assessments by their authors in order to maintain a common approach among the assessments. Despite the possibility that data may be viewed differently from person to person, the conclusions reached about relative risk provide a useful first step in considering future policy choices.

Snapshots in time

Comparative risk rankings represent a snapshot in time. The rankings reflect the state of scientific knowledge, exposure levels, risk management efforts, and professional judgment that exists today (most analyses for this project were written in late 2000 and the first half of 2001). Issues that ranked lower or higher within the bounds of this project might rank differently tomorrow, as new information becomes available or the nature of the threat changes. And new stressors can appear, as in the 2002 invasion of New Jersey by southern pine beetles, which damage pine forests. Because the ability to report on relative risk will always be imperfect, a definitive ranking is not possible. Nevertheless, the analysis conducted by the Technical Working Groups describes some clear differences in relative risk, and policy decisions need to be made. Information about relative risk, however imperfect and subject to change over time, offers an important consideration for these decisions.

Resource limitations and data gaps

Comparative risk analysis relies on the judgment of working group members given available data, resources, and time for completing assessments. For stressors for which there is sufficient scientific knowledge about the threat, along with documentation of exposure in New Jersey, analysts may have a high degree of confidence in assigning a score. Unfortunately, for many stressors there are gaps in knowledge regarding the nature of the threat (What are the effects of the stressor?) and/or exposure (To what extent are New Jersey populations or ecosystems exposed?). In these cases, working group members must apply "best professional judgment" and peer review in the determination of scores.

Stressors that received high scores characteristically reflected sound evidence of both the hazard and extent of exposure in New Jersey. While the confidence in each individual risk assessment may vary from stressor to stressor, issues assigned a high risk are typically well studied in terms of their adverse effects and there is sufficient evidence of the stressor in New Jersey populations or ecosystems. Assignment of a low risk, on the other hand, may reflect a number of different scenarios. The box below summarizes four possibilities to bear in mind when reviewing ranking results. The stressor summaries beginning on page 102 provide the TWGs' rationales for ranking.

Low Risk May Reflect...

... lack of statewide impacts.
Low ranking stressors may not pose a significant threat on a statewide basis, but may be causing substantial impacts in limited geographic, demographic or ecological areas of the state. Stressors may have localized effects that are quite severe, yet do not generate high scores relative to more widespread issues.

... good management.
Some stressors have low impacts today because of control strategies designed to control them. Risks could increase without such strategies.

... today's risk...but not tomorrow's.
Some stressors pose little or no threat today, yet high risks are possible in the future, particularly for biological stressors not yet established in New Jersey.

... a lack of data.
For issues not well studied, or for which little monitoring has been done in New Jersey, risk is typically ranked low. More data might show that the actual risk is higher.

ANALYSES

Analyses

Project Design

This report includes a great deal of information about risks to the New Jersey environment. The manner in which this information was gathered and reported provides a better understanding of the project, its intent, its limits, and its potential applications. This section describes how the project was structured and includes background on many of the decisions that influenced the outcome of this report.

Project design

The basic steps in designing the comparative risk project included:

- √ Determining project scope and general decision structure
- √ Selecting and recruiting participants
- √ Structuring the Technical Working Groups
- √ Providing an analytic framework for the TWGs
- √ Designing mechanisms for public input
- √ Developing a problem (or issue) list
- √ Designing a risk ranking process
- √ Determining conclusions from the technical analysis

The responsibility for these decisions was in the hands of three groups, an informal DEP project coordination team, a Steering Committee of representatives from diverse sectors of New Jersey, and Technical Working Groups with expertise in different aspects of environmental risks. As noted in the introduction to this report, this project began as the result of a charge from the Commissioner of DEP.

Project scope and organization structure

A DEP **project coordination team**, under the guidance of the Director of the Division of Science, Research, and Technology, designed an initial project structure after reviewing the progress of other comparative risk projects in the country. An important element in this initial project design was its recognition of the necessarily limited role of DEP staff in accomplishing project objectives. External participation and decision making were recognized as being critical for ensuring that the project reflected the range of values of New Jersey citizens and ensuring credibility for the final product. In addition, external participation would greatly enhance opportunities for broad dissemination of project analyses and conclusions.

After establishing a preliminary scope for the project, DEP expanded its project coordination team to include Dr. Clinton Andrews from Rutgers University. Dr. Andrews brought additional experience with the comparative risk method to the project. An ongoing role of the project coordination team was to oversee staffing and to facilitate the operations of the Steering Committee.

The **Steering Committee (SC)** made the key decisions affecting the scope of the NJCRP. The SC was a diverse group of prominent citizens drawn from the spectrum of stakeholders interested in New Jersey's environment (Appendix 1). While a process for assessing risks could have been designed by a small number of environmental scientists, successful projects have benefited from a wider range of participants. This has helped to ensure that the project product reflected the values and needs of a cross section of citizens. The Steering Committee helped ensure that technical assessments resulted in environmental information useful for public deliberation.

A key responsibility of the Steering Committee was to take a leadership role in overseeing the process and products of the **Technical Working Groups (TWGs)**, including the incorporation of information from public outreach efforts into the TWGs' selection of issues and risk characterization parameters.

The Steering Committee made several decisions to set boundaries to the scope of the project. These include:

- Analyses of impacts only five years into the future (excluding longer-term impacts, such as those due to climate change from greenhouse gases) to minimize uncertainties of long-term extrapolation.
- A limit on the number of separate stressors (that is, biological, chemical or physical entities or substances that have negative environmental impacts; examples include parasites, lead, and radiation), resulting in some related stressors being considered in a single analysis.
- Basing analysis on residual risk, consisting of the impacts not addressed by current environmental management efforts.
- The analyses would not consider occupational exposure.
- The analyses would consider impacts in New Jersey, excluding impacts outside of New Jersey even if New Jersey sources may be the cause.
- The analyses would be divided into human health, ecological, and socioeconomic impacts.
- The impact criteria to be used in analysis.

The SC also directed the project coordination team to solicit direct public input by means of focus groups, questionnaires, public displays, and a newsletter. Public input helped to generate the list of environmental stressors evaluated by the project, and to guide the process of comparing disparate human health, ecological, and socioeconomic impacts due to these stressors.

The SC and TWGs interacted frequently, iteratively developing the scope, methods and expected work products of the TWGs. This was particularly true of the templates (see Appendix 2) defining the way impacts would be analyzed.

The project coordination team had the initial responsibility for guiding the SC in structuring the project. This included establishing a relevant scope for the project that would ensure that results could be used for DEP's coordinated planning functions.

Selecting and recruiting participants

Initial appointments to New Jersey's Steering Committee were made by then-DEP Commissioner Shinn. But because of the importance of the role of the Steering Committee, its membership was a continual focus. The credibility of the project required the Steering Committee to be perceived as a well-rounded group, not overly weighted with any single perspective. In order to ensure that this balance was achieved, the Steering Committee itself reviewed its membership and sought additional members when gaps in representation were noted. Some environmental groups were active throughout the process, but others withdrew after initial planning, for reasons of higher priorities for their time and/or disliking the idea of "yet another study" (see Appendix 1).

Technical working groups

Human Health, Ecological Quality, and Socioeconomic Technical Working Groups had the primary responsibility for developing impact assessments for dozens of environmental issues. The project coordination team selected chairs for the TWGs, and these chairs worked with the Steering Committee to identify individuals with expertise to contribute to the stressor analyses (Appendix 1).

The Steering Committee's charge to the TWGs was to assign a score to each stressor according to a set of criteria enabling a ranking of issues based on relative risks to human health, ecological quality, or socioeconomic well-being. The workplans for the Technical Working Groups were coordinated by the project team, which expanded to include each TWG's chair.

Public input mechanisms

There are two key reasons for ensuring that public input is incorporated into a comparative risk project. The first is to ensure that the project develops and reports information about the environment in a manner that reflects public values. The second reason is to build a broader audience for the communication of the results. Individuals who participate in the public input processes are more likely to pay attention to the completed report and future discussions that result.

Rutgers University students sought to determine the relative weight New Jersey citizens put on different kinds of environmental impacts. The results of this study showed that there was greater value placed on human health impacts than on impacts to ecosystems or socioeconomic factors, but the importance of ecological health and socioeconomic factors was still significant.

In a separate effort, project coordination staff held seven informal discussions with different groups to gauge their reactions to the scope of the project and the definition of issues and impact criteria. The focus groups included religious leaders, watershed associations, environmental commission members, and environmental justice and housing advocates. These meetings confirmed the Steering Committee's view that the range of environmental issues and impact types considered in this project should be broad.

As a result of these public involvement exercises, the overall structure of the project was kept broad in its scope and the reporting of relative risks was confirmed as important for future policy discussions.

Development of the issue list

An early challenge was to structure the analysis in a way that was both comprehensive and comprehensible, yielding analytic results of value to those deliberating environmental policy choices. Because of the need to answer the primary question in an analytically sound manner, the list of issues to be evaluated was a critical decision.

The choice of an appropriate structure for the problem list was informed by examples taken from many comparative risk projects that preceded New Jersey's. In most cases, projects developed a list of environmental problems based on existing regulatory programs or public concerns. Such an approach results in a list that is not only long (public input in Ohio led to a starting list of more than 700 issues), but complicated by overlapping topics. A list may include issues such as:

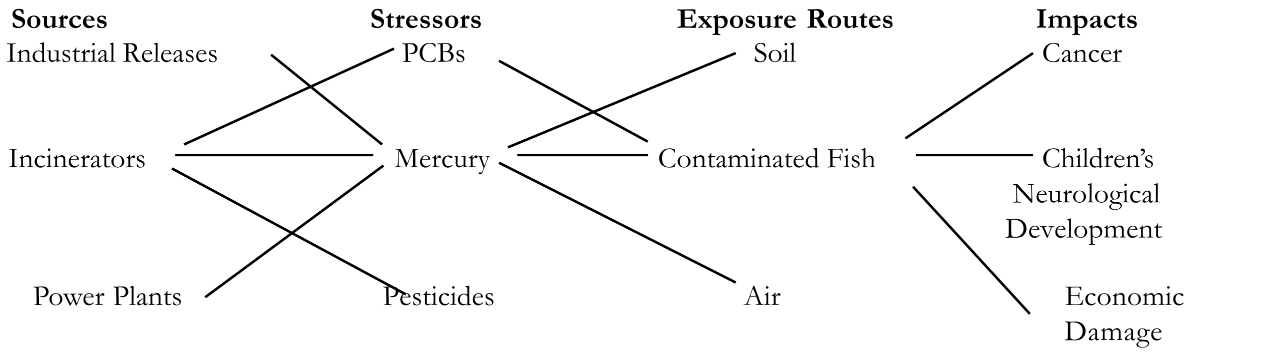
- Contaminated fish
- Solid waste incinerators
- Mercury
- Neurological impairment in children

All of these issues are important, but a systematic comparison of risks is difficult. Mercury is a pollutant that accumulates in contaminated fish, and solid waste incinerators are only one kind of source for mercury entering the environment. The impacts of mercury contamination may include neurological development effects in children. The web of cause and effect is complicated, and it is reasonable to ask whether this complexity can be overcome in a comparative analysis.

The example illustrates a connection between different kinds of environmental issues (Figure 1). In general, **sources** (solid waste incinerators) release **stressors** (mercury) that enter the environment and result in **exposures** (eating contaminated fish) that result in **impacts** (neurological impairment in children). Each of these kinds of issues requires a different analytic approach and reporting mechanism. An analysis of "contaminated fish" yields many types of stressors that create negative human health, ecological, and socioeconomic impacts. "Mercury" will be one of those stressors; PCBs and persistent pesticides are quite different in their paths of exposure and impacts. Similarly, an analysis of "developmental effects in children" will identify mercury as one of the stressors, with some exposures resulting from fish ingestion, some from other sources of mercury. The challenge for the comparative risk project was to provide information on all relevant issues without reporting a confusing mix of results from different analytical approaches.

The Steering Committee's solution was to strive for consistency by focusing the analysis on **stressors** (e.g. PCBs, pesticides, and mercury) while ensuring that a discussion of sources and exposures was included in each analysis and that impacts were reported in a consistent fashion to allow comparability. The

Figure 1. Relationships of Sources, Stressors, Exposure Routes and Impacts



Committee worked backward from "what matters most" in environmental quality (e.g., clean water) to be sure that important impacts and stressors were included.

The Steering Committee identified eleven broad categories of stressors. The TWGs detailed the stressors to include in these categories, amended in the light of reactions by the Steering Committee and attendees of the public focus groups. True comprehensiveness was an unattainable goal, but the final stressors list captured most of New Jersey's important environmental issues.

The complete list of stressors evaluated in this project is included on pages 100 and 101.

Issue analysis and criteria selection

After selecting the issue list, deciding the criteria against which to evaluate the issues was the next critical step. For the Human Health and Ecological Technical Working Groups, the result was a similar reporting template (Figure 2 and Appendix 2) which generally emphasized the following factors:

Figure 2. Content of Health Analysis Template
(see Appendix 2 for details on all three templates)

Hazard Identification

Stressor
Description of stressor (including etiology)
Stressor-specific impacts considered (including key impacts)

Exposure Assessment

Exposure routes and pathways considered
Population(s)/ecosystem(s) exposed statewide
Quantification of exposure levels statewide
Specific population(s) at increased risk
Quantification of exposure levels to population(s) at increased risk

Dose/Impact-Response Assessment

Quantitative dose/impact-assessment employed for each population considered

Risk Characterization

Risk estimate(s) by population at risk
Assessment of severity, persistence, irreversibility, frequency of effect(s)
Size of population(s) affected
Assessment of uncertainties in this assessment, data gaps
Potential for additional data to result in a significant future change in this risk estimate
Potential for future changes in the underlying risk from this stressor
Potential impact from catastrophic (low probability) events, likelihood
Extent to which risks are currently reduced through in-place regulations and controls

Relative Contributions of Sources to Risk

Impact Scores

The magnitude of impact, often expressed as the frequency or probability that a stressor causes an impact of concern

The geographic extent of exposure

The severity of impacts

Any special populations at risk

The irreversibility of the problems caused by the stressor

Risk is calculated by considering both exposure and dose-response relationships. Exposure is the amount of a stressor that might be breathed or eaten or otherwise encountered by the general public, or by particular sub-populations that may be at greater risk, or by plants and animals. Dose-response relations map the different levels of impacts at different levels of exposure.

For each stressor, the TWGs detailed different levels of severity, effects, and irreversibility of effects to better describe the particular human health or ecological impacts of concern.

The Socioeconomic TWG used a somewhat different approach. The first decision for the group, in consultation with the Steering Committee, was the determination of what specifically to include in an analysis of socioeconomic risk. Numerous comparative risk projects around the country have developed socioeconomic analyses of environmental issues (sometimes called "Quality of Life"). The TWG and Steering Committee reviewed these and selected the following five categories:

Property values
Employment
Costs (medical, physical damage, etc.)
Aesthetic damage
Psychological damage

Compared to human health and ecological impacts, there are fewer research results available on the socioeconomic impacts of environmental stressors. Therefore, the TWG used many sources of information regarding these types of impacts and attributed them to individual stressors with varying degrees of uncertainty (e.g., using property values impacts of brownfields to estimate such impacts for stressors often found at contaminated sites).

Deliberations of the Steering Committee resulted in the incorporation of additional factors in the assessments. They directed the TWGs to include the likelihood of catastrophic events, because their impacts can be important to consider even if the likelihood is very low. The Steering Committee also directed the TWGs to describe any trends in their analyses to capture any significant differences between current and future risks. Finally, the TWGs documented the degree of confidence in each risk assessment. Characterizing uncertainty was an important step in assigning different levels of risks, as well as providing directions for research (see pages 59-60 on uncertainty).

Each human health, ecological, and socioeconomic analysis also includes:

A description of the stressor

A list of the sources of the stressor

A brief summary of the current strategies to control the risk

The potential for additional data (if it were to be collected) to alter the risk estimate

A list of specific subpopulations, species, or ecosystems at greater risk

Ranking of the impacts posed by the stressor.

This report provides summaries of the information that led to the rankings. More detailed information is available in Appendices 3-5.

Human Health Impacts

How were human health risks evaluated?

The general approach for ranking human health risks considers three factors:

Severity of the risk
Size of the population affected

Any special populations at risk.

How were the scores used in the ranking determined?

The scores that were used to produce the human health risk ranking were derived from the relative severity of each health effect, the relative size of the population at significant risk, and whether there were discrete communities at elevated risk. Ranks were initially assigned by the authors using a common template, and then reviewed by the TWG Chair for completeness, accuracy, consistency, and reasonableness. The ranking was then reviewed independently by two reviewers. If the two reviewers agreed with the overall ranking assigned by the author to within one grade (i.e., H, M-H, M, M-L, L), the author's ranking was retained. In the few cases where the reviewers and authors failed to agree to within one grade, the TWG Chair mediated a discussion between the author and reviewers to facilitate a compromise. The full set of rankings was then reviewed by the full TWG for consistency and reasonableness. As with other TWG products, the final ranking of issues is subject to data gaps, uncertainty and the possibility of alternative application of subjective factors.

Severity

The severity of a stressor addresses both the type of adverse effect (e.g., cancer, skin irritation, developmental effects), and the magnitude of the risk for each effect at the exposure levels currently encountered in New Jersey. For example, while cancer is generally a severe endpoint, the risk of a cancer occurring to someone in New Jersey as a result of that person's exposure to a stressor may be low because exposure levels are low. For many of the stressors, cancer is an endpoint of concern, and in many cases, cancer leads to premature death. As a result of this factor, there is significant focus on cancer endpoints in the analysis. However, other stressors which act during fetal development can result in permanent effects on function and performance (including intelligence). No systematic distinction between the severity of different health effects was attempted in the human health assessments.

In addition to the severity of the outcome, the potency of the stressor was also considered. Thus, a carcinogen with relatively low potency (i.e., a large dose is needed to yield a given impact) might not, other factors being equal, be considered to be as severe as a carcinogen or a developmental toxicant that needs a smaller dose to produce the same effect (high potency).

Size of population

The size of the population exposed is a critical factor in the assessment of the overall population-based risk. If few people are exposed to a potent toxicant, few adverse effects will occur in the population as a whole. The magnitude of the exposure was a primary determinant of risk. All other factors being equal, the larger the exposure, the greater the risk. The frequency and duration of exposures is also a critical factor. For most stressors, brief and/or intermittent exposures even to a large population will carry less risk than more prolonged or frequent exposure (not necessarily true for pathogens). Some are more localized in their route of exposure (such as asbestos, radon), leading to a lower number of individuals affected. Stressors that are airborne (ozone) or present in drinking water (disinfection by-products) and foods (mercury, PCBs) may affect a large portion of the state's population.

Specific populations

The stressor analyses include information about specific populations at risk. Some populations are exposed to greater levels of a stressor and some populations are more susceptible to disease from exposure. An example of the former is dioxin exposure in populations whose diets contain unusually high proportions of fish or shellfish caught in contaminated waters. An example of the latter is lead exposure. Children, due to their rapidly developing neurological systems, are more susceptible to the effects of lead contamination than adults.

Ecological Quality Impacts

How were ecological risks evaluated?

The general approach developed by the Ecological Quality Technical Working Group was to consider three factors: the *severity/ irreversibility* of the effects(how bad are they when they happen?), the *frequency* of effects(how often do they happen?), and the *magnitude* or geographic extent of the effects (how much of New Jersey do they affect?).

How were the scores used in the ranking determined?

The scores that were used to produce the ecological risk ranking were derived from the relative severity, frequency, and magnitude of the stressors' effects as judged by members of the Ecological Quality Technical Working Group. Analysts used a common template (see Appendix 2) for evaluating data relevant to each stressor, and used the information to generate scores.

To account for these variations across ecosystem types, the ecological TWG identified five major ecosystem types for evaluation:

- Inland waters
- Marine waters
- Wetlands (freshwater and tidal)
- Forests
- Grasslands

For example, adverse effects from a stressor may occur predominately in marine waters, or it may not occur in marine waters at all. The TWG scored each ecosystem type 1 to 5 on each of the three criteria, multiplying the factors to achieve a single score (range 1 to 128) for each ecosystem type (see Figure 3). The TWG could not justify providing more weight to any single ecosystem type, therefore the resulting five scores were averaged to arrive at a single stressor score for the state. These scores were then used as the basis for the ecological risk ranking.

A result of this scoring scheme is that there are notable differences among issues that share similar rankings. Some issues ranked highly because of more moderate impacts across all ecosystems, or because of large impacts on a few ecosystems.

Severity/Irreversibility

The relative severity of a given ecological impact lies somewhere along a continuum of effects ranging from no detectable effect to a permanent, fundamental alteration or loss of an ecosystem. Severity may be expressed in terms of the seriousness of health/population effects in affected species: decreased reproductive success is a less severe effect than acute toxicity or death. It may also be expressed as a function of reversibility. The physical removal of habitat is judged to be more severe than a biological or chemical impact to habitat, from which the ecosystem may recover.

For many chemical stressors, the severity and irreversibility factors were considered using standard risk assessment methods. The assumption is that as exposure increases to a particular chemical, animal and plant species will experience increasingly severe health/ population effects. For many chemicals,

Figure 3. Ecosystem Assessment Scoring System

	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Severity					
Frequency					
Magnitude					
Total Score (SxFxM)					

Average Total Score: _____

ANALYSES - Process

reference exposures have been developed and accepted by ecotoxicologists as the thresholds for adverse effects in wildlife. The actual concentrations observed in New Jersey can be compared with these threshold values to produce a Hazard Quotient. The greater the chemical concentration, the greater the exposure, and consequently the hazard quotient value. The resulting hazard quotients help determine the severity factor for these chemical stressors.

For biological and physical stressors, analysts typically considered the numbers of species affected by the stressor, the ways they are affected, and the resulting impact on the structure and functioning of the ecosystem. Thus, a stressor that affects a "keystone" species or species at the base of the food chain may precipitate ecosystem-wide changes, and will be judged higher on the severity factor than a stressor that affects a species with fewer ecosystem ramifications. Again, the potential for reversibility of the impacts will also determine the degree of severity for physical and biological stressors.

Frequency

Frequency refers to the rate at which adverse effects are occurring or are predicted to occur. At the low end of the scale, there may be little or no chance that the stressor will ever create impacts in New Jersey. The stressor may cause problems on a rare or occasional basis, or, at the high end of the scale, is often and increasingly present in New Jersey.

Magnitude

In evaluating ecological risks, magnitude refers to the extent of the stressor's impact (percent of the state affected) across species, habitats or populations. This factor was used to allow comparison of the scale of impacts on a statewide basis. For some stressors, magnitude was also described in terms of the proportion of target species affected—percent of hemlock trees, number of species of birds.

Socioeconomic Impacts

Overall Process

Procedures for estimating the socioeconomic impacts of environmental stressors are in their infancy, and relevant data are even scarcer and more uncertain than equivalent data for human health or ecological impacts. As a result, most comparative risk projects have limited themselves to qualitative description of potential "quality of life" impacts. The members of the Socioeconomic Technical Working Group (SETWG)—representatives of several state government agencies, academia, EPA-Region II, and Resources for the Future, a nonprofit "think tank"—felt that, despite the difficulties, they would be abrogating their responsibilities if they limited themselves to description. They decided to set up, by consensus, criteria for (1) kinds of impacts that would be covered, (2) thresholds—such as minimum dollar amounts for economic impacts—for awarding Severity scores of High, Medium or Low, and (3) equivalent scores for assessing Duration and Scale (see below for definitions). The hope was that this approach would help analysts by allowing them, in the absence of stressor-specific information, to judge whether it was plausible for that stressor to exceed a given threshold in impacts. TWG members also thought it would help audiences by making the analytic process more transparent, and assuring that any error in such judgments was likely to occur in the same way for other stressors, thus making judgments of relative impacts more likely to be accurate. Once the SETWG agreed on these criteria, graduate students overseen by the TWG co-chairs (plus a few TWG members) applied these criteria to particular stressors. Completed analyses were reviewed by TWG co-chairs and by external reviewers from academia and EPA.

In general, SETWG did an analysis of socio-economic impacts for all stressors addressed by either the Human Health or Ecological

Quality TWGs, although in some cases (e.g., invasive plants) it combined stressors analyzed individually by another TWG.

Criteria

After considerable discussion, the SETWG settled upon five classes of socioeconomic impact that seemed to be important to people, while allowing reasonable justification (via evidence or logical argument) for judgments of impact. Many other kinds of impact were discussed, but they were deemed either less important or (usually) without any plausible or systematic basis other than personal opinion to support impact decisions.

Property Values. These values can decline in the presence, or suspected presence, of an environmental hazard. Concerns about property value impacts have been raised by citizens for local hazardous waste sites, proposed new nuclear power or waste disposal facilities in the area, or publicity about one's home being tested for indoor radon levels. The limited literature on this topic has concentrated on the effect of waste sites or industrial facilities of various kinds, and almost none of it has concerned the impact of stressors as defined in this study. This posed problems for analysis—for example, for many chemical stressors impacts on property values were extrapolated from waste-site values, which often contain such chemicals—but this class of impact was deemed important enough to risk such uncertainty in judgment.

Employment. This was another economic impact that seemed important to people and worth including. Although stressor-specific data were scarce here as well, potentially affected economic sectors were often obvious enough (such as fisheries or tourism) to make plausible judgments of the relative size of the impact. Multiplier effects (that is, one lost job in fisheries, for example, might result in additional lost jobs indirectly, through the fisherman's reduced expenditures on groceries, movies, etc.) were not estimated, since data on the magnitude of such effects for environmental stressors were unavailable.

Costs. Environmental problems cause out-of-pocket expenses, including health-related costs (such as hospital and other medical costs, lost wages), property-related costs (such as damage to automobiles, equipment, buildings, and infrastructure), production-related costs (such as damage to crops or fisheries, lost production of goods and services), and residual damages not otherwise accounted for. Because the focus of the NJCRP was on direct impacts of environmental stressors, not on management options, the costs of cleaning up the environment (for example) were not included in these estimates. The socioeconomic literature, combined with estimates from the other TWGs of the magnitude of human health or ecological impacts, allowed some plausible judgments of the magnitude of costs incurred.

Aesthetics. Environmental stressors, directly or indirectly, can offend human eyes, ears, or nose with obscured or unsightly views, awful noises, and bad smells. Evidence that people's environmental concerns are often driven by the experience of smarting eyes or noxious odors, as much or more in many cases than by abstract concern over health impacts, suggested that this was an important category of impacts to include. Clearly judgments of the magnitude of such aesthetic insults can vary, but equally clearly the literature and the other TWGs' evidence (such as that a given chemical stressor cannot be seen, tasted or smelled) allow some plausible judgments about relative impact.

Psychological Well-Being. Considerable debate occurred over this class of impact. Some TWG members argued initially that in analyses that were supposed to provide scientific judgment of the relative impact of stressors, it was imprudent to include an impact that seemed to reflect largely public, non-scientific beliefs. However, consensus was eventually reached that "worry" was a real social impact, whether it was transitory anxiety or full post-traumatic stress disorder, and deserved inclusion. Worry was defined as an emotional response to the combination of a perceived threat and perceived inability to control that threat, the one measure of psychological well-being on which there was some scientific literature. Furthermore, property value impacts were largely due to the perceptions of home buyers, realtors, and insurers about potential or actual environmental impacts: why should those perceptions be treated as any more "real" than worry simply because they were being estimated in dollars? As with property value impacts, considerable extrapolation from the limited data available was necessary, so results should be treated with caution. However, the systematic approach taken by the SETWG allows readers to judge for themselves the accuracy of these judgments. The inclusion of both property value and psychological impacts allowed "triangulation," with convergent results from different methods increasing confidence that the "true" relative value of socioeconomic impacts had been identified.

Criteria Definitions and Thresholds

Severity Criteria. Criteria were set to allow analysts to consistently determine the Severity of each class of impact for a given stressor, from 3 (High) to 1 (Low). For the first two economic-impact classes, the declines in property values and employment associated with the last severe recession in New Jersey (1988-1992) were used as the benchmark for High impacts, on the grounds that this would be a plausible analogy for most readers.

Property values in New Jersey dropped 4.2% from 1990 to 1992, the low point of the 1988-1992 recession. Thus 4.2% of all property values in New Jersey (over $442 billion) in 1998, or $21.8 billion, was set as the threshold for High impacts. A tenth of that (0.42%), or $2.18 billion, was the threshold for Medium impacts; anything less than that was presumed to be Low impact.

The 1988-1992 recession reduced employment by 5% in New Jersey. This value, or 200,000 jobs in 1997 (based on NJ Department of Labor data), was the criterion for High job impacts. A tenth of that (0.5%), or 20,000 jobs, was deemed a Medium impact, with anything less being deemed a Low impact.

A "high" (3) cost impact was defined as annual costs greater than $160 million statewide, roughly equivalent to a cost of $20 per person per year in New Jersey. The breakpoint for a "moderate" impact rating is defined as any stressor creating costs between $16 million and $160 million. Stressors creating costs of less than $16 million were assigned "low" scores.

Aesthetic severity was a combined judgment of levels of annoyance and presumed ability to avoid or adapt to the aesthetic insult. High Severity was deemed to occur when the impact was strongly annoying and avoidance or adaptation would be relatively costly or inconvenient, such as living under the flight path of an airport. Medium Severity involved moderate annoyance with moderate inconvenience or cost to avoid or adapt, or strongly annoying offenses that can be avoided or adapted to with little inconvenience or cost. Low ratings were assigned when little or no offense to the senses was likely, or moderate annoyance could be easily avoided or tolerated, such as purchasing a water filter to improve the taste of tap water.

Analysts were asked to take the role of an "average" resident of New Jersey in estimating the severity of worry about actual or potential impacts of a stressor on that person's immediate family and community. High Severity was judged to occur when the stressor is familiar or easily sensed, and arouses great worry. Medium scores were assigned when a familiar stressor seemed likely to arouse only moderate worry, or was unfamiliar but its impacts (if known) might arouse great worry. Low Severity scores were awarded to stressors that seemed to be familiar and unworrying, or unfamiliar but seemed unlikely to arouse much worry if their impacts became known.

Duration and Scale Criteria. Duration refers to the length of time that impacts are likely to persist: some are of short duration or reversible (e.g., unemployment in most cases), others can last for much longer and even be permanent. For example, a Duration score of 3 was assigned to unemployment that would seem to last more than the five-year time horizon of the NJCRP; a score of 2 if the job loss might last 1-5 years; and a 1 if it seemed to last less than a year. Scale encompasses the proportion of the state's area or the state's population affected. A Scale score of 3 was applied to statewide impacts, of 2 if impacts affected numerous neighborhoods, more than one county, or a subpopulation of more than 1000 people, and of 1 if impacts were highly localized, affecting only a few neighborhoods, a single county, or a small subpopulation.

How were the scores used in the ranking determined?

Each stressor was evaluated on five impact categories (property values, employment, costs, aesthetics, psychological well-being), and for each impact type a 3, 2 or 1 score was assigned separately for the Severity, Duration and Impact of that impact. For each impact type, its severity, duration and impact scores were multiplied to get a sub-score for that impact type (e.g., Unemployment=6 if Severity=3, Duration=2, and Scale=1). Then the sub-scores were averaged across the five impact types to get the overall score (Figure 4). Peer reviews were conducted by the TWG chair and outside reviewers.

In addition to this overall score, analysts also estimated the average uncertainty in that score, on the grounds that it would be useful for readers to know the degree of confidence analysts had in the score (Figure 5). This was based on the following criteria:

- High Uncertainty (3) was defined as cases for which the impact estimate was qualitative and poorly documented, no scientific consensus exists for estimating impacts, and/or no data specific to New Jersey were available. Scores were, on balance, quite arbitrary, and could be off by more than one (High vs. Low). It was no more probable that the reported score was correct than that a lower or higher score was correct, so the probability that the reported score is correct was about 33%.
- Medium Uncertainty (2) scores were assigned when some documentation existed, a literature relying on this estimating approach existed, and/or some New Jersey-specific data were used. If scores were wrong, they were, on balance, only off by one (such as High vs. Medium). There was at least a 50% probability (even odds or better) that the reported score was correct.
- Low Uncertainty (1) meant that the impact estimate was quantitative and well documented, scientific consensus existed on the estimation method, and/or New Jersey-specific data were used. It was highly probable (67% or better, for example one standard deviation) that the reported score was correct.

Figure 4. Socioeconomic Assessment Scoring System

Socioeconomic Impact Evaluation of Environmental Issue:
Scoring system: High (3), Medium (2), Low (1), and Insignificant (0.1).
Subtotal Risk = multiplicative product of the three factors; Total Risk is the sum of subtotal risks.

Socioeconomic Impact Factors Affecting Risk Estimation	Property Values	Employment	Costs Incurred	Aesthetic Levels	Psychological Impacts
Severity					
Duration/ Irreversibility					
Scale (spatial, population)					
Subtotal Risk					

Average Risk (0 – 5 years)	Average Risk (5 years plus)

Figure 5. Socioeconomic Uncertainty Scoring System

Socioeconomic	Property Values	Employment	Costs Incurred	Aesthetic Levels	Psychological Impacts	Average Uncertainty
Uncertainty Level						

Examples of Analytic Results

The assessment of relative impacts of environmental stressors on human health, ecological quality, and socioeconomic conditions has been the focus of the analysis so far. In addition to the stressor-specific impact summaries and analyses, these rankings may be the main interest for most readers of this report.

However, the full analyses contain much more information than these overall rankings. Just as the Steering Committee decided to forego a single ranking integrating health, ecological and socioeconomic impacts, on the grounds that such a ranking would obscure important information, the same could be said of the three overall rankings-each provides only one of several perspectives on environmental impacts. The purpose of this section is to provide alternative perspectives based on the full set of information, which may prove equally valuable to audiences for this report. Details on each of these dimensions of environmental impact can be found in the full analysis for each stressor (Appendices 3-5).

Some of this information involves further details, and implied rankings, based upon information that appears in the earlier ranking tables. **Uncertainty** can be a critical factor in how one evaluates overall rankings: for example, one might be more confident that major action is warranted on a high-ranking stressor with low uncertainty than on a high-ranking stressor with high uncertainty. Uncertainty also can be important in setting priorities for environmental monitoring, data analysis, and research, since these activities can help increase confidence in impact estimates or stressor reduction strategies. This section thus includes a ranking of stressors by level of uncertainty, plus a set of monitoring, analysis, and research priorities proposed by the Technical Working Group (TWG) chairs.

Analysts were asked to project the **Trend** of impacts (getting better or worse, or staying the same) in the immediate future, on the grounds that knowing which stressors were likely to worsen their impacts might be as valuable in priority-setting as knowing their current impacts. They were asked to judge how trends in the recent past might be affected by likely near-term policy or other changes (excluding the effect of hypothetical changes of which there was no plausible evidence). The short-term trend analysis was intended to minimize the errors that accumulate at an ever-increasing rate as predictions are made further into the future. This short-term focus may have understated the trend for a few stressors (such as greenhouse gases), but otherwise allows comparability. Stressors are grouped by whether the judged trend is better, the same, or worse.

Catastrophic potential is the likelihood of a major disaster occurring as the result of a single incident or closely-grouped (in time) set of incidents. Substantial impacts can occur, but these may be very unlikely (low probability of occurrence). Although relatively few stressors were judged to have more than "low" catastrophic potential, this was assessed by analysts and ranked in this section in case it would be useful to readers.

This section also offers information on **"populations at risk."** The overall rankings are based upon estimates of statewide impact, but in many cases there are human sub-populations, ecosystems, non-human species, or geographic locations within New Jersey that are at particular risk. This can be important for priority-setting: for example, it might be deemed important to deal with stressors that put fetuses and children at particular risk even if those stressors are ranked low in overall impact. Information on these at-risk sub-populations, ecosystems, species and locations is provided for each TWG, as appropriate.

The Socioeconomic TWG analyzed impacts for **five different conditions** before producing an overall impact score. Since some people might find some of these conditions more important than others, this section provides rankings for each of the five dimensions separately.

TWGs also were asked to identify major **sources of stressors**, such as large business or agriculture, as a potential first step in identifying risk-reduction strategies. These sources are identified for the Health and Ecological TWGs.

Finally, earlier sections of this report summarized findings on the basis of category of impact: human health, ecological quality, and socioeconomic conditions. Some people might be more comfortable with discussions of impact according to the **type of stressor**, of which many such categorizations are possible. Here impacts are summarized according to whether stressors are biological (such as a plant or animal or microorganism), chemical (the kind of environmental stressor with which most people might be most familiar), or physical (such as light, noise, or radiation).

Uncertainty

In any scientific endeavor, some uncertainty is inevitable. Uncertainty arises from incomplete or conflicting information, such as whether a stressor causes cancer in humans, how large an area is affected by a stressor, or whether a given concentration of a stressor in streams harms aquatic species. There may be good understanding about environmental impacts in general, but not about a stressor's occurrence, exposures to it, or vulnerable populations in New Jersey. In such cases, data from other sources may be extrapolated to New Jersey, which might over- or underestimate the impacts in this state.

Uncertainty itself may in some cases become a stressor, when it heightens worry about a particular stressor, potentially affecting such outcomes as property values. Once the nature and extent of a hazard are well-established, people and institutions usually find ways to cope with it; if its existence or magnitude are uncertain, this interferes with everything from investment decisions to choices of where to live.

TWG analysts were asked to report their level of confidence in the impact estimates they produced, on a scale from "high" to "low" uncertainty. The examples in the following table show the varied confidence in rankings even for high-ranking stressors. For example, health impacts from lead and radon, and ecological impacts from land use change, are viewed as quite certain by analysts, but health impacts of indoor microbes and ecological impacts of historical use of pesticides are quite uncertain. Sometimes different TWGs analyzing the same stressor came to identical conclusions about the uncertainty, but in other cases—due to differences in the impacts considered or available evidence—they did not.

Information about uncertainty in rankings, both that given in the following table and the more detailed information in the full analyses (Appendices 3-5), can help decision-makers determine what kinds of additional information might be most useful in setting priorities for reduction of environmental impacts. (Recommendations by TWG chairs on research, data assessment, and monitoring priorities appear after the Uncertainty table.)

One caution should be noted. When there is relatively high uncertainty, this can pose difficulty for ranking stressors. Should one provide a "high" rank, so as to err on the side of caution? A "low" rank, given the absence of firm evidence of any harm? A "medium" rank, to hedge one's bets? Or refuse to rank the stressor at all because of the high uncertainty? Comparative risk projects have taken at least one of these options, and often all of them across various stressors; none is more or less valid. In the New Jersey project, TWGs did not establish standard approaches to this problem (except for avoiding non-ranking), so judgments for particular stressors may not be entirely consistent. However, given that the aim was relative rather than absolute rankings, and that the number of high-ranked stressors with high uncertainty is relatively small, this is unlikely to skew the results greatly.

Table 6. Rankings of Stressors by Level of Uncertainty

Overall Ranking

UNCERTAINTY	RANKINGS: High/Medium-High	RANKINGS: Medium
High	Indoor asthma inducers (H) Land use change (S) Lead (S) Pesticides-historical use (E) Pesticides-indoor (H)	Chromium (H) Endocrine disruptors (H) Indoor microbial air pollution (S) Legionella (H) Mercury (H) Pesticides-food, outdoor, water (H) Phthalates (E)
Medium-High	Arsenic (S) Deer (S) Indoor asthma inducers (S) Particulate matter (S) PCBs (S) Pesticides (S) Petroleum spills (S) Phosphorus (S) Radium (H) Secondhand tobacco smoke (S) Ultraviolet radiation (S)	1, 3-butadiene (H) Acrolein (H) Endocrine disruptors (S)
Medium	Carbon monoxide-indoor (H) Dioxins/furans (H) Habitat loss (E) Mercury (E) Ozone (ground level) (H) Particulate matter (H) Polychlorinated biphenyls (PCBs) (H, S) Secondhand tobacco smoke (H) Ultraviolet radiation (E) Volatile organic compounds-carcinogenic (H)	Arsenic (H) Benzene (H) Cadmium (E) Dioxins/furans (S) Disinfection byproducts (H) Endocrine disruptors (E) Formaldehyde (H) Geese (E) Inadvertent animal mortality (E, S) Invasive plants (E, S) Lead (E) Nitrogen pollution (E) Noise (S) Overharvesting (marine) (E) Ozone (ground level) (S) PAHs (S) Petroleum spills (E) Polychlorinated biphenyls (PCBs) (E) Radon (S) Starlings (E) Sulfur oxides (S) Water overuse (S)
Medium-Low		Deer (E) Nitrogen oxides (H)
Low	Habitat fragmentation (E) Increase in impervious surface (E) Lead (H) Radon (H) Hemlock woolly adelgid (E)	Catastrophic radioactive release (E) Phosphorus (E) Ultraviolet radiation (H)

Stressors with Low Overall Ranking and High/Medium-High Uncertainty:

Health:
- Cryptosporidium-drinking water
- ELF/EMF
- Greenhouse gases
- Indoor microbial air pollution
- MTBE
- Noise
- PAHs
- Waterborne pathogens-drinking water (M-H)
- West Nile virus (M-H)

Ecological:
- ELF/EMF (M-H)
- Genetically modified organisms
- Light pollution
- Off road vehicles
- Pets as predators
- QPX parasite in shellfish
- Road salt

H=Health TWG, E=Ecological TWG, S=Socioeconomic TWG

Monitoring, Data Analysis and Research Needs

The uncertainties and data gaps discussed briefly here, and in more detail in the individual stressor analyses (see Appendices), offer opportunities for environmental monitoring, analysis of existing data, and/or research to reduce uncertainties about impact rankings or to help identify strategies for impact reduction. The following are suggestions for monitoring, analysis, and research for stressors whose relatively high overall rank and/or uncertainty imply these priorities will be particularly helpful, offered by the chairs of the Human Health and Ecological Quality Technical Working Groups. Generic suggestions for improving Socioeconomic Conditions impact estimates follow.

HUMAN HEALTH

Stressor (Overall Rank, Uncertainty)	Needs
Dioxins/Furans (H, M)	**Monitoring** The extent of exposure to dioxins in the New Jersey population is not known. While there is a significant background level of exposure in the U.S. in general from the diet, environmental contamination data suggest that some populations may have exposures which are significantly elevated above background. These include consumers of contaminated crabs in the New York/New Jersey Harbor Estuary. **Research** Very limited data exist on the health effects of dioxin, particularly its developmental effects (of increasing concern), and the human-specific dose-response relationships for those effects.
PCBs (H, M)	**Research** Different mixtures of PCBs are present in the environment, and in human tissues. The relative risk of different types of health effect (e.g., cancer, developmental deficits) for the different individual PCBs and their numerous mixtures is not clearly understood.
Ozone, ground level (H, M)	**Research** Some data reveal the relationship between ozone levels and severe cases (hospital and emergency room emissions) of asthma in New Jersey, but the extent to which milder cases of asthma are related to ozone levels in New Jersey is not known. Further research is needed to assess the health impact of current ozone levels in New Jersey.
Indoor asthma inducers (M-H, H)	**Research** Although some of the triggers of asthma in the indoor environment are known, the overall etiology of asthma and the environmental contribution are not yet well understood. The combination of environmental triggers is complex and their interaction is not understood. In addition, the interaction between indoor and outdoor triggers (e.g., ozone) is not understood. Epidemiologic studies are needed to elucidate these contributions and interactions, and their possible relationship to the causation of asthma.

ANALYSES - Results

HUMAN HEALTH

Stressor (Overall Rank, Uncertainty)	**Needs**
Radium (M-H, M-H)	**Monitoring** Because water softeners remove radium to some extent from tap water (whether used for that purpose or for general removal of minerals in hard water), the extent of increased radium exposure at the tap in New Jersey is not known. In addition, radium exposure through ingestion of New Jersey dairy and agricultural products is not known.
Volatile organic chemicals (VOCs) – carcinogenic (M-H, M)	**Research** The prime uncertainty is carcinogenic potential for humans at environmental levels of exposure (currently extrapolated from animal models), which may be reduced by basic research into the toxicology of these compounds.
Chromium (M, H)	**Monitoring** Few measurements of chromium concentrations in air are available. Model-based predictions are highly uncertain as to the fraction of total chromium contributed by the carcinogenic hexavalent form. The prevalence of chromium allergic sensitivity in the population is not well characterized, and there are few if any data on the incidence of chromium allergic dermatitis from non-occupational exposures. **Research** Current data do not suggest hexavalent chromium is carcinogenic by ingestion, but few studies directly address the potential health impact of this route of exposure.
Endocrine disruptors (M, H)	**Monitoring** There are no data on human exposure to potential endocrine-disrupting chemicals in the New Jersey environment. For many endocrine disruptors, exposure is likely to have both dietary and environmental components which may be difficult to separate. Exposure surveys and ultimately monitoring of the New Jersey population are needed to address these considerations. **Research** Endocrine-disrupting potential is known for few environmental contaminants; only a small fraction of chemicals of potential concern have been screened or tested, and reliable short-term screens for endocrine disrupting activity are still under development. The relationship between animal models or in vitro testing and demonstrable effects in humans is not clear.
Legionella (M, H)	**Monitoring** Because legionella is not accurately diagnosed or reported in most cases, the estimates of its incidence and its mortality in New Jersey are highly uncertain. The number of deaths per year in New Jersey estimated to result from legionella infection varies six-fold as a result.

HUMAN HEALTH

Stressor (Overall Rank, Uncertainty)	Needs
Mercury (M, H)	**Monitoring** Data on exposure to elemental mercury are lacking entirely for its use in cultural/folk practices or due to spills and breakage in homes. Few or no data are available on the extent of exposure to methylmercury in New Jersey among high-end fish consumers. **Research** Few studies of good quality are available on the risk of relatively subtle and/or idiopathic health effects from low-level elemental mercury exposure from dental amalgams. Few data are available to characterize potentially subtle health effects from exposure to methylmercury among adults and older children.
Pesticides-indoor (M, H)	**Monitoring** There are few or no data on indoor pesticide use or exposure in New Jersey. Systematic monitoring could document the extent of exposure and risk to various populations in New Jersey. **Research** The sensitive populations for various pesticides are not clearly defined. In addition, the effects of low or moderate exposure to pesticides on sensitive populations are not well characterized.
Pesticides-outdoor (M, H)	**Monitoring** There are few or no data on outdoor pesticide use or exposure in New Jersey. Systematic monitoring could document the extent of exposure and risk to various populations in New Jersey. **Research** The sensitive populations for various pesticides are not clearly defined. In addition, the effects of low or moderate exposure to pesticides on sensitive populations are not well characterized.
Pesticides-water (M, H)	**Monitoring** Few data exist on pesticide levels in private wells. **Research** Although levels in public-supply drinking water are uniformly low, little research has been done on possible interactions of low levels of multiple pesticides (also a concern for private wells).
Acrolein (M, M-H)	**Monitoring** Few data are available on indoor levels of acrolein. **Research** EPA's Reference Concentration for acrolein, the basis for estimates of potential impacts at concentrations measured or modeled in New Jersey, stems from animal data with a relatively large uncertainty factor adjustment (1000).
1,3-butadiene (M, M-H)	**Monitoring** Measurement data (as opposed to model predictions) of New Jersey concentrations exist only for the Camden area. Risk estimates for other areas, and for the state as a whole, are based solely on modeled data. Increased air monitoring is needed to validate the model-based predictions. **Research** Generic uncertainty exists on extrapolation of human cancer risks from animal toxicity data, and human epidemiologic data on cancer risk are somewhat contradictory.

HUMAN HEALTH

Stressor (Overall Rank, Uncertainty)	Needs
Arsenic (M, M)	**Research** Fundamental uncertainties exist about the basic toxicology of arsenic, including the shape of the cancer dose-response curve at low doses. Current measures of arsenic exposure are potentially confounded by the much less toxic (organic) forms of arsenic ingested with seafood.
Benzene (M, M)	**Monitoring** There are few data on benzene levels in private wells in New Jersey. Data on exposure to benzene in air are limited to model predictions. **Research** Although the cancer potency data for benzene are based on human occupational studies, significant uncertainty exists in the interpretation of those data for derivation of cancer potency estimates.
Disinfection byproducts (M, M)	**Monitoring** There is no systematic monitoring of drinking water in New Jersey for disinfection byproducts other than trihalomethanes. **Research** The various possible disinfection byproducts can occur with various frequencies, in various combinations, and at various concentrations. This makes interpretation and application of epidemiologic data uncertain.

ECOLOGICAL QUALITY

Stressor (Overall Rank, Uncertainty)	Needs
Habitat loss (H, M)	**Monitoring** There is a great need for ongoing quantitative analysis of loss of different kinds of habitat at the state level to determine if rates of land use change are increasing, decreasing or stable. **Research** There needs to be more research that focuses directly on the effects of habitat loss on New Jersey plants and animals.
Pesticides-historical use(M-H, H)	**Monitoring** More monitoring needs to be done to see how many of the bodies of water in New Jersey have chlorinated pesticides found in the sediment, water column, and aquatic life. Also more monitoring needs to be done to see how many more contaminants are entering New Jersey's surface and ground water due to erosion and runoff of soil from the urbanization of farmland. Migrating birds such as ducks and geese should be monitored for DDT and other pesticides by analyzing the wings of hunter-killed waterfowl. **Research** More research is needed to see if levels of DDT, chlordane, and other chlorinated pesticides and their metabolites found in New Jersey's environment are acting as endocrine disrupters on at-risk species in New Jersey. Other potential effects of chlorinated pesticides that should be investigated include immune suppression and abnormal nesting behavior (adversely affecting chick survival) in New Jersey gulls and terns.

ECOLOGICAL QUALITY

Stressor (Overall Rank, Uncertainty)	Needs
Metals (mercury, cadmium, lead) (M-H or M, M)	**Monitoring** There are limited data for most metals including those ranked M or M-H for all media (e.g., soil, sediment, and surface water), and limited temporal/spatial data. No or limited (e.g., mercury) monitoring of biota. **Research** Effects of metals-contaminated sediment on benthic organisms. **Data Analysis** Increased use of electronic data/data storage will allow more in-depth analysis of spatial/temporal patterns of metals in media (e.g., soils, sediments) and allow comparison with ecological benchmarks.
Endocrine Disruptors (M, M)	**Monitoring** Additional chemical concentration data are required to better characterize both the severity and extent of endocrine disruptors. Systematic periodic monitoring data are necessary to properly assess whether endocrine disruptor contamination or exposure is improving or degrading. **Research** Data on effects are needed. There are a large number of untested compounds.
Natural Resource Use and Impacts (Overharvesting (marine) , Water Overuse, Inadvertent Animal Mortality) (M, M)	**Monitoring** The magnitude of overharvesting of horseshoe crabs in New Jersey needs to be determined. There is a lack of comprehensive data on inadvertent animal mortality. **Research** Water overuse: need to develop ecological flow goals and methods; a USGS-DEP research project is underway to examine the flow characteristics and basis for developing ecological flow goals and methodologies for New Jersey streams. Data from this project may help define the current risk and impacts of water overuse in the state.
Nitrogen Pollution (M, M)	**Research** Fuller understanding of the nitrogen cycle could shift the concern from local water quality to regional water quality, terrestrial ecosystems, and the global climate.
PCBs (M, M)	**Research** Research that isolates PCB-specific impacts from impacts due to general chemical pollution is needed. **Data Analysis** Increased use of electronic data will allow more in-depth analysis of spatial/temporal patterns of PCBs and other organic compounds in media (e.g., soils, sediments) and allow comparison with ecological benchmarks.
Petroleum Spills (M, M)	**Research** Effects of repeated small oil spills on ecosystems.
Plants, Invasive (M, M)	**Monitoring** Statewide populations/occurrences, and rates of spread; long-term monitoring of control efforts are needed. **Research** Quantification of impacts is needed (e.g., biodiversity impacts). Comprehensive research plan is recommended.
Plants, Native (*Phragmites*) (M, M)	**Research** Better quantification of rate of spread; more experimental evidence of effects on nutrient cycling and fish habitat, and to disentangle the effects of the invasion from the effects of salt hay farming, tide restriction, ditching, and other often associated disturbances. More information on the effects of the invasion in non-tidal systems.

ANALYSES - Results

Stressor (Overall Rank, Uncertainty)	**Needs**
Native Animals (deer and geese) (M,M or M-L)	**Research** Deer – determine harvest levels that avoid potential long-term ecological impacts to plant communities; document secondary impacts of herbivory on plants/animals. Geese – impacts to ecosystems including nutrient input to waterways, interspecific competition, and impacts to biodiversity.

SOCIO-ECONOMIC CONDITIONS

	Needs
All Stressors	Overall, suggested priorities for reducing uncertainties involve (1) Costs, (2) Job Losses, (3) Property Values, (4) Aesthetics, and (5) Worry (or psychological impacts), in that order. The order of priorities is a combined estimate of relative importance of these factors, the likelihood of progress on valid measurement and statewide monitoring of these impact categories, and the probability that reduction of these uncertainties would make a substantial difference to environmental management. An important initial task is to determine whether stressor-based estimates of socioeconomic impacts are the most useful for environmental management priority-setting. In some cases (e.g., hazardous waste sites), individual stressors are so mixed at particular sites or in their impacts (e.g., on worry) that it might be more worthwhile to conduct estimates on a site-based or other aggregate level. This decision will affect priorities for reducing socioeconomic uncertainties; the following list assumes a stressor-based definition.
General Cost Estimates	General methods for estimating costs, job losses, and property values are reasonably well developed, particularly for health impacts, even if still far behind methods for human health risk assessment. State government could ensure that expertise on these evolving methods is available in state, either at universities or on staff (e.g., of DEP). Improved estimates of health and ecological impacts (see Human Health and Ecological Quality suggestions above) will produce improvements in the socioeconomic estimates of those impacts' costs, job losses and property values as well.
Direct Costs	Costs due directly to stressor exposures (i.e., without prior health or ecological impacts), such as paint damage due to air pollution, are more problematic to estimate, although in most cases of lower magnitude than indirect costs via health and ecological impacts. Better methods to measure, or at least impute, the portion of all such costs attributable to environmental conditions (much less specific stressors) would be a great help. There is currently no systematic approach to monitoring such costs, either in New Jersey or elsewhere.

SOCIO-ECONOMIC CONDITIONS

Stressor (Overall Rank, Uncertainty)	**Needs**
Job Loss, Monitoring, & NJ specific data	Job losses due to environmental regulation have been a long-time focus of environmental economics, given the "jobs versus environment" debate. Insuring that this emphasis within the state is expanded beyond regulatory effects to the effects of changes in environmental conditions at the margin overall would be helpful, as would institution of a monitoring system.
Property Value Impacts	Property value impacts are unlikely to occur as widely across stressors as do costs or job losses, so they have a lower priority. Distinguishing environmental contributions to property value gains and losses is still in its infancy, and there is no systematic effort to track these contributions. Measures that can distinguish the impacts of aesthetics and worry on property values from the impacts of more direct environmental contributions would be particularly useful.
Aesthetic Impacts	Aesthetic impacts apply to even fewer stressors, and are likely to evoke considerable variability in response (particularly for visual insults). However, people who believe they suffer from such impacts are likely to rate them as very undesirable. Emerging technologies and research methods offer the potential of standardizing estimates of such impacts, but considerable support will be needed to develop and systematically apply such methods, so that these impacts get the attention they deserve.
Worry/ Psychological Impacts	Methods for measuring psychological impacts (i.e., "worry" as defined for this project) are better developed than methods for dealing with aesthetic impacts. There is as yet little standardization in these measures, nor in which kinds of impacts are worth attention (e.g., the kind that can be assessed relatively quickly, but are perhaps transient, versus more serious but rarer impacts that need in-depth assessment). No system currently exists for assessing psychological impacts regularly and systematically across the state and across different stressors. The existing literature suggests that a variety of factors (e.g., sense of personal control over the threat; degree of trust in environmental managers; [sometimes] knowledge about the risk or control methods) affect worry judgments. It is not yet known to what degree attempts to improve (for example) people's generic sense of personal control over threats, versus dealing with their sense of control over a particular environmental threat, would reduce such impacts.

SOCIO-ECONOMIC CONDITIONS

Stressor (Overall Rank, Uncertainty)	**Needs**
Other Socioeconomic Impacts	There are numerous socioeconomic impacts that occur but are not easily measured, including loss of social capital, diminished quality of life, and decreased peace of mind. This project did not attempt to develop any measures of these impacts due to limited resources and lack of scientific consensus on best approaches. Further research on measurement strategies would be immensely valuable.
Stressor-specific Research Needs (examples; see Appendix 5 for more)	**Brownfields** The following data would be helpful to provide a rigorous measurement of reductions in property value due to brownfields: 1. The amount of acreage in New Jersey considered "brownfields." 2. Number of residential and commercial properties within one-quarter mile of a brownfield and the current assessed value of this land. 3. More precise accounting of property value losses due to nearby contamination. 4. More knowledge about the health effects of brownfields. **Lead** It would be useful to conduct econometric research on property values that includes the presence of environmental lead as an independent variable in a hedonic regression. **Land Use Change** Data needed to better quantify the following socioeconomic impacts of land use change: · Aesthetic impacts · Psychological impacts · Consumers' preference for suburbs **Radon/Radium** Data Needs: 1. Non-fatal cancers attributed to radon and treatment costs. 2. Fatal and non-fatal cancers attributed to radium and treatment costs. 3. Numbers of houses (radon) and industrial sites (radium) at risk in New Jersey. 4. Number of houses/buildings that have been mitigated or remediated. 5. Sales prices of homes with high levels; number mitigated. 6. Surveys of individual level of worry related to radon and radium. 7. Work time lost due to illness caused by radon and radium.

ANALYSES - Results

Trend

Which problems are getting worse?

Which problems are getting better?

"Trend" in these assessments refers to the overall direction of change in the impact of the stressor during the next five years. As such it reflects an informed prediction which is subject to uncertainties in future policies and actions. Many stressors were judged to have no significant trends at all; in those cases, there is no evidence demonstrating that the stressor or its effects are increasing or decreasing. These stressors have relatively low impacts, and tend to vary somewhat from year to year and place to place. Microbiological stressors for the most part fall into this category. Even while exposure and infection rates are difficult to quantify, it is unlikely that the presence of these organisms in the environment is either increasing or decreasing over time.

About 40% of the problems evaluated show unquestionable improvements. Notably, improvements can be seen in the groups of chemical stressors, which account for about two thirds of the positive trends. As these are the targets of most environmental regulations, perhaps it's not surprising that the presence of chemicals has been declining in recent years. More stringent emissions requirements, chemical bans, and ongoing waste site cleanups have all contributed to lower levels of chemical contamination in New Jersey. Most of the air pollutants associated with automobile and power plant emissions are decreasing. These include carbon monoxide, butadiene, benzene, MTBE, and sulfur dioxide. Secondary problems such as ozone formation and acid precipitation are also showing improvement. Significant progress has also been made in reducing the impacts of secondhand tobacco smoke, in part due to smoking restrictions but also because fewer people are choosing to smoke. The incidence of floatables (beach and shoreline litter) has declined dramatically since New Jersey initiated its Operation Clean Shores program.

On the other hand, many stressors are likely to have impacts that remain unchanged or clearly get worse. Unlike chemical pollutants, many biological and physical stressors are unregulated and largely uncontrolled. These stressors include land use change, along with associated increases in habitat loss, habitat fragmentation, impervious surfaces, and water use. Other stressors are often compounded by these changes. Opportunistic pests such as geese and starlings, as well as a long list of invasive plants, tend to flourish in disturbed habitats, outcompeting other native species for food and nesting sites. Controlling these biological stressors presents its own unique set of challenges, while controlling the impacts of human development requires a prudent balancing of costs, benefits, and diverse human values. Traditional regulatory responses are not well suited to these kinds of consideration.

For some issues, determination of a single trend is difficult. In the case of lead, there are clear improvements in terms of human health risk, due to extensive education, screening, and remediation efforts. However, since lead continues to be released to the environment, ecosystems and wildlife are potentially at increased risk.

Whether or not these identified trends persist depends on a number of factors. Any improvements in air pollution achieved via better emissions controls will be offset by future increases in fuel consumption and energy use. Policy decisions, particularly at the local level, will largely determine the rate and extent of land use change and thus its potential for environmental degradation. Identifying and filling in data gaps may help target priority problems, potentially resulting in dramatic improvements. The NJCRP Steering Committee recommends increased monitoring with respect to issues with potentially worsening trends, to help focus resources where they will provide the greatest benefit (see Recommendations, beginning on page 89). The suggested monitoring, data analysis, and research priorities (page 61), as well as the full analyses from which these suggestions were drawn, offer an agenda for reducing data gaps before the next NJCRP is undertaken.

The summary on the following page is taken from the section on "potential for future changes in the underlying risk from this stressor" from the analytic template (Appendix 2), collapsing the 7-point scale used there into better, same, and worse trend judgements.

Table 7. Trend

TREND	HEALTH	ECOLOGICAL	SOCIOECONOMIC
Better	1,3-butadiene Arsenic Benzene Carbon monoxide (CO)-outdoor and indoor Chromium Cryptosporidium - drinking water Dioxins/furans Disinfection byproducts ELF/EMF Lead Lyme Disease Mercury MTBE Nitrates/Nitrogen in Water Noise Ozone (ground level) PCBs Pesticides - food Pesticides - outdoor Pesticides - water Radon Secondhand tobacco smoke Sulfur oxides VOCs-carcinogenic VOCs-noncarcinogenic West Nile virus	Asian longhorned beetle Arsenic Channelization Dioxins/furans ELF/EMF Floatables Hemlock woolly adelgid Inadvertent animal mortality Overharvesting (marine) Ozone (ground level) PCBs Pesticides-historical use Pesticides-present Petroleum spills Road salt Tin	1,3-butadiene Acid precipitation Arsenic Benzene Carbon monoxide (CO) Chromium Deer Dermo and MSX parasites in oysters Dioxins/furans Disinfection byproducts Floatables Lead Mercury MTBE Overharvesting (marine) Ozone (ground level) PCBs Pesticides Petroleum spills Radon Road salt Secondhand tobacco smoke Sulfur oxides Tin VOCs West Nile virus
Same	Acrolein Airborne Pathogens Cadmium Cryptosporidium -recreational water Formaldehyde Greenhouse gases Hanta virus Indoor microbial air pollution Legionella Nickel Nitrogen oxides PAHs Particulate matter Pesticides - indoor Pfiesteria Radionuclides Radium Waterborne pathogens (recreational water and drinking water)	Acid precipitation Blue-green algae Chromium Deer Dredging EHD virus in deer Green/red tides Habitat fragmentation Habitat loss Increased impervious surface Mercury MSX parasites in oysters Nickel Nitrogen pollution Off road vehicles PAHs Pets as predators Pfiesteria Phosphorus Phthalates QPX parasite in shellfish Starlings Thermal pollution VOCs Zinc	Acrolein Cadmium Catastrophic radioactive release Cryptosporidium Dredging EHD virus in deer ELF/EMF Formaldehyde Green/red tides Hanta virus Inadvertent animal mortality Indoor asthma inducers Indoor microbial air pollution Legionella Malaria and encephalitis Nickel Nitrogen pollution PAHs Particulate matter Pfiesteria Phosphorus QPX parasite in shellfish Radium Thermal pollution
Worse	Endocrine Disruptors Indoor Asthma Inducers Ultraviolet Radiation	Brown tide Cadmium Catastrophic radioactive release Copper Dermo parasite in oysters Endocrine disruptors Geese Genetically modified organisms (GMOs) Greenhouse gases Invasive plants Lead Light pollution Noise Ultraviolet radiation Water overuse West Nile virus Zebra mussels	Asian longhorned beetle Brown tide Copper Endocrine disruptors Geese GMOs Greenhouse gases Hemlock woolly adelgid Invasive plants Land use change Light pollution Off road vehicles Pets as predators Noise Starlings Ultraviolet radiation Waterborne pathogens Water overuse Zebra mussels

Catastrophic Potential

For most stressors, the impacts which are occurring, or may occur in the future, are relatively constant. However, for a minority of stressors, there exists a low probability for acute, widespread impacts far beyond the day to day, or average, level of risk. In contrast with stressors for which there is a continuous, more or less estimable level of exposure, these stressors also have a characteristic potential for large-scale, severe impacts to human or ecological health that cannot be predicted using standard risk assessment models. Catastrophic potential was not taken into account in the rankings; this information is provided for those readers who might wish to do so in setting their own priorities.

Catastrophic impacts are typically associated with accidents. Catastrophic radiation releases from nuclear power plants, and petroleum spills are obvious examples of potentially catastrophic stressors (note that the Human Health TWG decided that routine releases of radionuclides from nuclear reactors were a more pertinent stressor than catastrophic releases). Pesticides and endocrine disruptors were also judged to have potentially catastrophic impacts as a result of individual or institutional misuse or carelessness.

There are a number of biological stressors that were judged to have potentially catastrophic impacts to ecosystems. The MSX parasite, which infests and kills oysters, has caused massive die-offs in the past, and continues to present a threat. Brown tide, a recurrent seasonal algae bloom, has been occurring more frequently and lasting longer in recent years. The extent of the damage that may be caused by more severe bloom events is unknown.

Human activity may also bring about potentially catastrophic effects. Large-scale land use changes may increase the potential for damaging floods. Commercial harvesting of the horseshoe crab for bait has depleted that population to the extent that migratory bird populations are negatively affected by the reduction in crab eggs as a food source.

For a very few stressors, there is so much uncertainty that catastrophic effects are included within a wide range of potential impacts. Much of the concern associated with genetically modified organisms (GMOs) centers on the highly uncertain, but possibly severe, ecological consequences.

Table 8. Catastrophic Potential

	Health	Ecological	Socioeconomic
H	Greenhouse gases Pesticides-indoor	Brown tide Hemlock woolly adelgid Inadvertent animal mortality Petroleum spills	
MH	Pesticides-outdoor	Impervious surface	
M	Endocrine disruptors	Overharvesting (marine) MSX parasites in oysters Zebra mussels	Asian longhorned beetle Catastrophic radioactive release Cryptosporidium Endocrine disruptors Genetically modified organisms(GMOs) Land use change Petroleum spills Pesticides
ML	Particulate matter	Asian longhorned beetle QPX in shellfish	

Note: Stressors with Low catastrophic potential are not listed.

Populations At Risk

Technical Working Groups described for each stressor any populations or entities at "increased risk." The risks from a given stressor may be greater for certain individuals, species, or places for a number of reasons. They may be more likely to become exposed than the general population. They may be exposed to greater concentrations of the stressor, or are exposed more frequently. Or they may be more susceptible to the stressor's effects than other people or ecosystems.

Equity demands that differences in impacts are minimized to the extent feasible, and consistent with the goal of reducing impacts overall. "Increased" risk is relative only to the estimated statewide risk for that particular stressor, and does not imply anything about the seriousness of the risk. So while certain individuals or places may be deemed at "increased risk," the absolute risk level from that particular stressor can still be quite low. Thus, any population-specific risk should be carefully considered within the overall risk picture, to avoid undue focus on a subset of potentially less significant risks.

Human Health

Because they are still developing, children and the unborn are at increased risk from the health effects of a number of stressors, particularly chemicals. Their immature immune systems also place them at increased risk from disease-causing organisms. The elderly, and people with existing health problems, are also more susceptible to the effects of environmental stressors. Asthmatics, for example, are at increased risk from several stressors that aggravate this condition and trigger additional episodes. Note that these groups are no more likely to become exposed than the general population, but they are more likely to experience health effects as a result. Groups cited here do not include those (such as with genetic predispositions to certain diseases) for whom we lack enough information to provide a reasonable basis for protection above and beyond that given to an average New Jersey citizen. Knowledge may advance enough to include them in the next comparative risk report. Notable subpopulations at increased risk are highlighted in Table 9 below.

Table 9. Selected Subpopulations at Increased Risk for Health Effects

Children
- Acrolein
- Arsenic
- Extremely low frequency/electromagnetic fields
- Endocrine disruptors
- Greenhouse gases
- Indoor asthma inducers
- Lead
- Lyme disease
- Mercury
- Nitrogen oxides (NO_x)
- Ozone (ground level)
- Particulate matter
- Pesticides
- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Secondhand tobacco smoke
- SOx
- Waterborne pathogens

Fetuses
- Disinfectant byproducts
- Endocrine disruptors
- Mercury
- Waterborne pathogens

Elderly
- Greenhouse gases
- Particulate matter
- Waterborne pathogens
- West Nile virus

People with Asthma
- Indoor asthma inducers
- Nitrogen oxides (NO_x)
- Ozone (ground level)
- Particulate matter
- Sulfur oxides (SO_x)

People with Immune Disorders
- Airborne pathogens
- Cryptosporidium
- Legionella
- Waterborne pathogens

People with Chronic Lung/Cardiovascular Disease
- Greenhouse gases
- Noise
- Ozone (ground level)
- Particulate matter

Increased health risk may also stem from an increased risk of exposure. Individuals living near sources of stressors are at greater risk than those at greater distances. Urban populations are at increased risk from the effects of many types of stressors as a result of their proximity and more constant exposure. Personal behaviors can also affect the degree of risk—smokers, for example, are at increased risk from radon, particulates, and PAHs. Special populations or geographic areas at increased risk are noted in the "What's at Risk?" section of each stressor summary.

Table 10. Locations with Elevated Health Risks

Location		Stressor
Urban Areas		1,3-Butadiene Acrolein Benzene (highly traveled roads) Indoor Asthma Inducers Nitrogen Oxides PAHs (in air)
Suburban/Rural Areas		Lyme disease
Rural/Agricultural Areas		Pesticides in ground water (shallow wells)
Counties		
	Atlantic	Mercury (private wells)
	Bergen	Carbon Monoxide; West Nile Virus*
	Burlington	Carbon Monoxide
	Camden	Sulfur Oxides
	Essex	Sulfur Oxides (likely); VOCs-carcinogenic (acetaldehyde)
	Gloucester	Sulfur Oxides
	Hudson	Chromium (particularly Jersey City); West Nile Virus*
	Hunterdon	Lyme disease
	Middlesex	VOCs-carcinogenic (acetaldehyde)
	Monmouth	West Nile Virus*
	Morris	Lyme disease; Sulfur Oxides; West Nile Virus*
	Ocean	Mercury (private wells)
	Passaic	West Nile Virus*
	Somerset	Lyme disease
	Union	Carbon Monoxide; Sulfur Oxides
	Warren	Lyme disease
Water Areas	Recreational	Cryptosporidium (freshwater); Waterborne Pathogens (marine or freshwater)
	NY/NJ Harbor Estuary	Dioxin (in crabs and lobsters, particularly Newark Bay)
	Coastal Areas	Greenhouse gases; Ozone (ground level);Ultraviolet Radiation
	Flood Zones	Greenhouse gases
	Kirkwood-Cohansey Aquifer	Mercury (private wells, mostly Ocean and Atlantic counties—see *Counties*); Radium (private wells) Radium
Northeastern NJ	Newark Basin (10 North-Central NJ counties)	Greenhouse gases (ground level ozone)

* Note that it is not possible to determine the exact geographic area where the individuals were bitten by the infected mosquito.

ANALYSES - Results

Ecosystems

Four stressors were consistently rated high or medium-high for all five ecosystems studied. These stressors included habitat loss, habitat fragmentation, increased impervious surface, and ultraviolet radiation, which were discussed in the statewide ranking. The following paragraphs describe other stressors that were ranked highly for individual ecosystems. Valuable additional information can be garnered by examining risks and trends on an ecosystem or regional basis, as in the following figures.

High Risks to Inland Waters

The tendency for some compounds to accumulate in sediments increases their risk to aquatic ecosystems. Chemical stressors such as PCBs, mercury, and lead accumulate in aquatic sediments, resulting in increasingly severe reproductive and developmental effects throughout the food chain. Wildlife at the upper levels, such as raptors, may experience severe reproductive effects, including reproductive failure. Endocrine disruptors such as phthalates may also cause reproductive effects in aquatic ecosystems. Inland lakes are particularly susceptible to the effects of phosphorus, since excessive levels of this nutrient are introduced via urban and agricultural runoff, causing excessive plant and algae growth. Overabundance of Canada geese also creates disproportional impacts to inland lakes, affecting the natural balance of species and contributing to excess nutrient levels with their droppings.

Medium-High	*Worse*	Geese
	Worse	Lead
	Worse	Phosphorus
	Same	Mercury
	Same	Phthalates
	Better	Pesticides (historic use)
	Better	Polychlorinated biphenyls (PCBs)

Figure 6. High risks to inland waters

High Risks to Marine Waters

Like inland waters, marine ecosystems are also at greater risk from compounds that accumulate in the water column and bottom sediments, such as endocrine disruptors, pesticides, mercury and lead. Nitrogen, acting as the saltwater equivalent of phosphorus, similarly alters nutrient levels in marine ecosystems, causing the excessive growth of some algae, which can become toxic.

Some of the most significant risks to marine waters are stressors that affect only marine waters. The duration and severity of the seasonal algal bloom known as brown tide has worsened in recent years. Blooms, which reduce light penetration and growth of submerged plants, affect the availability of suitable habitat for a variety of fish and shellfish species. The diamondback terrapin, the only species of turtle in the United States that inhabits saltwater marshes, is accidentally killed at alarming rates. Thousands are inadvertently drowned in crab pots or killed by vehicles each year. Overharvesting, using the example of the horseshoe crab, also ranks very highly among stressors to marine ecosystems.

High	*Worse*	Brown tide
	Better	Overharvesting (marine)
Medium-High	*Worse*	Lead
	Same	Endocrine disruptors
	Same	Nitrogen pollution

Figure 7. High risks to marine waters

High Risks to Wetlands

As with the other aquatic ecosystems, wetlands are similarly affected by persistent chemical stressors such as PCBs and phthalates. Estuarine wetlands are also at increased risk from the adverse effects of petroleum spills. Inland wetlands and saltwater estuaries are also at increased risk from the effects of nutrients, with phosphorus having the greatest impacts on freshwater wetlands and nitrogen resulting in adverse effects on estuaries. Invasive plant species, especially purple loosestrife and phragmites, are becoming increasingly dominant in wetlands. The effects of the resulting reduction or elimination of other native plants is potentially irreversible and affects a variety of wetland-dependent wildlife. Deer and the hemlock woolly adelgid, an insect pest that poses a catastrophic threat to hemlock stands, also rank high in impacts to wetland ecosystems. As noted above, there is high inadvertent mortality for diamondback terrapins in saltwater marshes.

Medium-High	*Worse*	Invasive plants
	Worse	Phosphorus
	Same	Deer
	Same	Nitrogen
	Same	Phthalates
	Same	Petroleum Spills
	Better	Hemlock woolly adelgid
	Better	Inadvertent animal mortality
	Better	PCBs

Figure 8. High risks to wetlands

High Risks to Forests

Biological stressors pose the highest risks to forest ecosystems. The hemlock woolly adelgid is an insect pest that has already infested more than 90% of New Jersey hemlock forests. Once infested, trees rarely recover. Among the impacts associated with a loss of hemlock trees are an increasing risk of forest fires, changes in forest nutrient cycles, and loss of rare species habitat. Invasive plants are also judged to present a high risk to forest ecosystems. Often sold as ornamentals, non-native species of trees and shrubs can invade forest ecosystems, displacing native species upon which wildlife are dependent. Increasing densities of white-tailed deer and starlings also create significant impacts to forest health by altering the balance and diversity of woodland communities, by limiting recruitment and disrupting natural successional dynamics.

High	*Same*	Deer
	Better	Hemlock woolly adelgid
Medium-High	*Same*	Starlings
	Worse	Invasive plants

Figure 9. High risks to forests

High Risks to Grasslands

As with forest ecosystems, the overabundance of white-tailed deer is among the highest risks to grassland ecosystems. The number of deer in the state has doubled in the past twenty years, and the ecological impacts associated with their browsing are exacerbated by ongoing rates of suburban development. Residential areas and parks tend to create "deer refuges" where the animals can rapidly increase their numbers in the absence of hunting or natural predators. Historically used pesticides (e.g., DDT and chlordane) are also a concern due to their persistence and adverse effects on wildlife.

Medium-High	*Same*	Deer
	Better	Pesticides (Historic Use)

Figure 10. High risks to grasslands

The following table (Table 11) lists stressors deemed to have "high" or "medium-high" impacts on particular ecosystem types in particular watershed management areas (see map for their locations). As with other rankings, the scoring was based on readily available data, literature, and professional judgment. The robustness of the scoring is highly stressor-specific (e.g., for individual impacts on a watershed there is a sound basis for ranking impacts of brown tide or hemlock woolly adelgid, but less for statewide stressors such as lead or invasive plants). Peer reviews were conducted for statewide rankings only, not for these watershed-level rankings.

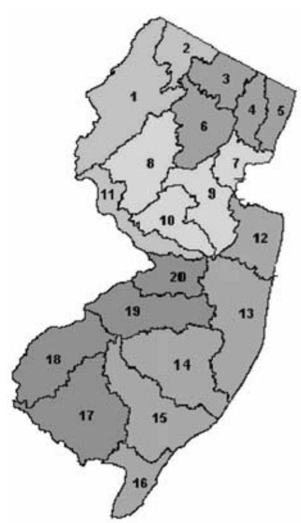


Figure 11. Watershed Management Regions

Table 11. Stressors with High or Medium-High Impacts on Watersheds

	Upper Delaware	Passaic	Raritan	Atlantic	Lower Delaware
Inland Waters	Catastrophic radioactive releases Geese Habitat fragmentation Habitat loss Increase in impervious surface Pesticides-present use Zebra mussels	Arsenic (M-H) Catastrophic radioactive releases Chromium (M-H) Copper (M-H) Geese Habitat fragmentation Habitat loss Increase in impervious surface Lead (M-H) Mercury (M-H) PAHs (M-H) PCBs (M-H) Pesticides-present use Zebra mussels	Arsenic Catastrophic radioactive releases Copper (M-H) Geese Habitat fragmentation Habitat loss Increase in impervious surface Lead (M-H) Mercury (M-H) PAHs (M-H) PCBs Zebra mussels	Catastrophic radioactive releases Copper (M-H) Geese Habitat fragmentation Habitat loss Increase in impervious surface Mercury (M-H) PCBs (M-H) Water overuse (M-H) Zebra mussels	Catastrophic radioactive releases Geese Habitat fragmentation Habitat loss Increase in impervious surface Water overuse (M-H) Zebra mussels
Marine Waters		Catastrophic radioactive releases Chromium Copper (M-H) Dioxin Dredging Endocrine disruptors Habitat fragmentation Habitat loss Increase in impervious surface Lead (M-H) Nitrogen Mercury PAHs	Catastrophic radioactive releases Copper (M-H) Dioxin (M-H) Endocrine disruptors Habitat fragmentation Habitat loss Increase in impervious surface Lead (M-H) Nitrogen Mercury PAHs (M-H) Petroleum spills Tin (M-H)	Catastrophic radioactive releases Brown tide Habitat fragmentation Habitat loss Overharvesting (marine) Inadvertent animal mortality Increase in impervious surface Lead (M-H) Nitrogen	Catastrophic radioactive releases Dermo parasite in oysters Endocrine disruptors Habitat fragmentation Habitat loss Overharvesting (marine) Inadvertent animal mortality Increase in impervious surface Lead (M-H) Nitrogen
Wetlands	Catastrophic radioactive releases Deer Garlic mustard Geese (M-H) Habitat fragmentation Habitat loss Increase in impervious Japanese honeysuckle (M-H) Phthalates Purple loosestrife Phragmites Multiflora rose (M-H) Norway maple (M-H) Tree-of-heaven (M-H)	Catastrophic radioactive releases Chromium Copper (M-H) Deer Garlic mustard Geese (M-H) Habitat fragmentation Habitat loss Increase in impervious surface Japanese honeysuckle (M-H) Multiflora rose (M-H) Mercury (M-H) Norway maple (M-H) PAHs Phthalates Phragmites Purple loosestrife Tree-of-heaven (M-H)	Arsenic (M-H) Catastrophic radioactive releases Copper (M-H) Deer Garlic mustard Geese (M-H) Habitat fragmentation Habitat loss Increase in impervious surface Mercury (M-H) Multiflora rose (M-H) Norway maple (M-H) PAHs (M-H) Petroleum spills Phragmites Phthalates Purple loosestrife Tree-of-heaven (M-H)	Catastrophic radioactive releases Deer Garlic mustard Geese (M-H) Habitat fragmentation Habitat loss Overharvesting (marine) Inadvertent animal mortality Increase in impervious surface Nitrogen Phragmites Phthalates Purple loosestrife Tree-of-heaven (M-H) Water overuse (M-H)	Arsenic (M-H) Deer Garlic mustard Geese (M-H) Habitat fragmentation Habitat loss Overharvesting (marine) Increase in impervious surface Inadvertent animal mortality Phragmites Phthalates Purple loosestrife Nitrogen Tree-of-heaven (M-H) Water overuse (M-H)
Grasslands	Catastrophic radioactive releases Habitat fragmentation Habitat loss	Catastrophic radioactive releases Habitat fragmentation Habitat loss	Catastrophic radioactive releases Habitat fragmentation Habitat loss	Catastrophic radioactive releases Habitat fragmentation Habitat loss	Catastrophic radioactive releases Habitat fragmentation Habitat loss
Forests	Asiatic bittersweet Catastrophic radioactive releases Deer Garlic mustard Habitat fragmentation Habitat loss Hemlock woolly adelgid Increase in impervious surface Japanese barberry Japanese honeysuckle Multiflora rose Norway maple Tree-of-heaven	Asiatic bittersweet Catastrophic radioactive releases Deer Garlic mustard Habitat fragmentation Habitat loss Hemlock woolly adelgid Increase in impervious surface Japanese barberry Japanese honeysuckle Multiflora rose Norway maple Tree-of-heaven	Asiatic bittersweet Catastrophic radioactive releases Deer Garlic mustard Habitat fragmentation Habitat loss Hemlock woolly adelgid Increase in impervious surface Japanese barberry Japanese honeysuckle Multiflora rose Norway maple Tree-of-heaven	Asiatic bittersweet Catastrophic radioactive releases Deer Garlic mustard Habitat fragmentation Habitat loss Hemlock woolly adelgid Increase in impervious surface Japanese barberry Japanese honeysuckle (M-H) Multiflora rose Norway maple Tree-of-heaven	Asiatic bittersweet Catastrophic radioactive releases Deer Garlic mustard Habitat fragmentation Habitat loss Hemlock woolly adelgid Increase in impervious surface Japanese barberry Japanese honeysuckle (M-H) Multiflora rose Norway maple Tree-of-heaven

Aquatic life, wildlife, plants and whole ecosystems are at increased risk from a variety of stressors, particularly chemicals. Persistent chemicals, as well as metals such as lead and mercury, remain in the aquatic environment for long periods of time. Contaminants may bioaccumulate in the food chain, reaching higher concentrations in the tissues of fish and the animals that consume them, and resulting in increased risk.

For many stressors, birds represent a population of concern. Forest-breeding birds have been identified as among those at increased risk from habitat loss and fragmentation. Healthy bird populations require large expanses of uninterrupted forest canopy; as these forest "patches" decrease in size, the more adaptable birds become more prevalent and species diversity is reduced. Fish eating birds and mammals are at increased risk from a number of chemical stressors as well (e.g., mercury, pesticides, and PCBs). Not only are they exposed to high concentrations of persistent stressors through bioaccumulation, they are also highly susceptible to reproductive effects as a result of that exposure.

Terrestrial plants and trees are also at increased risk from a number of stressors. In addition to direct impacts due to habitat loss, stressors such as invasive plants and deer reduce plant community biodiversity and lead to secondary impacts (e.g., reduced breeding bird diversity). Due to their habitat requirements, amphibians are at increased risk due to habitat loss and habitat fragmentation. Mammals are at increased risk due to contaminants including lead and pesticides.

Specific ecosystem types may also be at increased risk from particular ecological stressors. For example, sensitive, high quality ecosystems such as the Pinelands may be at greater risk from the effects of chemical stressors such as acid precipitation, and from habitat disturbances.

Table 12. Examples of Wildlife and Ecosystems at Increased Risk

Aquatic Plants and Bottom-Dwelling Animals
Arsenic
Brown tide
Cadmium
Chromium
Copper
Dermo parasite in oysters
Dredging
MSX parasites in oysters
Nitrogen pollution
Pesticides
Polycyclic aromatic hydrocarbons (PAHs)
Overharvesting (marine)
QPX parasite in shellfish
Water use/overuse
Zinc

Fish and Shellfish
Cadmium
Dioxin
Harmful algae
Nitrogen pollution
Petroleum spills
Pesticides
Phosphorus

Birds
Electromagnetic fields
Floatables
Habitat fragmentation
Habitat loss
Lead
Light pollution
Mercury
Noise
Overharvesting(marine)
Petroleum spills
Pesticides
Pets as predators
Polychlorinated biphenyls (PCBs)
Starlings

Pinelands
Acid precipitation
Habitat loss/fragmentation
Mercury

Amphibians
Habitat loss
Habitat fragmentation

Terrestrial Plants and Trees
Acid precipitation
Deer
Habitat loss
Hemlock woolly adelgid
Invasive plants

Mammals
Catastrophic radioactive release
Electromagnetic fields
Lead
Pesticides-current use

Socioeconomic

The socioeconomic assessments focused on damage costs imposed by stressors, as well as risks to property values, employment, aesthetics, and psychological well being. In the many cases where medical costs drove the risk estimate, populations at increased risk tend to follow the human health effects. Thus, special populations at increased socioeconomic risk will often include children, the elderly, and people with existing health problems.

Low-income residents are at increased risk from a number of stressors as a result of the higher prevalence of the conditions that result in exposure. The risks from lead, for example, are increased in older buildings that have not been renovated—lower income residents are more likely to occupy these homes. Urban residents may also be at increased risk for property value impacts due to their proximity to brownfields and other sources of chemical waste. Urban residents may also bear a disproportionate share of damage costs and loss of value associated with certain stressors.

Even while statewide risks were judged to be low, some stressors may cause significant problems in the communities where they occur. This is true for a number of stressors to shore and coastal environments. Residents in coastal areas and lakeshore communities may be at increased risk from negative employment or property losses due to localized aesthetic impacts, such as those associated with floatables or algal blooms.

Table 13. Examples of Groups and Areas at Increased Socioeconomic Risk

Children
Cryptosporidium
Lead
Mercury
Nitrogen oxides (NO_X)
Ozone (ground level)
Particulate matter
Pesticides

Elderly
Legionella
Ozone (ground level)
Particulate matter
Pesticides

People with Asthma
Nitrogen oxides (NO_X)
Ozone (ground level)
Particulate matter

Low-Income Households
Indoor asthma inducers
Lead
Noise
Pesticides
Radon
Secondhand tobacco smoke

Urban Areas
1, 3-butadiene
Dioxins/furans
Formaldehyde
Radium

Coastal Areas/Shore Communities
Floatables
Greenhouse gases
Green/red tides
Particulate matter
Petroleum spills

Rankings by Socioeconomic Dimensions

In the process of developing overall rankings, the Socioeconomic TWG produced ratings of how each stressor affected individual dimensions (e.g., Property Values or Aesthetics) of socioeconomic conditions. These ratings were correlated but distinctive enough to be of potential interest. Inferred rankings below use the same thresholds (e.g., between High and Medium-High) as for the overall SE rankings; stressors with Low rankings are omitted due to lack of space.

Table 14. Rankings by Socioeconomic Dimensions

Property Values	Employment	Costs	Aesthetics	Worry
High Land use change	**High**	**High** APs Arsenic STS IAI Land use change Lead Ozone Particulates UV	**High** Deer Land use change Lead Particulates Pesticides Phosphorus Sulfur oxides	**High** EDs IAI Land use change Lead Pesticides Ultraviolet radiation
Medium-High Noise	**Medium-High** Arsenic Invasive Plants Land use change	**Medium-High** 1,3-butadiene Acrolein Deer Dioxins/furans Formaldehyde IAM Invasive plants Pesticides Petroleum spills PCBs Radon Water overuse WPs	**Medium-High** STS Light pollution Petroleum spills	**Medium-High** Arsenic Dioxins/furans PCBs PAHs
Medium 1,3-butadiene Acrolein CRR Deer Lead Pesticides PCBs Phosphorus	**Medium** Dermo parasites in oysters PCBs	**Medium** Acids CO CRR Dermo parasites in oysters DBPs Dredging EDs Mercury Nickel Nitrogen oxides Phosphorus PAHs VOCs	**Medium** HWA IAM ELF/EMF Noise Overharvesting PCBs VOCs	**Medium** CRR Deer GGs IAM Noise Particulates Petroleum spills Water overuse
Medium-Low Floatables Radon Water overuse	**Medium-Low** Chromium Floatables Mercury	**Medium-Low** Channelization Chromium Cryptosporidium Floatables Geese HWA Sulfur oxides West Nile virus Zebra mussels	**Medium-Low** Channelization Chromium Floatables Geese GRT MTBE Off-road vehicles Ozone (ground level)	**Medium-Low** Chromium Cryptosporidium STS Floatables GMOs Mercury MTBE ELF/EMF Radon West Nile virus Zebra mussels

Definitions:

APs=airborne pathogens
CO=carbon monoxide
CRR=catastrophic radioactive release
DBPs=disinfection byproducts
EDs=endocrine disruptors
STS=secondhand tobacco smoke
ELF/EMF=extremely low frequency/ electromagnetic fields

GGs=greenhouse gases
GMOs=genetically modified organisms
GRT=green and red tides
HWA=hemlock woolly adelgid
IAI=indoor asthma inducers
IAM=inadvertent animal mortality
MTBE=methyl tertiary butyl ether

PAHs=polycyclic aromatic hydrocarbons
PCBs=polychlorinated biphenyls
UV=ultraviolet radiation
VOCs=volatile organic compounds
WPs=waterborne pathogens

Major Sources of Stressors

TWGs were asked to identify the relative contribution of various primary (e.g., business, agriculture) and diffuse (e.g., sediment, biota [living creatures]) sources to the levels of stressors in the New Jersey environment. The aim was to provide very general guidance to those interested in opportunities for risk reduction, particularly where a single strategy might be able to reduce the levels of multiple stressors simultaneously (see Recommendations section). Note that even for stressors defined exactly the same, it can be reasonable for different TWGs to rate the importance of stressors differently. For example, golf courses (Recreational) are not a significant source of arsenic exposures for people, but they are for wildlife. However, more detailed analysis will be needed to identify particular strategies that might be effective in reducing stressor levels. The parenthetical information on large business sources for health stressors shows the additional detail available in some analyses, but this level of detail was not systematically assessed for all stressors.

Table 15. Sources That Are "High" or "Medium-High" for Listed Stressors

SOURCES	HEALTH	ECOLOGICAL
Primary Sources Large Business/Industry	**H:** Airborne pathogens (composting facilities, sanitary landfills, wastewater treatment plants), Benzene (manufacturing and solvent use; vehicular petroleum use, including construction equipment), Extremely low frequency/electromagnetic fields (broadcasting and communications, microwave ovens, MRI and medical diathermy machines, radio-frequency arc welders, etc.), Endocrine disruptors (pharmaceuticals, consumer products), Greenhouse gases (power plants), M-H: NOx (utility and large industry external combustion units), SOx (large utility boilers), VOCs -carcinogenic (ethylene oxide, fumigants in food industry; acetaldehyde, combustion products in chemical industry)	**H:** Acid deposition (sulfur emissions from coal-burning power plant), Arsenic (coal - fired utilities, past pesticide manufacturing), Asiatic Bittersweet (horticultural/landscape), Cadmium (smelting, plating), CR radiation (nuclear power industry), Chromium (chromate ore processing, electroplating, metal finishing, production of stainless & heat-resistant steels, production of refractory products, pigment production, leather tanning, textile manufacturing), Copper (electronic, and electrical industries, water purveyors), Extremely low frequency/electromagnetic fields (electricity producers & users), Impervious surface (land development), Japanese Barberry (ornamental shrub for landscaping), Japanese Honeysuckle (residential landscape), Lead (construction for tank linings, piping, equipment handling corrosive gases & liquids, x-ray & atomic radiation protection, manufacturing metal alloys, paints & pigments, ceramics, lead storage batteries), Mercury (energy & heat production, products containing mercury, management of mercury-containing waste), Oil spills (oil transport, lightering, and transfer), Ozone (NOx & hydrocarbon emissions), PAHs (industrial chemical wastes such as coal tar, petroleum refinery sludges, waste oils & fuels & wood treating residue, heat & power generation, controlled refuse incineration), Phragmites (filling for construction activity), Phthalates (used in production of household & consumer goods), VOCs (automobile emissions, by-product of reactions among compounds in the air, sewage treatment plants, stormwater runoff), Water overuse (power generation)
Small Business/Industry	**H:** Benzene, Greenhouse gases, Air pathogens, Extremely low frequency/electromagnetic fields, Ozone (VOC), UV Radiation, Mercury (elemental-dental practices)	**H:** Arsenic, Cadmium, Chromium, Mercury, Lead, Copper, Overharvesting (marine), Inadvertent animal mortality, Water overuse, Pesticides-current use (aquatic herbicides, mosquito larvicides), Phthalates, Asiatic bittersweet, Impervious surface, Japanese Barberry, Japanese Honeysuckle, Purple Loosestrife, Phragmites
Transportation	**H:** 1,3-butadiene, Benzene, Greenhouse gases, Air pathogens (in a few carriers), Formaldehyde, MBTE, Ozone (VOCs, NOx), Particulates, PAHs M-H: Acrolein, Noise Pollution, VOCs (Non-carcinogenic)	**H:** Inadvertent animal mortality, Acid precipitation, Ozone, Road salt, PAHs, VOCs, Habitat loss, Habitat fragmentation, Impervious surface, Extremely low frequency/electromagnetic fields, Noise (overflights), Light, Zinc

ANALYSES - Results

Table 15. Sources That Are "High" or "Medium-High" for Listed Stressors - "continued"

SOURCES	HEALTH	ECOLOGICAL
Residential	**H:** Carbon monoxide, Greenhouse gases, Air pathogens (some homes), Endocrine disruptors, Secondhand tobacco smoke, Formaldehyde, Asthma inducers, Mercury (Elemental), Ozone (VOCs), Pesticides (indoors, outdoors, in water), Radium	**H:** Copper, Water overuse, Currently used pesticides (Aquatic herbicides, mosquito larvicides; Diazinon and similar pesticides), Norway Maple, Habitat loss, Habitat fragmentation, Increase in impervious surface M-H: Phosphorus
Agriculture	**H:** Endocrine disruptors, Mercury (inorganic-historical), Nitrates, Pesticides (on food, in water)	**H:** Arsenic, Copper, Zinc, Overharvesting (marine), Endocrine disruptors, Currently used pesticides (Oxamyl, Diazinon, synthetic pyrethroids, atrizine), Phragmites, Multiflora Rose M-H: Phosphorus
Recreation	**H:** Secondhand tobacco smoke, Asthma inducers, Noise pollution (occasionally), Pesticides (outdoors), Waterborne pathogens	**H:** Arsenic, Copper, Currently used pesticides (aquatic herbicides, mosquito larvicides), Dredging, Multiflora Rose, Noise (recreational and underwater), Light (depends on uses of communications towers)
Resource Extraction		**H:** Chromium, Overharvesting (marine), PAHs, Asiatic bittersweet, Japanese Honeysuckle, Inadvertent animal mortality
Government	**H:** Airborne pathogens (a few locations), Waterborne pathogens	**H:** Water overuse, Road salt, Currently used pesticides (mosquito larvicides, synthetic pyrethroids), Phragmites, Multiflora Rose
Natural Sources/Processes	**H:** Airborne pathogens, Indoor Microbial air pollution, Legionella, Radon (air, water), UV Radiation, Hanta virus M-H: Arsenic	**H:** Arsenic, Copper, Water overuse, PAHs, Asiatic bittersweet, Norway maple, Tree of Heaven, Garlic mustard, Japanese barberry, Japanese honeysuckle, Phragmites, Multiflora rose, Brown tide
Orphan Contaminated Sites	**H:** MTBE M-H: Chromium, PAHs	**H:** Dioxin (case specific), Phragmites, Copper
Diffuse Sources Sediment Sinks	**H:** Arsenic (in specific locations), Cadmium, Endocrine disruptors, Mercury (methylmercury) M-H: PCBs	**H:** Endocrine disruptors, PCBs, Arsenic, Chromium, Mercury, Zinc, PAHs, Historic use of pesticides (DDT, Chlordane), Phthalates
Soil Sinks	**H:** Indoor microbes, Mercury (inorganic, methylmercury), Nitrates, Pesticides (indoors), Radium M-H: Lead	**H:** Arsenic, Chromium, PAHs, Historic use of pesticides (DDT, Chlordane), Purple Loosestrife, Japanese Stiltgrass, Multiflora Rose
Non-Local Air Sources (incl. deposition)	**H:** Greenhouse gases, Mercury (methylmercury), Particulates M-H: Nitrogen oxides in air, PAHs	**H:** Mercury, PAHs, Phthalates, Chromium
Groundwater sinks	**H:** Radium	None
Biota Sinks	**H:** Cadmium, Cryptosporidium, Legionella, Mercury (inorganic, methylmercury), Pesticides (food), PCBs, Waterborne pathogens, Hanta virus M-H: Endocrine disruptors	**H:** Historic use of pesticides (DDT, Chlordane), Phthalates

Types of Stressors

Another way to examine these results is to consider the kind of stressor that is involved. The following pages discuss the relative impacts of biological, chemical and physical stressors.

Biological stressors are microorganisms, plants, or animals that can affect human health, ecosystems, or social and economic conditions. Bacteria, molds, parasites, and viruses are common biological stressors that may pose a risk when present in large enough numbers in surface water, drinking water, and indoor air. Parasites and toxins may result in large-scale mortality of fish, shellfish, and other wildlife. Excessive amounts of algae (algal "blooms") are another common type of biological stressor. Blooms such as brown tide reduce sunlight necessary for other species' survival, and some forms of algae can be toxic. Invasive plants include "exotic" species (plants introduced accidentally or intentionally to this area) as well as native species that thrive in disturbed soils. Invasive plants typically outcompete other species, destroying habitat and disrupting established food webs. Excessive numbers of insects and animals can cause adverse impacts.

Along with its socioeconomic benefits, industrialization has resulted in large quantities of chemicals in New Jersey's air, land, and water. In fact, it is the chemical stressors group that most people have come to associate with human-caused environmental damage. A number of chemicals are released as byproducts of combustion processes in automobiles, waste incineration, and power generation. Secondary problems associated with these include acid precipitation, climate change, and ground-level ozone. Organic and inorganic chemicals that are intentionally introduced to attain a desired environmental impact include pesticides and fertilizers (phosphorus and nitrogen), road salt, and antibiotics. Environmental tobacco smoke (also known as secondhand smoke) is considered a chemical stressor for this report. Metals, typically released to the environment via industrial processes and uncontrolled waste sites, include cadmium, chromium, copper, lead, mercury, tin and zinc. Naturally occurring chemicals, such as arsenic, may also pose a risk when present in harmful quantities in ground water used for drinking.

Physical stressors affect human health or habitat quality through mechanisms other than a biological or chemical agent. Radiation damages or destroys living tissue by breaking chemical bonds, causing reactions among biological molecules, and producing mutations in DNA. Excess noise and light are also physical stressors that can have adverse effects on both humans and wildlife. Ecosystems are increasingly undermined by physical stressors. When a forest is cleared for development, associated habitat is fragmented or lost, resulting in losses of native species. Similarly, when the course of a river is changed for flood control or navigation, existing habitats are altered or eliminated. Physical stressors also include those arising from individual or commercial activity that has negative effects on ecological populations: floatables (litter), inadvertent animal mortality, off road vehicles, and overharvesting. Finally, issues related to water quantity and temperature are considered within this category.

Biological Stressors

Microorganisms

All of New Jersey is exposed to potentially harmful microbiological stressors from time to time. Contact with bacteria, fungi, molds, and parasites in the air or water generally produce no adverse effects, either because the organism is not generally infectious, because the number of organisms is below the infectious dose, or because the body's immune system effectively counters the infection. However, in some cases exposure can produce mild to serious respiratory and gastrointestinal illness. Most cases are mild, and the majority are not reported, thus risk estimation is difficult. While no more likely to become exposed, asthmatics and others with pre-existing health problems are at greater risk for developing more serious symptoms. New Jersey has had no confirmed cases for over a decade of *Giardia or Cryptosporidium,* two of the environmental pathogens which have evoked the greatest concern nationwide. West Nile virus, which is transmitted by mosquitos, has on rare occasions caused severe illness or death, but most infections produce no symptoms. On the other hand, New Jersey ranks among the top five states in the nation for documented cases of Lyme disease, with more than 2,000 cases annually. Lyme disease is treatable, but can result in serious long-term health problems if undiagnosed. Trends in risks from microorganisms are likely to remain fairly stable. While the number of cases may vary from year to year, the long-term incidence of microbiological illness is not anticipated to change significantly.

Microbiological risks to New Jersey ecosystems are considered low. With the exception of the Dermo and MSX parasites' catastrophic reduction of the oyster population over the past few decades, wildlife mortality associated with microbiological infection is not considered to be a significant or widespread threat.

Plants

Plant stressors are primarily an ecological concern in New Jersey, although toxic algae can result in minor human health problems as well. Historically, algal blooms have occurred in specific locations and at times of the year when conditions are conducive to a bloom event. Brown tide blooms appear to be occurring more often and lasting longer; more research is needed to determine the impact of natural and human influences on algae populations. Invasive plants threaten native species and ecosystems. These species tend to outcompete native species, reducing biodiversity and the availability of important food sources for wildlife. Invasive plants spread vigorously in disturbed habitats, so stressors that promote habitat degradation and alteration will also exacerbate the risks from invasive plants. Moreover, many species of invasive plants continue to be sold as ornamental species, creating an ongoing source of new infestations. The risks from genetically modified organisms (GMOs) continue to be debated within the scientific community and the likelihood and magnitude of adverse effects remain uncertain.

Animals

There are no human health impacts associated with the vertebrate and invertebrate animal stressors evaluated. As with invasive plants, ongoing urbanization promotes an increasing dominance by nuisance animal species. Geese and starlings thrive in suburban landscapes, crowding other species and congregating in massive flocks. Pets also threaten wildlife, particularly songbirds and nesting shorebirds. Residential development results in a loss of habitat compounded by an associated increase in pet populations. In addition to preying on birds and small rodents, cats can also outnumber and outcompete wild predators such as hawks. A small number of stressors have the potential for catastrophic impacts to New Jersey ecosystems. The hemlock woolly adelgid is an insect pest that has already affected most of New Jersey's hemlock stands, and unless an effective predator is introduced will eventually infest and ultimately destroy them. Although there are no known infestations in New Jersey forests, the Asian longhorned beetle, if introduced, could pose a serious threat to hardwood species, especially maples. Finally, zebra mussels will inevitably become established in New Jersey. When this occurs, freshwater aquatic ecosystem dynamics will be dramatically altered as has been the case in the 20 or so states invaded to date.

Chemical Stressors

There are two general types of effects resulting from chemical contamination of the New Jersey environment. Acute effects generally occur during or shortly after relatively brief exposure to high levels of a chemical. Accidental spills or misuse of pesticides, petroleum, or industrial chemicals are typical scenarios resulting in acute effects. In New Jersey, these acute events are rare and not the main factor behind the ranking of most chemical risks. The other types of effects are those that result from long term exposure to lower concentrations of contamination. These chronic effects can result from contamination of water, soil, sediments, air, or food. The effects themselves are less easily pinpointed to specific contaminants except in cases where particular chemicals have unique effects, which, e.g., is the case with lead poisoning of children. The field of risk assessment is largely focused on the chronic effects of chemical contaminants and most of the reported risk in New Jersey is from populations exposed to low levels of these pollutants.

Products of combustion

Intentional burning of fossil fuels in vehicles, boilers and industrial facilities leads to the emission of several compounds. In the cases of ozone, NOx, carbon monoxide, particulate matter, formaldehyde, and acrolein, combustion is the primary path for release into the environment. In all of these cases, the effects are the result of inhalation and the primary effect is on the respiratory system. Some individuals are particularly sensitive to these airborne contaminants, including asthmatics, individuals with cardiovascular disease and the elderly. Ozone remains a high human health risk in New Jersey while other combustion products result in medium or medium-low risks. Ecosystems are not significantly affected, although the long term exposure to these pollutants may be a stress. These combustion products have been the focus of significant regulation and in most cases their impacts have been decreasing, but recent increases in the combustion of fossil fuels may result in future increases in effects.

Benzene and some volatile organic compounds (VOCs) are released from fuel transfer or from incomplete combustion. They can cause respiratory problems or cancer when breathed in, through drinking water.

Contaminants of fossil fuels, including sulfur (leading to SO_X), mercury and, historically, lead, also cause health and ecological problems typically through deposition. Once these contaminants reach the soil, they are either directly toxic (lead) or alter soil and water chemistry (SO_X) or undergo chemical changes where they enter the food chain (mercury). In the cases of lead and SO_X, regulation has led to significant reduction but the persistence of lead in soil results in continuing high socioeconomic and human health risks. For mercury, regulations are more recent and the concentrations in the environment are still causing significant ecological and human health risks.

Other organic chemicals

Organic chemicals include a wide range of chemical classes and the potential toxicologic effects on humans and ecosystems are diverse. In some cases, such as PCBs, dioxin and some historic-use pesticides, the chemical properties include long term stability which has resulted in continuing impacts on humans and ecosystems. This contributes to these chemicals posing high or medium-high impacts to human health (dioxin) or ecosystems (PCBs and historic-use pesticides). Chlorine-containing VOCs are often significant cancer-causing agents and pose medium-high risks to human health.

Secondhand tobacco smoke does not fit easily into any category because it includes a mix of contaminants. Regardless of its classification, however, such smoke poses great risk to New Jerseyans' health.

Finally, it should be noted that of the tens of thousands of chemicals in existence, only a few types or examples were able to be evaluated as part of the NJCRP.

Metals and inorganic chemicals

Metals and inorganic chemicals do not degrade over time and New Jersey is suffering the effects from historic use. These effects are particularly pronounced in aquatic environments, where toxic metals such as mercury, lead, chromium, tin, and nickel pose significant ecological risks.

Phosphorus and nitrogen are continually being added to aquatic environments. They pose medium risks to ecological systems because they supply nutrients to algae where resulting population increases can cause oxygen depletion and shift the balance of species to those requiring less oxygen. The nature of these risks to aquatic systems that are valued for aesthetic and recreational purposes leads to high socio-economic risks.

General effects

It is difficult to identify the impacts to the environment from individual chemicals because of the co-existence of many different contaminants resulting from many different sources across wide areas.

However, there is some evidence of general chemical contamination. Toxic sediments contribute to the reduction of species richness in most New Jersey urban river environments. A significant percentage of foods are contaminated with pesticides. Drinking water from both surface and ground water sources may contain chemical contamination. Fortunately, the level of contamination of food and public drinking water is almost always lower than the standards that are developed to protect human health. The situation with toxic pollutants in air may suggest greater risk. The EPA's National Air Toxics Assessment suggests that several pollutants exceed benchmark levels and the criteria pollutants (especially ozone and particulates) remain at levels known to affect human health. Drinking water from private residential wells is in some cases also a source of elevated risk, because of the shallow depth of most private wells and the historical tendency for private wells to remain untested in the absence of specific known contamination (starting in 2002 private wells must be tested when a real estate transfer occurs).

For almost every air pollutant, the concentration indoors is greater than the concentration outdoors, and for almost every New Jersey citizen, the time spent indoors is greater than the time spent outdoors. The combination of these two factors results in the risks from indoor air pollution generally being greater than outdoor pollution.

Physical Stressors

By far the greatest risks to New Jersey ecosystems are the group of physical stressors relating to land-disturbing activities. The continued expansion of suburban development exemplifies large-scale land use changes that foster increasing rates of habitat fragmentation and loss, impervious surface cover, inadvertent animal mortality, light and noise pollution, and water overuse. Development pressure continues statewide, and remaining high quality habitats, such as the Pinelands, Highlands, and Cape May regions, are at greater risk than existing urbanized areas. The disturbance or loss of large expanses of forested and wetland areas results in a significant decline in native plants and animals, dramatically alters hydrologic flow patterns and water quality, and promotes over-population of disturbance-tolerant nuisance species of plants and animals. While there are few studies documenting the specific effects of land use changes on New Jersey species, the ecological impacts of habitat alteration are well documented, as are the extent and magnitude of land use change in the state. Returning developed land to an undeveloped condition is not likely to be practical on a large scale. However, New Jersey has restricted development in over 3 million acres of protected land, over 900,000 of which have been permanently protected as open space. In light of human population and economic pressures, New Jersey faces a continuing challenge in effectively slowing the rate of development-related impacts to ecosystems.

A number of stressors in this category relate to radiation. Exposure to radiation in any form increases the risk of a variety of cancers. There are scientific uncertainties regarding the effects of very low doses of radiation as well as the numbers of people in the state that may be exposed to unhealthy levels. Reductions in stratospheric ozone may have contributed to an increased incidence in skin cancers in human populations, and changes in ecosystem dynamics stemming from the effects of excess UV radiation on plankton. Several thousand cases of skin cancer are attributed to ultraviolet radiation each year.

Naturally-occurring levels of underground radium and radon also contribute to excess cancer cases in New Jersey—radon levels are primarily responsible for an estimated 1,400 lung cancers. Risks from sources of radiation are likely to decline over time, as people control their exposures to UV radiation and have their homes tested and remediated, if necessary, for radon. Electromagnetic fields are a type of radiation without the potential to cause cancer directly. The health impacts from exposure to this kind of radiation are highly uncertain.

Because the majority of available monitoring and research dollars has been directed at chemical stressors, there remains a great deal of uncertainty regarding the risks of many physical stressors. As a result, an apparent lack of evidence for ecological effects does not necessarily mean there are none. Off-road vehicles, noise, light, floatables, and channelization are examples of physical stressors on fish and wildlife that have not been systematically researched. Additional data have the potential to shed new light on any of these issues, and risks may appear lower than they actually are.

Steering Committee Findings and Recommendations

SC - Recommendations

There is a wealth of information in the reports from the Technical Working Groups. Much of this information is going to be useful for specific policy discussions over the next several years. The Steering Committee focused on stressors that ranked high on more than one TWG's ranking or that appeared to be relatively neglected, and on themes that deserve consideration for New Jersey's future environmental management. Other stressors ranked high by a single work group remain important even if they are not in the following findings. Four general classes of environmental threat were identified.

Key Findings

Land use change lies at the heart of many of New Jersey's environmental problems, particularly those related to ecological health.

Not only does land use change cause direct impacts to habitat by the conversion of natural lands to human development, and the fragmentation of contiguous ecosystems necessary for migration and to maintain sufficient territories for large mammals, but indirect effects on ecological systems result in tipping the balance of several of the state's ecosystems. For example, changing land use can cause an increase in the amount of paved surface and rooftops, resulting in increased stormwater flows into New Jersey streams and rivers. In areas with undisturbed vegetation, rain and snow melt percolates more slowly into surface soils. These soils remove contaminants, and the resulting water either enters subsurface aquifers or seeps into streams without eroding soils. Increased human development has led to a greater interaction between deer and people with increased automobile accidents and damage to ornamental plants. Land use change particularly harms older communities, by skewing employment patterns and reducing property values, while brownfields (contaminated urban areas) take land off of the development market. As a result, development takes place instead in undeveloped areas, requiring new infrastructure and spreading undesired impacts more widely.

Physical transformation of the landscape in New Jersey deserves much more attention and action to minimize undesirable impacts while addressing basic needs for housing and quality of life. This stressor, in experts' views, produced, by far, the largest negative ecological and socioeconomic impacts. This conclusion reinforces the growing belief among many New Jersey citizens and organizations that converting forest and farm land to commercial and residential use creates major problems for the quality of ecological systems and human life in the state. There is an enormous challenge in determining how to reduce these negative effects without losing substantive benefits or creating new problems. New Jersey has already developed and revised the State Development and Redevelopment Plan and the Sustainable State initiative; set up the Sustainable State Institute; encouraged brownfields redevelopment; and increased purchases of open space by state and local governments. But these efforts still fall far short of what is needed merely to prevent further deterioration, much less to begin reducing these impacts. The Steering Committee did not evaluate whether recent policy proposals, by such groups as New Jersey Future or the Coalition for Affordable Housing and the Environment, are the best way to go; this was not part of its mission. However, the high negative impacts confirmed by the Comparative Risk Project should motivate the state and other environmental managers to strengthen their efforts to reduce or avoid these impacts.

Indoor pollution problems were among the highest threats in both the health and socioeconomic analyses, and deserve more attention from environmental and public health managers. Several stressors ranked as having "high" human health risk are primarily or entirely problems of indoor air pollution: secondhand tobacco smoke (STS), radon, indoor asthma inducers, carbon monoxide, and indoor microbial air pollution. Formaldehyde and several volatile organic compounds (VOCs) may pose indoor exposures of concern, although there is insufficient evidence to quantify the risk. In addition to the increased concentrations of indoor pollutants, average New Jersey citizens spend most of their time indoors. This can result in exposures to pollutants several-fold higher from indoor conditions as compared to outdoor conditions, even though it should be noted that outdoor sources are major contributors to indoor problems for some pollutants (e.g., VOCs).

Indoor air as a significant health risk suggests a major opportunity to improve human health with a common indoor-air strategy. Currently, with few exceptions (radon; secondhand tobacco smoke in public spaces), indoor air pollutants are not only unregulated, but are subject to no systematic attempt to address them through such other means as monitoring or education. The rationale for a lack of programmatic effort toward dealing with such issues has been the absence of legislative authorization and appropriations for government action, in turn due to a perceived lack of positive mandate for regulation of privately-owned indoor spaces, particularly private residences. But several indoor spaces are publicly owned (e.g., schools), or subject to regulation despite private ownership (e.g., day care facilities), or targets of environmental education (e.g., indoor radon). The New Jersey Department of Health and Senior Services has been concerned enough about public health implications of indoor air pollution to begin discussion of an action plan. The Steering Committee calls for a partnership of DEP and other environmental managers with DHSS to examine systematically indoor air pollution's impacts and management options, and to take action against these problems. All policy tools should be considered, including education, market incentives, and a command-and-control regulatory approach. The current approach, with inconsistent attempts at education and persuasion for some pollutants, is clearly not sufficient for the magnitude of the problem.

Other serious indoor health problems involve skin contact or ingestion, particularly for children, rather than air pollution. These pollutants include lead and indoor use of pesticides. Although both situations have improved—lead has been banned for use as a gasoline additive and in paint; the more dangerous pesticides have been banned and commercial applicators of pesticides must be certified—there is still room for improvement. This is particularly the case, again, for in-home exposures, for which education and/or remediation efforts are still weak.

Invasive species pose a serious ecological threat to several New Jersey ecosystems. Invasive plants—comprising purple loosestrife, Norway maple, and garlic mustard, plus seven other plants analyzed here and hundreds more not analyzed—threaten biodiversity and ecological integrity in several ecosystems. Wetlands are a particular concern, but invasive plants thrive wherever disturbed soil is found, which is often the result of land use change. The Asian longhorned beetle is an example of a problem insect, which destroy forests in New Jersey if not for so far vigilant control efforts. The hemlock woolly adelgid has damaged more than 90% of the state's hemlock forests. The 2002 upswings in the southern pine beetle (in its first-ever appearance in New Jersey, currently ravaging Cape May and the Pinelands) and the gypsy moth are other examples of problem insects. The zebra mussel has already destroyed freshwater ecosystems in over a dozen states, and this thumbnail-sized mollusk is likely to reach New Jersey within five years.

Several outdoor contaminants continue to pose health risks, despite progress in reducing outdoor air pollution, remediating brownfields, and removing lead from gasoline. Examples include ground-level ozone and nitrogen oxides in air, and lead and other pollutants remaining in urban soils. Further progress in these areas will be difficult, given such obstacles as the regional and global contributions to New Jersey air pollution, and the funding and liability problems still associated with site remediation.

Next steps

In addition to the four highlighted classes of environmental issues, the Steering Committee identified some directions for future policy discussions that should be based on the technical information included in this report.

Addressing many of these problems will require partnerships among agencies of state government. Environmental health threats indoors are certainly shared interests of DEP and DHSS, and the New Jersey Department of Community Affairs also might play an important role. Partnerships with the New Jersey Departments of Agriculture and Transportation can constructively address other issues; school-related problems (from energy use to integrated pest management) can be dealt with in partnership with the New Jersey Department of Education.

These are only a few examples of potentially helpful partnerships. Given the importance of these problems, DEP should take the lead in suggesting briefings for other cabinet officers, and in scheduling regular cross-agency meetings to advance action on these problems.

Dealing with the significant environmental problems created by land use changes will require DEP to take a lead role in working with the new Office of Smart Growth and the Smart Growth Policy Council, as well as with local planning officials.

The DEP should partner with DHSS and other appropriate organizations to systematically examine impacts and management options for dealing with indoor environmental problems (both air pollution and others), and to take action against these problems. There will be challenges to moving beyond the current limited focus on education and persuasion for just some of these pollutants. A particularly difficult problem is addressing pollution inside private residences, since the tradition has been to have the home-owner take responsibility. However, there is precedent for government involvement even here (e.g., in building codes), homeowners clearly need help in dealing with such problems, and the Steering Committee believes that government, in partnership with others, can produce creative solutions.

Clearly there is insufficient information about several environmental threats; increased monitoring, data assessment and research may help design and implement effective risk reduction strategies. Several stressors pose known risks but the sources of pollutants are uncertain and the identification of geographic or demographic population areas at risk is incomplete. Monitoring programs may help the state focus resources in geographic areas or economic sectors that will provide the greatest benefit, as in tracking invasive species and certain air pollutants. Trend judgments by the experts also offer a basis for making these decisions. For example, potentially worsening trends for such problems as global climate change, zebra mussels, and genetically modified organisms imply that certain areas or types of impacts deserve to be targeted for monitoring to provide an early warning in case impacts may threaten human or ecological health. More research on some issues will help in understanding future policy options. Although for many stressors sufficient data were available to give experts great confidence in their judgments of relative impact, this was not true in all cases. For example, indoor asthma inducers and pesticides ranked high in both health impact and uncertainty; research to clarify interactions of asthma causes and monitoring to determine the extent of indoor pesticide exposure would be helpful. Among stressors with high ecological impact, the ratings of historical-use pesticides were highly uncertain; monitoring of bird and water concentrations and research on endocrine disruption and immunity effects are needed. Several other stressors (such as Cryptosporidium, pets as predators and extremely low frequency radiation, among others) received "Low" overall scores for human health or ecological impacts, but the ranking was highly uncertain.

We are not recommending that priority setting and stressor reduction must await resolution of these uncertainties. Impact reduction opportunities might be effective and efficient even in the face of uncertainty; "paralysis by analysis" is not our intention. However, where existing management options are difficult or expensive to implement, with serious doubts about whether they will actually reduce net environmental impacts, targeted research and monitoring can be a vital step toward identifying the best actions.

A high priority should be placed on identifying and targeting sources that produce multiple stressors. Stressors that co-occur (i.e., come from the same sources, often as the result of identical processes) offer the potential for more effective environmental management, since strategies directed at reducing emissions of one of these stressors may in many (but not all) cases reduce the others as well. Air pollutants are one example where a set of stressors (e.g., "greenhouse" gases promoting global climate change; outdoor air pollutants; air toxics) can be jointly reduced by single actions (e.g., more efficient energy use; alternative fuels; emission reductions technology). Even if some of the affected stressors rank low in relative impact, a focus on tackling common sources can still maximize the reduction in impacts from a given expenditure of resources and time. Although DEP and the private sector are already doing this to some extent for air pollutants, this approach can be emphasized, and extended to other areas (e.g., curbing the spread of invasive plant species). As part of its mandate, NJCRP was asked to identify the sources of stressors, a less detailed version of the source allocation of pollutants in the Netherlands green plans. The result (see pages 72-73) is not sufficient for such targeting but does provide a useful first step.

State officials and New Jersey's Congressional delegation should seek assistance from the federal government in dealing with sources originating outside New Jersey borders and other problems that can benefit from federal assistance. Criteria air pollutants, such as NO_x (also a precursor to the criteria pollutant of ground-level ozone) and SO_x, blown into the state to exacerbate locally-derived air pollution, and pollution of water bodies (e.g., New York-New Jersey Harbor estuary, Delaware River) are well-known examples of this problem. Emission of "greenhouse gases" has global sources and global climate change impacts, and some invasive species (such as zebra mussels, not yet observed in New Jersey, but likely to appear in the next few years), are examples whose impacts have not yet occurred but also involve out-of-state sources. New Jersey has been trying to deal with transboundary air pollution for several years (e.g., in the Ozone Transport Assessment Group, active in the 1990s), and is the first state to set a numerical target for reducing its own emissions of greenhouse gases, in part as a means to set an example to others. New Jersey has a responsibility to take action on its own sources of these stressors. But federal legislation could stop the sales of invasive plants as landscaping ornamentals. Federal laws also could place restrictions on air pollutants, either through efficiency standards or reduced pollutant limits, as well as hold others accountable.

Several problems do not involve out-of-state sources, but can benefit from federal assistance. Changing land use may require a coordinated strategy combining local government zoning authorities, state agency funding priorities, and changes in federal policies to reduce dispersed development.

Uncertainties about basic mechanisms of stressor action (i.e., toxicology) require federal support for research, and New Jersey's Congressional delegation should ensure that the appropriate agencies (e.g., Environmental Protection Agency [EPA]; National Institutes of Health) have the necessary resources.

Local discussions of comparative risks may yield important new environmental protection efforts. Several environmental problems identified in this report will be difficult to manage at a state level. Varying local conditions, or the need to promote changes in behavior in a broad base of local citizens suggests that local discussions of relative risk could be productive in such areas as obtaining more local, detailed monitoring data or local planning leading to beneficial changes in land use decisions. Although this project reported geographic areas at particular risk where this information was available it focused on statewide impacts. Localities have environmental problems that may differ from statewide averages, and exploring what those are may help inform local governments' ability to set their own priorities.

A pilot local comparative risk project has begun in New Jersey as a collaboration between New Brunswick and Rutgers University. DEP's initial environmental partnerships with cities and counties and its watershed management efforts provide potential vehicles for further comparative risk project work at the local level. Making NJCRP analyses and rankings available on the World Wide Web, as planned, is an additional opportunity for fostering deliberation among New Jersey citizens about relative environmental impacts and priorities at all geographic and political levels.

NJCRP results should be used by DEP as part of its risk-based and performance-based management system, to ensure that the agency's goals, objectives, environmental indicators, and action priorities are addressing important opportunities to reduce negative environmental impacts.

DEP has made great progress in improving its ability to identify where progress in environmental quality is or is not being made, and whether its efforts are directed appropriately, since its strategic planning began in 1995. However, NJCRP analyses have the potential to add further insight, and the agency should take advantage of that opportunity.

The State should consider repeating NJCRP at regular intervals, because it is a strong and useful complement to topic- and program-specific analyses. DEP will review NJCRP's eventual contribution to the agency's strategic planning and to environmental progress before deciding whether to pursue another round of the Project. Our own experience has shown that the educational value of this exercise, for participants and audiences alike, is by itself reason to seriously consider repeating the NJCRP, and that its planning value will be demonstrated. EPA sponsored similar comparative risk projects for metropolitan areas, municipalities, tribes, and watersheds for several years, and their results consistently support our beliefs regarding its value as a complement to topic-specific and program-specific analyses.

Given the slow changes in environmental conditions and the time necessary to enact program changes through planning and implementation, we suggest that the Comparative Risk Project need not be repeated at the state level for at least ten years.

Stressor Summaries

STRESSOR SUMMARIES

This section includes brief summaries of the information on stressor impacts produced by the Technical Working Group (TWG) analyses.

The purpose of these summaries is two-fold:

- Provide background information as a rationale for the stressor rankings given earlier
- Provide an introduction to the much more detailed information about the stressor and its impacts that appears in the analyses in Appendices 3-6

Each summary contains the following information:

- The name of the stressor
- The rankings given by each TWG that analyzed the stressor (see symbol key below)
- A trend indication (better, same, worse)
- A definition of the stressor and description of the kind of impacts it can cause in general
- A "What's at risk?" section outlining the areas or populations (human or ecological) in the state that are potentially threatened by negative impacts of the stressor
- One or more sections entitled "What are the [human health, ecological, and/or socioeconomic] impacts in New Jersey?," summarizing the type and magnitude of these impact types that seem most likely in the state
- A "What's being done?" section that describes the degree to which regulations or other environmental management strategies are currently being used to reduce the stressor's impacts.

Ranking Index

H	High
M - H	Medium-High
M	Medium
M - L	Medium-Low
L	Low

Although the NJCRP aimed to keep stressor names and definitions as consistent as possible across Technical Working Groups (TWGs), this was not always possible. These inconsistencies fall into the following categories:

- The nature of differing health, ecological or socioeconomic impacts. For example, for pesticides the Health TWG chose to focus on, and distinguish among, different routes of exposure: air, water, food, and (via skin contact as well as breathing) indoors; the Ecological TWG felt the distinction between historic uses (leading to concentrations of pesticides left in soils and sediments) and current uses was more pertinent to ecological impacts. The Socioeconomic TWG chose a single comprehensive analysis of pesticides, on the judgment that these impacts would not vary in kind across the types the other TWGs were defining (as well as reducing the workload of a TWG doing more analyses than the other groups). A separate summary was written for each of these except the socioeconomic result, which was inserted as a standard item in each pesticide summary.
- Convenience. With its larger workload, the Socioeconomic TWG was probably most inclined to combine multiple related stressors into one analysis. For example, it produced a single "Invasive Plants" analysis, to avoid having separate analyses for each of the ten individual plant analyses (see Appendix 4) that the Ecological TWG produced, and combined Radon and Radium into a single analysis. By contrast, for the other TWGs such combinations were most likely for "residual" stressors—that is, where some members of a large class of stressors seemed to deserve individual treatment (e.g., their impacts were judged to be higher, and/or they had a higher public profile and thus merited separate attention and/or there was more information about them), but analysts did not want to ignore the remaining stressors in that category. One Ecological summary (and its rankings in earlier tables in the report) comprises "Invasive Plants," in order to avoid having separate summaries or rankings for each of the ten individual plants analyzed.

Overlapping Stressors

The table below shows examples of stressors that fall into related categories, but may be assigned different names within or across Technical Working Groups (TWGs). For example, the first row shows that ecological impacts of habitat loss and fragmentation, and of impervious surfaces, are included in the analysis of socioeconomic impacts of land use change. The fourth row shows another form of overlap: each of the TWGs wrote an Endocrine Disruptors analysis, but each also separately analyzed other stressors (e.g., dioxins, phthalates) that do or may have endocrine-disrupting properties. A similar phenomenon occurs for volatile organic compounds (VOCs). Note that a given stressor may appear in more than one of these overlap categories (e.g., disinfection byproducts).

Table 16. Overlapping Stressors

HEALTH	ECOLOGICAL	SOCIOECONOMIC
	Habitat loss Habitat fragmentation Increase in impervious surface	Land use change
Radionuclides	Catastrophic radioactive release	Catastrophic radioactive release
	Invasive plants (separate analyses of tree-of-heaven, Norway maple, multiflora rose, Japanese barberry, Asiatic bittersweet, Japanese honeysuckle, garlic mustard, purple loosestrife, Japanese stilt grass, common reed)	Invasive Plants
Dioxin Endocrine disruptors PCBs Phthalates	Dioxin Endocrine disruptors PCBs Pesticides, historic & current Phthalates Tin (tributyltin)	Dioxin Endocrine disruptors PCBs Tin (tributyltin)
Pesticides, indoor Pesticides in drinking water Pesticides in food Pesticides, outdoor	Pesticides, historic Pesticides, current	Pesticides
Radium Radon	Radium Radon	Radium Radon
Nitrogen oxides Nitrogen pollution Ozone (ground level) Sulfur oxides	Acid precipitation Nitrogen pollution Ozone (ground level)	 Nitrogen pollution Ozone (ground level) Sulfur oxides
1,3-butadiene Acrolein Benzene Disinfection byproducts Formaldehyde MTBE Ozone (ground level) Volatile organic compounds (VOCs), carcinogenic VOCs non-carcinogenic	VOCs Ozone (ground level)	1,3-butadiene Acrolein Benzene Disinfection byproducts MTBE Ozone (ground level) VOCs
Cryptosporidium Legionella Waterborne pathogens		Cryptosporidium Legionella Waterborne pathogens
Deer (collisions) Lyme disease	Deer	Deer (including Lyme disease)

Table 17. Issues Rankings (alphabetical order)

	Human Health	Ecological	Socioeconomic		Human Health	Ecological	Socioeconomic
1-3-butadiene	M		M - L	Genetically modified organisms		L	L
Acid precipitation		M - L		Greenhouse gases	L	M - L	M - L
Acrolein	M		M - L	Green/red tides		L	L
Airborne Pathogens	M - L			Habitat fragmentation		H	
Arsenic	M	M - L	M - H	Habitat loss		H	
Asian longhorned beetle		L	L	Hanta virus	L		L
Benzene	M		L	Hemlock woolly adelgid		M - H	M - L
Blue-green algae		L		Inadvertent animal mortality		M	M
Brown tide		M - L	L	Increase in impervious surface		M - H	
Cadmium	L	M	L	Indoor asthma inducers	M - H		M - H
Carbon monoxide	M - H *indoor* | M - L *outdoor*		L	Indoor microbial air pollution	L		M
Catastrophic radioactive release		M	M - L	Invasive plants		M	M
Channelization		L		Land use change			H
Chromium	M	M - L	M - L	Lead	H	M	H
Copper		M - L	L	Legionella	M		L
Cryptosporidium	M - L *recreational water* | L *drinking water*		L	Light pollution		L	M - L
Deer		M	M - H	Lyme disease	L		
Dermo in oysters		L	M - L	Mercury	M	M - H	M - L
Dioxin and Furans	M - H	M - L	M	Methyl tertiary butyl ether (MTBE)	L		M - L
Disinfection byproducts	M		L	MSX parasite in oysters		L	M - L
Dredging		M - L	L	Nickel	L	M - L	L
EHD virus in deer		L	L	Nitrogen oxides (NOx)	M		L
Endocrine disruptors	M	M	M	Nitrogen pollution	L	M	L
Extremely low freqency/ electromagnetic fields	L	L	M - L	Noise	L	M - L	M
Floatables		L	M - L	Off-road vehicles		M - L	L
Formaldehyde	M		M - L	Overharvesting (marine)		M	L
Geese		M	L	Ozone (ground level)	H	L	M

Ranking Index

H = High
M-H = Medium-High
M = Medium
M-L = Medium-Low
L = Low

Table 17. Issues Rankings (alphabetical order) - continued

	Human Health	Ecological	Socioeconomic
Particulate matter	H		M - H
Pesticides			M - H
Pesticides, present use		M - L	
Pesticides,food	M		
Pesticides, historic use		M - H	
Pesticides, indoor	M - H		
Pesticides, outdoor	M		
Pesticides, water	M		
Petroleum spills		M	M - H
Pets as predators		L	L
Pfiesteria	L	L	L
Phosphorus		M	M - H
Phthalates	M	L	
Polychlorinated biphenyls (PCBs)	H	M	M - H
Polycyclic aromatic hydrocarbons(PAHs)	L	M - L	M
QPX parasite in shellfish		L	L
Radionuclides	L		
Radium	M - H		L
Radon	H		M
Road Salt		L	L
Secondhand tobacco smoke	H		M - H
Starlings		M	L
Sulfur oxides (SOx)	M - L		M
Thermal Pollution		L	L
Tin		M - L	L
Ultraviolet radiation	M	M - H	M - H
VOCs		L	M - L
VOCs, carcinogenic	M - H	L	M - L
VOCs, non-carcinogenic	M - L	L	M - L
Waterborne pathogens	M (recreational water) | L (drinking water)		M - L
Water overuse		M - L	M
West Nile Virus	L	M - L	L
Zebra mussels		L	L
Zinc		M - L	L

Ranking Index
H = High
M-H = Medium-High
M = Medium
M-L = Medium-Low
L = Low

STRESSOR SUMMARIES

1,3-butadiene

Human Health Risk	**M**
Ecological Risk	
Socioeconomic Risk	**M - L**

1,3 -butadiene is a volatile chemical with a gasoline-like odor. It is used in the production of rubber and plastics, and is also a byproduct of incomplete combustion. Motor vehicle exhaust is the largest source of butadiene in New Jersey. Due to its volatility, the impacts of butadiene primarily result from the inhalation of contaminated air (see also the summary for Volatile Organic Compounds). At concentrations in air likely to be encountered in New Jersey, 1,3-butadiene may irritate the eyes, nose, and throat. Butadiene is classified as a known human carcinogen.

What's at risk?

The entire state is exposed to ambient levels of 1,3-butadiene as a result of motor vehicle traffic. People whose health is otherwise compromised may be at greater risk for health effects. Individuals living or working near traffic arteries are likely to be exposed to higher concentrations than rural residents. Individuals operating lawn mowers, motor boats, chainsaws, and other types of motorized equipment could also be exposed to higher levels, as 2-cycle engines appear to emit much greater quantities of butadiene than motor vehicles.

What are the human health impacts in New Jersey?

The average concentration of 1,3-butadiene in outdoor air was measured in Camden in 1997. This concentration (0.07 parts per billion), if extrapolated to the entire state, could be expected to result in 2-3 additional cancers per year statewide. However, concentrations are likely to be lower in less urban areas, and most people spend much of their day indoors, where concentrations are lower. Therefore, measured concentrations are likely to overstate the actual cancer risk.

What are the socioeconomic impacts in New Jersey?

Based on National Institutes of Health studies, medical costs for the treatment of cancer average $60,000 per case. Thus there are likely to be some costs associated with the effects of butadiene exposure. There are property value impacts associated with air pollution generally, a portion of which may be attributable to butadiene.

What's being done?

Concentrations of 1,3-butadiene in outdoor air have been decreasing. Like carbon monoxide, butadiene is a product of incomplete combustion, and its presence in automobile exhaust is controlled to a significant degree by catalytic converters. Regulations aimed at reducing ozone levels through the control of VOCs continue to reduce emissions of butadiene.

Acid Precipitation

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	M - L

Sulfur dioxide and nitrogen oxides are air pollutants that may be distributed hundreds of miles from their original sources. Coal burning power plants are the primary sources of sulfur emissions, while automobiles are largely responsible for emissions of nitrogen oxides. Both types of pollutants are acidic, and contribute to the acidification of lakes and streams when they are washed out of the atmosphere via rain, snow, and other precipitation. Other risks associated with each pollutant individually are discussed separately.

What's at risk?

Impacts to aquatic ecosystems are the primary concern, although forest systems are also affected by acid precipitation.

What are the ecological impacts in New Jersey?

Trout are especially sensitive to acidic conditions, and there have been occasions in New Jersey where reproduction has been reduced or halted as a result of melting of highly acidic snows. The natural buffering capacity of streams and lakes determines the extent to which they are affected by acid precipitation. Most New Jersey waterbodies have good buffering capacity, which somewhat protects these ecosystems from the impacts of acid deposition. So while the entire state receives acid precipitation, only 5-10% of New Jersey habitats are vulnerable to its effects.

What are the socioeconomic impacts in New Jersey?

Acid precipitation (particularly dry deposition) can cause discoloration of, or eat away at, stone buildings, monuments, and tombstones. Effects appear to be primarily aesthetic, less than the impacts of non-acidic rain, and can be fixed fairly easily. Socioeconomic impacts are likely to be low in New Jersey.

What's being done?

Sulfur dioxide emissions from power plants and nitrogen oxide emissions from vehicles are regulated under the Clean Air Act. Improvements made in control technologies can be offset, however, by increasing energy and fuel use.

Acrolein

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	M - L

Acrolein is a reactive chemical with a piercing odor that is a by-product of combustion. It is chemically similar to formaldehyde, and has similar effects. It is used in the synthesis of some chemical products, including tear gas, but most of the acrolein in the environment is the result of fossil fuel emissions from industrial and vehicle sources. Acrolein is an irritant, affecting mucous membranes and the eyes. It may also affect respiratory function, particularly in children.

Who's at risk?

Acrolein is a pervasive pollutant with higher concentrations in urban areas. Therefore, urban areas are exposed to increased risk compared with less urbanized areas in the state. Data are currently insufficient to evaluate indoor exposures. Children are more susceptible to infections after exposure and those reporting Multiple Chemical Sensitivities (MCS) may be particularly susceptible to acrolein because of its odor, and the relationship between odor and MCS symptoms.

What are the human health impacts in New Jersey?

Monitoring has shown that exposures in urban areas can be twenty times the Reference Concentration established by EPA. While these levels are still below the concentration at which laboratory (animal) studies have produced observable health effects, there may be thousands of people that will experience the irritant effects of acrolein. In other areas of the state, acrolein may contribute to respiratory irritation resulting from exposure to low levels of multiple respiratory irritants. There are approximately 330,000 children under age three in New Jersey that are potentially at risk for immune system effect; although the risk of such effects is considered low, a subset of these children reside in urban areas.

What are the socioeconomic impacts in New Jersey?

No individual socioeconomic factor poses a large risk in New Jersey, although acrolein contributes to reduced property value and increased medical costs associated with air pollution generally. The total costs for air pollution damage approach one billion dollars in lost property values and several million dollars in medical costs. Acrolein is a small part of the overall air pollution problem.

What's being done?

Acrolein concentrations are reduced as the result of general pollution controls on combustion sources.

Airborne pathogens

Human Health Risk	M - L
Ecological Risk	
Socioeconomic Risk	

Airborne pathogens include fungal spores and bacteria that are released to the air during wastewater treatment, sanitary landfill operations, composting, and various farming practices. Sources of these pathogens include fungal growth associated with warm wet areas, and agricultural activities that generate large quantities of organic dusts that may contain high concentrations of bacterial toxins. Some pathogens are associated with bird or bat droppings. Human health effects include respiratory infections, allergic responses, eye, nose and throat irritation, as well as more severe cases involving fever and shortness of breath. Related reports include *Legionella*, Hantavirus, indoor microbial pollution, and indoor asthma inducers.

What's at risk?

Exposure to low levels of airborne spores is universal, but disease is uncommon. Infants and the elderly are particularly subject to fungal infections. Individuals with compromised immune systems or other underlying disease are more susceptible to the health effects that may result from exposure to airborne pathogens. Asthmatics are also especially sensitive to fungal allergens. Workers near concentrated sources such as composting facilities are at increased risk of exposure, as are people who are occupationally exposed to higher than normal concentrations of bird or bat droppings.

What are the human health impacts in New Jersey?

There is very little information regarding the number of illnesses that may be attributed to airborne pathogens. Thresholds for allergic response are regularly exceeded near composting facilities. In some cases, elevated levels may exist up to 1 kilometer from the facility. Dust-inducing agricultural practices can produce concentrations of bacterial toxins far in excess of those known to affect lung function. Natural sources such as bird and bat droppings may also result in localized exposures to elevated levels of pathogens.

What's being done?

There are no regulations on airborne pathogen generation. Occupational guidance is available for protecting workers from exposure.

Socioeconomic costs probably run in the tens of millions.

Arsenic

Human Health Risk	M
Ecological Risk	M - L
Socioeconomic Risk	M- H

Arsenic is a trace element normally found in soil, water, food, and the human body. Trace amounts are believed to be essential for life. The former widespread use of arsenic in pesticides, its release from copper smelting, and its continued use in metal plating and wood treatment has resulted in greater concentrations of arsenic in certain areas. An inorganic form of arsenic, arsenic trioxide, is a known human carcinogen and is associated with cancers of the lung, skin, liver, kidney, and bladder. Inorganic arsenic may also cause neurological disorders.

STRESSOR SUMMARIES

What's at risk?

Up to 5% of New Jersey's land acreage may be affected by historical use of arsenical pesticides, and inadvertent ingestion of contaminated soil by children may occur. Lead arsenate was a pesticide used in fruit orchards, vegetable fields, golf courses, and turf farms, and conversion of such land to residential use provides opportunities for exposure through soil ingestion. Others at risk include individuals with elevated arsenic levels in their public water supplies or private wells, and industrial workers exposed to inorganic arsine gas released into the air.

What are the human health impacts in New Jersey?

A large fraction of the New Jersey population is exposed to slightly elevated levels of arsenic in the air. About 5 million residents are potentially at risk due to ground water sources of drinking water. Estimates show less than one case of cancer per year statewide is due to inhalation of ambient levels of arsenic in air.

What are the ecological impacts in New Jersey?

A large number of plant and animal species may be affected, potentially altering biological integrity, biodiversity and ecosystem health. Most historic exposures and effects have occurred in the vicinity of manufacturing or hazardous waste sites. Data on specific effects on organisms and populations, as well as a better assessment of the distribution of arsenic from widespread agricultural use, would help determine the ecological effects of arsenic exposure.

What are the socioeconomic impacts in New Jersey?

Socioeconomic impacts of arsenic include the costs of bladder and lung cancers, and the associated loss of productivity, which are estimated to be over $16 million per year. Assuming a 5% drop in property value for contaminated sites, property value losses may total over $2 billion to which arsenic contributes. Property values have been shown to rebound to normal levels once cleanup has been completed. Arsenic, along with other constituents of hazardous waste sites, is likely to cause high levels of worry for New Jersey residents unsure about the impacts of contamination in their areas.

What's being done?

The use of arsenical pesticides has been discontinued. Arsenic is included in federal regulations on air emissions, hazardous waste, and other environmental programs. In 2001, EPA reduced the acceptable level of arsenic in drinking water from 50 parts per billion to 10 ppb. New Jersey DEP has adopted a soil cleanup standard to apply in remediation of hazardous sites and has convened a task force to address historic pesticide contamination.

Asian longhorned beetle

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

The Asian longhorn beetle is an insect indigenous to China. The beetle has inadvertently been brought into the United States via Chinese imports shipped in solid wood packing material. Since its discovery in 1996, the beetle has been detected in warehouses in 14 states, including three in New Jersey. As with other wood boring pests, the beetle is a serious threat to many species of hardwood trees, especially maples. It has no natural enemies in the western hemisphere, and current treatment efforts focus on the destruction of infected trees.

What's at risk?

If introduced into New Jersey's forest ecosystems, potentially all the state's hardwood forests are at risk of damage from this beetle. There are approximately 1,991,000 acres of forested land in New Jersey.

What are the ecological impacts in New Jersey?

Beetles have been found in warehouses in Cream Ridge, Linden, and New Brunswick. Currently, there is no known forest infestation. If introduced into New Jersey ecosystems, the insects can be spread by movement of infested wood (firewood, lumber) and by adult beetles flying to nearby trees. The beetle affects terrestrial ecosystems by infesting and killing many species of hardwood trees. Destruction of trees could reduce the abundance of native species, increasing the proportion of invasive exotics such as Japanese barberry. Extensive forest loss can result in changes in forest function and lead to secondary impacts (e.g., increased erosion).

What are the socioeconomic impacts in New Jersey?

Although the potential impact could be enormous, the slow natural spread of the beetle, vigorous efforts to limit entry of new insects into the U.S., and immediate eradication of infestations when found should keep socioeconomic costs minimal for the foreseeable future.

What's being done?

The New Jersey Department of Agriculture maintains a Pest Detection Program and the New Jersey Forest Service (in DEP) has an Insect and Disease Management Program. In addition, the U.S. Department of Agriculture maintains forest monitoring programs, requires special treatment of wooden crates shipped to the United States, and quarantines affected areas. Although it is possible that the beetle has escaped detection in New Jersey ecosystems, the insects appear to spread relatively slowly. It is likely that federal and state surveillance efforts would detect an infestation before it reached widespread, catastrophic proportions.

Benzene

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	L

Benzene is a colorless liquid which is present as a constituent of petroleum. It has industrial application as a chemical intermediate and as solvent. Benzene is added to gasoline to increase the octane rating and is also a minor constituent of tobacco smoke. People become exposed to benzene through inhalation of vapors that are present at low background levels in the environment, as well as at elevated levels in some specific environments, particularly at gas stations. Benzene can contaminate ground water used for drinking, mostly as the result of leaking petroleum storage tanks. Benzene is a human carcinogen. It is also toxic to the liver and central nervous system, but these non-cancer effects are uncommon in non-occupational settings.

STRESSOR SUMMARIES

What's at risk?

The general population is exposed to relatively low, background concentrations and higher levels when fueling vehicles with gasoline containing benzene. Individuals working at service stations and in industrial facilities using benzene would have higher exposures than the general public. Drinking water is a potential source of exposure, but known cases of benzene-contaminated drinking water are quickly addressed.

What are the human health impacts in New Jersey?

Excluding occupational exposures, the general public is exposed to outdoor benzene levels that may result in a total of 30 to 109 additional lifetime cancer cases in New Jersey. The higher rate reflects exposures in more urban areas. This amounts to between 0.4 and 1.6 additional cases per year attributable to benzene. Non-cancer risks from benzene are likely to be low. This assessment did not focus on indoor exposures which may be significantly higher than exposures to outdoor ambient conditions.

What are the socioeconomic impacts in New Jersey?

No impacts are hypothesized with respect to unemployment or aesthetics. There is no evidence that the public is seriously concerned, or property values in New Jersey are negatively affected. Medical costs associated with the potential health effects of benzene are well below the threshold for moderate impacts, thus the socioeconomic impacts of benzene are judged to be low.

What's being done?

The benzene content of gasoline is regulated, and the use of benzene in consumer products is being phased out. Benzene in drinking water is often monitored in areas where there is a history of contamination.

Blue-green algae

Human Health Risk	
Ecological Risk	**L**
Socioeconomic Risk	

Blue-green or toxic freshwater algae thrive in eutrophic lakes and reservoirs. Eutrophication or growth of algae is a natural process of aging lakes that can take thousands of years, but it is often hastened by human addition of fertilizers and other nutrients. Like other forms of phytoplankton, blue-green algae grow excessively under these high-nutrient conditions. Also known as cyanobacteria, these toxic algal blooms appear as scum along shorelines, cause pungent odors and tastes in drinking water, and can cause fish kills. Freshwater algae blooms are readily treated with algicides, which are commonly used in water treatment processes and applied directly to affected water bodies that may be used for swimming.

What's at risk?

Livestock, pets, and wildlife are potentially at risk for ingesting water contaminated with toxic algae in eutrophic lakes, ponds, and reservoirs throughout the state. There is a potential for humans to become exposed to the toxin by ingesting water that has been treated for cyanobacteria. There is evidence that commonly used algicides promote rapid die-off of algae cells, consequently releasing harmful quantities of toxins subsequent to treatment.

What are the ecological impacts in New Jersey?

There is no information on the extent of impacts to New Jersey aquatic ecosystems from blooms of freshwater algae. Excessive algae interferes with light penetration and reduces oxygen levels in the water, creating adverse impacts to aquatic plants and organisms throughout the food chain. Moreover, the toxicity associated with cyanobacteria has the potential for causing massive fish kills, but there are no documented reports of this in New Jersey. Blooms have been severe enough to interfere with water intakes and treatment processes in New Jersey.

What's being done?

Studies have shown that lime or alum treatment may be preferable for the control of toxic algal blooms because these treatments appear to leave the cells intact after death, thus reducing the risk of releasing toxins via the control agent. However, neither material is registered by the EPA for use as an algicide. Further investigation is warranted regarding the presence of cyanobacteria in drinking water and/or swimming areas that have been treated for algal blooms.

Brown tide

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	L

Brown tide blooms are caused by rapid growth of a golden-brown algae in shallow saltwater estuaries. Natural processes that result in high salinity and low flow conditions could be causing these blooms, which typically occur during the months of May to July, and sometimes again in early fall.

What's at risk?

Blooms are a recurring natural phenomenon in southern Barnegat Bay and Little Egg Harbor. Blooms have also been documented in Great Bay, coastal bays, and Great Egg Harbor. Any shallow estuary with similar characteristics and the right combination of environmental variables could develop a brown tide bloom, potentially affecting 25-50% of the state's estuarine waters. Socioeconomic effects are restricted to bay-front property owners, commercial shellfish producers, and recreational users in Barnegat Bay and Little Egg Harbor.

What are the ecological impacts in New Jersey?

Recurring brown tide blooms have been documented for five of the past seven years. In 1999 and 2000, the blooms were significantly more severe. Blooms discolor the water, reducing the amount of light penetration, and subsequently the growth of underwater vegetation such as eelgrass. Eelgrass beds provide nursery habitat for young aquatic animals and are necessary to sustain healthy populations of fish and shellfish. Blooms also interfere with feeding and growth of juvenile clams, mussels, and scallops. Unusually high mortality rates (up to 80%) for bay scallops have been documented in Long Island bays experiencing brown tide blooms. Research is needed to determine the similarities between Long Island and New Jersey bay conditions to accurately assess risks to New Jersey bays. Populations may rebound once the bloom subsides, but blooms lasting longer than one to two months may cause severe impacts to shellfish populations.

What are the socioeconomic impacts in New Jersey?

Brown tide blooms are a significant concern in areas where they occur. Bay front property values may be negatively affected and there is a local employment impact associated with a reduction or loss of shellfish. However, these socioeconomic effects are restricted to a relatively small number of bay-front property owners, commercial shellfish producers, and recreational users in Barnegat Bay and Little Egg Harbor. Thus the statewide socioeconomic impacts are judged to be low.

What's being done?

The Brown Tide Assessment Project was established in 2000 to monitor the spatial and temporal extent of brown tide blooms through 2002. Because brown tide blooms are natural phenomena, environmental and biological factors need to be studied in order to assess the extent of impacts on marine ecosystems and to develop effective management strategies.

Cadmium

Human Health Risk	L
Ecological Risk	M
Socioeconomic Risk	L

Cadmium is a rare, naturally-occurring metal found in the atmosphere as a result of volcanic activity, ocean spray, and forest fires. Industrially, cadmium is used in electroplating processes, pigments, batteries, plastics, and alloys. Exposure can occur through direct ingestion of contaminated soil and by ingestion of plants grown in contaminated soil. Relatively high concentrations of cadmium can occur in shellfish. Shellfish ingest sediments as they feed, which may expose humans who consume them to harmful levels. Human exposures can also result from air and drinking water concentrations. Chronic low level exposures may result in kidney damage, and cadmium is a carcinogen by inhalation.

What's at risk?

The general population is exposed to low levels of cadmium in food. Subpopulations at increased risk include subsistence fishing populations and others who consume shellfish from cadmium concentrated waters. Increased dietary exposure may also result from consumption of crops grown on soil amended with cadmium-containing sludge. Freshwater aquatic organisms are most sensitive to cadmium, marine organisms are less sensitive, and mammals and birds are comparatively resistant. Since cadmium bioaccumulates, freshwater species higher on the food chain are particularly vulnerable.

What are the human health impacts in New Jersey?

Background levels to which the general population is exposed (including food, air, and drinking water pathways) are estimated at 30-50 micrograms per day. More than 95% of this exposure results from levels of cadmium in the general food supply. Changes in kidney function have been observed beginning at 200 micrograms per day. The extent to which these changes predict serious kidney problems is unclear. However, recent research indicates that even at background levels, about 1% of the population may develop adverse health effects. Subsistence shellfishing populations may be exposed to cadmium levels seven times higher than background, placing them over the threshold for changes in kidney function. New Jersey air concentrations are below the level at which scientists expect additional cancers might occur. There are few data indicating that cadmium exposure in New Jersey results in significant kidney effects.

What are the ecological impacts in New Jersey?

There are no regions in the state with excessively high cadmium levels as a result of industrial waste, however, the high sensitivity of aquatic invertebrates puts all aquatic habitats potentially at risk. These organisms are an integral part of the food chain, and cadmium can accumulate virtually everywhere as a result of atmospheric deposition. While there is no regular monitoring for cadmium in New Jersey, soil sampling for cadmium near contaminated sites has shown elevated levels. In most cases, the samples exceeded the benchmark by a factor of two or less.

What are the socioeconomic impacts in New Jersey?

Available evidence does not indicate that cadmium poses a threat to employment or property values. Estimates indicate that the cost of illnesses associated with cadmium are low, however, the damage to kidney function is permanent. Therefore, the socioeconomic risks are judged to be low to medium.

What's being done?

Industrial discharges of cadmium to the environment are regulated, and cadmium-contaminated hazardous waste sites are cleaned up in accordance with federal and state law. There are no regulations on food, which is the biggest source of exposure in human populations. Use of cadmium in consumer products is being reduced.

Carbon Monoxide (CO)

	indoor	outdoor
Human Health Risk	M - H	M - L
Ecological Risk		
Socioeconomic Risk	L	

Carbon monoxide (CO) is a colorless, odorless gas formed as a byproduct of incomplete combustion. A component of motor vehicle exhaust, as much as 95% of outdoor concentrations may be attributed to vehicle emissions in urban areas. Carbon monoxide may also concentrate indoors as a result of improperly functioning home appliances such as furnaces, water heaters, and gas stoves. When inhaled, carbon monoxide affects the body's ability to bind oxygen to hemoglobin in the blood, depriving the body of oxygen. At low levels of exposure, symptoms associated with decreased oxygen availability may result; for example, CO may trigger an attack in angina patients. Extreme exposures can result in asphyxiation and death.

What's at risk?

The general population is exposed to low levels of carbon monoxide in the ambient (outdoor) air. Residents of urbanized areas are exposed to slightly higher levels, as are any individuals spending time in locations with a high concentration of vehicles (e.g., parking garages, traffic congestion). Households with gas appliances may be exposed to concentrations up to 15 times greater than ambient outdoor levels. Elderly residents are at increased risk of congestive heart failure resulting from the effects of CO exposure. The approximately 35,000 angina sufferers in urban New Jersey counties are particularly susceptible to the effects of carbon monoxide at observed levels. Smoking cigarettes increases personal exposure to CO significantly.

What are the human health impacts in New Jersey?

The National Ambient Air Quality standard for carbon monoxide is 9 parts per million (ppm) averaged over an 8-hour period, and 35 ppm maximum over a 1-hour period. Annual averages in New Jersey are in the 1-2 ppm range. About 1% of the time, urban counties may show slightly elevated concentrations, while remaining below the national standard. Health effects at these levels include the aggravation of angina or other conditions that are associated with decreased oxygen availability. About 35,000 urban residents suffer from chronic angina. Carbon monoxide has also been linked to congestive heart failure, especially among the elderly. About 6% of congestive heart failures in urban areas may be associated with elevated CO levels. At very high levels of exposure, CO can be deadly. Based on national estimates, about 400 New Jerseyans require medical attention for CO poisoning each year, with 4-25 deaths resulting. These exposures are generally due to intentional exposures to vehicle exhaust in enclosed areas, or malfunctioning home appliances.

What are the socioeconomic impacts in New Jersey?

The principal socioeconomic impacts of CO are the costs of health care associated with accidental exposures, heart failure, and treatment of other conditions that may be attributed to elevated levels of carbon monoxide. While it is difficult to estimate the incidence of health problems in New Jersey that are related to carbon monoxide levels, available information suggests these costs may total several million dollars per year.

What's being done?

Carbon monoxide is regulated under the National Ambient Air Quality Standards program. Emissions requirements have resulted in significant improvements over the last 30 years, and maximum recorded levels of CO in New Jersey have remained below the health standard since 1995. Household appliances are constructed to minimize CO generation, but poorly maintained burners may cause significant emissions and are not currently the subject of regulation.

Catastrophic radioactive release

Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	M - L

A catastrophic accident at a commercial nuclear powered generating station would release large quantities of radioactive substances to the environment. The release of radioactive gases, aerosols, and particles, extending over a prolonged period of time, would result in impacts to all living species. A catastrophic release in Chernobyl killed nearby trees and resulted in acute and chronic effects among a wide range of species.

What's at risk?

There are four nuclear power plants in New Jersey and another six in nearby counties of neighboring states. Virtually the entire population is within a 50-mile radius of at least one of these facilities. All species in all ecosystems are susceptible to damage from radioactive release. Plants show a wide range of sensitivities to the effects of radiation and animals generally fall within this range. Mammals are most sensitive, followed by birds, fish, reptiles, and insects. Embryos and juveniles are more sensitive to radiation than adults.

What are the ecological impacts in New Jersey?

A catastrophic release in New Jersey could cause the death of many species, a long term risk for reproduction and development, and the possible extirpation of species already under population pressures due to reduced habitat. The probability of such an event, however, is low.

What are the socioeconomic impacts in New Jersey?

The costs of remediation from a significant accident at a nuclear power facility could be greater than one billion dollars. The psychological effects associated with the low probability of a catastrophic event is small but significant. There may also be property value reductions resulting from the possibility of an accidental release.

What's being done?

The Nuclear Regulatory Commission, the U.S. Environmental Protection Agency, U.S. Department of Energy, and U.S. Department of Transportation are responsible for establishing radiation protection regulations. These agencies work with international organizations to assure that regulations are based on internationally recognized scientific studies.

Channelization

Risk	
Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	

Channelization is the alteration of natural stream drainage patterns for the purposes of flood control or improved navigation. Stream channel alterations may involve dredging, straightening, and the construction of levees. Channelization is a controversial issue: projects can kill aquatic organisms, destroy wetlands, and cause erosion and additional flooding downstream. Some maintain that channelization projects actually increase flood damage in the long run.

What's at risk?

Aquatic systems and associated wetlands and riparian habitat are at risk. Most channelization occurred historically, and in urban areas. However, the U.S. Army Corps of Engineers currently has more than 20 flood control projects in New Jersey, whose taxpayers bear the costs associated with channelization projects. While impossible to predict the location or extent of the damage, it is anticipated that some private property owners downstream of the projects will suffer damage from increased flooding.

What are the ecological impacts in New Jersey?

Negative impacts include loss of habitat, increased flow and erosion, changes in aquatic populations, increased water temperature, and other physical and chemical changes. The majority of impacts most likely occurred historically. The exact extent of channelization in NJ and associated impacts have not been adequately characterized.

What's being done?

Channelization projects increasingly encounter opposition from environmentalists and resource managers who argue that flood control policies should focus on curtailing development rather than futile attempts to alter natural stream channels. Increasing emphasis on storm water programs that reduce paved surfaces and allow for more natural absorption of water may reduce the perceived need for channelization projects. Current flood control projects require minimization and/or mitigation of impacts. State permits are required for encroachment activities, such as channelization.

Chromium

Human Health Risk	**M**
Ecological Risk	**M - L**
Socioeconomic Risk	**M - L**

Chromium is a metallic element that exists in the environment in two different chemical states, Cr^{+3} and Cr^{+6}. Cr^{+3} can occur naturally, Cr^{+6} occurs solely as the result of human processes such as the manufacture of pigments, anti-corrosives, pressure treated wood, chrome steel alloys, and in leather tanning. A strong corrosive agent, Cr^{+6} can cause severe irritation of mucous membranes, skin, and the upper respiratory tract. It is also a prevalent allergen, found in many common home and workplace products. Cr^{+6} is a human carcinogen via the inhalation route of exposure.

What's at risk?

It is estimated that 1-2% of the general population is sensitized to chromium, and there are no known factors leading to increased susceptibility to cancer as a result of exposure to chromium. Exposures are elevated for residents adjacent to some waste sites known to be contaminated with chromium. Approximately 180 sites in and around Jersey City (Hudson County) were used as disposal sites for chromate production waste. Ecosystems are largely exposed via contaminated sediments and soils near waste sites. Drinking water contamination is isolated and sporadic.

What are the human health impacts in New Jersey?

Based on measured levels of total chromium in outdoor air at residences adjacent to historical disposal sites, the cancer risk was calculated at 4.8-8.4 additional cancers per 100,000 people. The number of people exposed on or near waste sites is unknown; however, most of these sites have subsequently been remediated. Average ambient air concentrations in New Jersey are estimated to result in a lifetime cancer risk of 1.7 in 100,000 people, corresponding to 2 excess cancers per year statewide. In the county with the highest estimated ambient air chromium levels the risk is estimated to be 28 times the overall New Jersey average. This estimate, however, is uncertain, as it assumes that Cr^{+6} constitutes a fixed fraction of Cr emissions from all sources. The actual proportion of Cr^{+6} as a fraction of all Cr emissions in New Jersey is currently unknown. Occasional exceedances (two incidents in the past six years) of drinking water standards have temporarily exposed tens of thousands of individuals to concentrations exceeding reference doses for short periods of time.

What are the ecological impacts in New Jersey?

Toxicity to aquatic organisms can lead to changes in biological integrity and biodiversity. In New Jersey, measured concentrations exceed benchmark values in sediments with a greater frequency in inland waters but greater severity in marine waters. Sediments from wetlands also show concentrations exceeding benchmark values. Urban/terrestrial areas with chromium contaminated fill are also at potential risk.

What are the socioeconomic impacts in New Jersey?

No individual socioeconomic factor poses a large risk in New Jersey although some aesthetic, psychological, monetary and employment costs may be evident.

What's being done?

Waste site clean up is slowly reducing the number of sites with known chromate contamination. Drinking water is regularly monitored to ensure that chromium contamination events are infrequent and not severe.

Copper

Human Health Risk	
Ecological Risk	**M - L**
Socioeconomic Risk	**L**

Copper is a metallic element with many industrial and consumer applications. Copper salts such as copper sulfate, are effective algicides that can be toxic to humans and wildlife at high doses. Copper sulfate is an odorless blue or green-white powder or solid that has been widely used to control algae in lakes, ponds, reservoirs, and irrigation systems. Direct application may result in a significant reduction in populations of aquatic life, including invertebrates, plants, and fish. Copper has a low toxicity for humans, although excessive levels in drinking water have resulted in mild symptoms including headaches, nausea, and diarrhea. Potential risks relate primarily to aquatic ecosystems, and a human health risk assessment was not conducted.

What's at risk?

Copper sulfate is very toxic to organisms that eat fish, and highly toxic to fish, amphibians, and crustaceans. The use of copper sulfate for temporary algae control can produce significant zooplankton mortality, and may also adversely affect trout, ornamental goldfish, and other sensitive fish in soft water. Soil organisms at industrial or hazardous waste sites are also at risk.

What are the ecological impacts in New Jersey?

In New Jersey the use of copper sulfate as an algicide has been on the rise since 1992. In addition, several hazardous waste sites contain copper concentrations above threshold values for ecological effects. The greatest impacts are to aquatic systems, due to its direct toxicity and indirectly because of oxygen depletion that results from the decay of large amounts of vegetation. Soil concentrations are below acceptable residential soil benchmarks, so effects on terrestrial systems are probably minimal. While copper continues to be ubiquitous in the environment, there is no evidence of substantial ecological impacts.

What are the socioeconomic impacts in New Jersey?

Costs associated with any copper-related illness appear to be minimal and there is little evidence that copper has enough of an adverse effect on ecosystems to threaten employment (in shellfish harvesting for example) or property values. There is also little reason to conclude that copper produces aesthetic impacts in New Jersey, or creates anxiety.

What's being done?

The use of copper sulfate has been regulated by the DEP Pesticide Control Program since 1989. Chelated copper products are available for use. These are less toxic to fish and aquatic invertebrates.

Cryptosporidium

Human Health Risk	**L** *drinking water*	**M - L** *recreational water*
Ecological Risk	–	
Socioeconomic Risk	**L**	

Cryptosporidum is an intestinal parasite that infects humans and animals. Infections in healthy people can result in relatively minor and self-limiting symptoms including nausea, cramps, diarrhea, and vomiting. In those with weakened immune systems, severe and potentialy life-threatening illness may occur. Egg stage organisms are excreted in the feces of infected individuals and animals, and are found in virtually all lakes, rivers, and streams. Able to resist most forms of chemical disinfection, large numbers of *Cryptosporidium* in public drinking water supplies caused widespread illness in the City of Milwaukee in 1993.

What's at risk?

Three million of New Jersey's eight million residents get their drinking water from surface water sources that could potentially be contaminated with harmful levels of *Cryptosporidium*. People may also become exposed while swimming, or coming in contact with the feces of infected individuals. Wildlife can also be exposed and infected, but ecological impacts are negligible.

What are the human health impacts in New Jersey?

There have been no confirmed reports of outbreaks due to drinking water in New Jersey since 1976. However, it is difficult to estimate how many people are affected by a waterborne illness because not everyone exposed will develop symptoms and many cases go unreported. In healthy populations, the increased number of cases of minor gastrointestinal illness may be as many as 19,000 or as few as 300 per year. Estimates for the subpopulation of immune-compromised people range from less than 1 death per year to a high-end estimate of 5-10 additional deaths per year. There was a single documented case of Cryptosporidium infection from recreational bathing in New Jersey in 1994 with 135 cases reported.

What are the socioeconomic impacts to New Jersey?

Costs associated with *Cryptosporidium* (doctor's visits, lost time) are relatively insignificant given the expected low frequency of illness, and while the possibility of an outbreak may cause concern, the psychological impacts associated with this stressor are also judged to be relatively minimal.

What's being done?

All public water supplies in New Jersey are filtered; filtration results in significant reduction in the number of organisms, to an average concentration of below 0.0001 organism per liter. Drinking water treatment technologies exist that would provide further protection, but these are not likely to be employed on a widespread basis because of the high costs involved. *Cryptosporidium* is not regulated in waters used for recreational purposes, except where they also serve as sources of drinking water.

STRESSOR SUMMARIES

Deer

Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	M - H

White-tailed deer (*Odocoileus virginianus*) have the ability to rapidly increase their numbers, particularly in suburban areas where public parks can act as deer refuges, hunting is reduced and there is a lack of natural predators. Overabundance of deer can lead to agricultural damage, deer/vehicle collisions, increased incidence of Lyme disease, and damage to natural ecosystems. Statewide, the number of deer has increased to 200,000, more than double the population twenty years ago.

What's at risk?

Humans are at risk from auto collisions and Lyme disease (see separate summary). Also particularly at risk are hardwood seedlings, agricultural crops, suburban shrubbery, and plant communities in forested areas.

What are the ecological impacts in New Jersey?

Ecological effects from deer overpopulation include changes in diversity among plant species. Deer are selective browsers and prefer young woody plants, such as hardwood seedlings. Researchers indicate that once the density of 20 deer per square mile is reached for several years, noticeable changes in native plant communities occur. This threatens to reduce bird and mammal breeding habitat, and may change long term forest health and biodiversity.

What are the socioeconomic impacts in New Jersey?

Impacts include economic losses suffered from Lyme disease, loss of crops, reduced property values from damaged landscaping, replacement costs of landscaping, and auto collision costs. Passenger vehicles collide with deer approximately 20,000 times per year. Agricultural losses alone are estimated at $20 million to $40 million annually. New Jersey has one of the highest rates of Lyme disease in the country, with 1722 cases in 1999. The estimated cost of Lyme disease to New Jersey is approximately $75 million per year. No cost has been estimated for the psychological effects of severe disability caused by untreated cases. The total cost of deer overpopulation is estimated at $120 to $160 million. Other impacts include conflict over deer control strategies, and the possible long-term aesthetic and forestry employment effects of damaged tree seedlings. (Note: socioeconomic analysis combined "deer" and "Lyme disease" impacts.)

What's being done?

Intensive management of the state's deer herd is being undertaken, primarily through sport hunting and issuance of deer predation permits to farmers. Experimental deer management programs have also been implemented.

Dermo disease in oysters

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	M - L

New Jersey oyster yields today are less than half the level of twenty years ago, and less than one tenth of what they were fifty years ago. Parasitic infection by *Dermocystidium marinus* and other protozoa such as MSX (see separate report on page 149) are responsible for decimating the state's oyster population. The parasites were introduced into Delaware Bay in the mid-1950s via seed oysters imported from the lower Chesapeake Bay. Massive losses in the late 1950s were followed by a gradual period of recovery, until the oyster population was devastated by another outbreak in 1990.

What's at risk?

Eastern (aka American) oyster populations over most of the New Jersey side of Delaware Bay experience high rates of mortality. Eastern oysters on the Atlantic coast are also affected. Younger oysters are less likely to become infected and have lower mortality rates than older oysters.

What are the ecological impacts in New Jersey?

The Dermo parasite causes a reduction in shell and soft tissue growth in infected oysters. Infection impairs the oysters' ability to open and feed, resulting in severe emaciation and high mortality rates. In 1953, New Jersey harvested 8.5 million tons of Eastern oysters. Current yields of about 700,000 pounds have rebounded from a low of just 585 pounds in 1993. The distribution of the parasite is not linked to environmental contaminants; Dermo is prevalent in both clean and polluted water. Oyster population decline significantly reduces the filtration of suspended particles in estuary ecosystems, such as Delaware Bay.

What are the socioeconomic costs to New Jersey?

Returning the oyster industry to historic levels would restore hundreds of jobs and contribute an estimated $40 million to New Jersey's economy. (MSX parasites are included in this analysis.)

What's being done?

Management actions to reduce the impact of Dermo disease focus on maintaining low salinity levels that help protect young oysters from infection, and on the possible introduction of disease-resistant strains of oysters.

Dioxins and Furans

Human Health Risk	M - H
Ecological Risk	M - L
Socioeconomic Risk	M

Polychlorinated dibenzodioxins and polychlorinated dibenzofurans are a group of structurally similar chlorinated compounds that result from the combustion of complex organic material in the presence of chlorine. These compounds may also arise as by-products of paper production or the synthesis of certain pesticides. These trace contaminants are biologically active at very low concentrations and accumulate in soils and sediments via air and wastewater releases. Aquatic animals feeding on sediment-dwelling organisms accumulate dioxin in their tissues, and terrestrial organisms become exposed by feeding on aquatic organisms or other terrestrial species (including plants) that have taken up dioxin from the soil. Terrestrial food chains also accumulate dioxins through fat and dairy products.

What's at risk?

Because dioxin is ubiquitous in our environment, all species are exposed. Animals higher on the food chain can be exposed to greater quantities as a result of bioaccumulation in the environment. For humans, the primary sources of dioxin are meat, fish, and dairy products. Individuals may be exposed to high levels of dioxin when contaminated fish and shellfish are a significant part of the diet. Dioxin is a carcinogen and also affects other biological functions such as the reproductive system of many species.

What are the human health impacts in New Jersey?

In the general population, dioxin exposure may contribute to an additional 20-200 cases of cancer per year in New Jersey. Highly exposed individuals such as those who regularly eat contaminated shellfish from New York\New Jersey harbor may face individual risks that are forty times the general population risk of 1.8 – 18 excess cancers per 10,000 population. Non-cancer effects are also possible, but no concrete estimates are available.

What are the ecological impacts in New Jersey?

Species inhabiting dioxin-contaminated sediments are exposed to levels in excess of benchmarks established for ecological health. Some species of fish are very sensitive to dioxin and will experience reproduction and developmental effects at measured levels. Fish-eating birds may be exposed to significant dioxin contamination as a result of fish tissue contamination.

What are the socioeconomic impacts in New Jersey?

The socioeconomic risks from dioxin are generally low, although psychological impacts are noticeable because of well-publicized dioxin contamination at Love Canal, New York and in Times Beach, Missouri. Dollar costs associated with the health impacts from dioxin may be as much as $12 million per year.

What's being done?

Dioxin releases from several types of facilities are regulated, resulting in a steady decrease in emissions. Sites contaminated with dioxins as a result of chemical operations are being identified, isolated from human exposure, and slowly cleaned up. Bans on the consumption of shellfish that is known to be contaminated are intended to reduce the exposure to those for whom shellfish is a subsistence food.

Disinfection byproducts

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	L

Disinfection byproducts (DBPs) are a group of chemicals formed by the reaction of active chlorinating agents and simple organic molecules during the disinfective treatment of surface water. DBPs remain in the drinking water ultimately consumed by the public. DBPs have been linked to bladder and possibly other cancers, neural tube birth defects (such as spina bifida), and spontaneous abortions. The DBPs with the highest concentration include the trihalomethanes (THMs) and the haloacetic acids (HAAs).

Who's at risk?

About 55% of the New Jersey population is served by water utilities supplied by surface water, with varying levels of DBPs. Populations at increased risk include pregnant mothers and their fetuses, particularly when their drinking water is derived from treated surface water.

What are the human health impacts in New Jersey?

Based on population percentages established by EPA, DBPs may be expected to cause 40-350 cases of bladder cancer, 2 neural tube defects, and 200 miscarriages each year in New Jersey. About 25% of the New Jersey population, or half of people served by surface water based systems, are exposed to THM levels greater than 50 parts per billion (ppb), as compared to people served by private wells, which generally have less than 5 ppb. While the US EPA sets the standard for THM at 80 ppb, studies have linked neural tube defects with THM levels greater than 40 ppb.

What are the socioeconomic impacts in New Jersey?

The largest socioeconomic impacts of DBPs are the health care costs attributed to bladder cancer and neural tube birth defects. Estimates of bladder cancer costs range from about $5 million to about $17 million, and birth defect estimates range from $2 to $3 million per year. Overall, the costs total between $7 million and $20 million.

What's being done?

The Maximum Contaminant Level (MCL) for total THMs in drinking water was recently reduced to 80 ppb, and an MCL for total HAAs level was recently established at 60 ppb.

Dredging

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	L

Dredging is the removal of sediment from the bottom of a water body to deepen and/or widen channels for navigation. In more recent years dredging has been used to remove sediment that is known to be polluted. Dredging affects aquatic environments by killing plants and animals, clouding the water with sediment, and destroying habitat. There are also human health issues associated with dredging of contaminated sediments—these risks are described for each specific contaminant (e.g., PCBs) in the appropriate sections.

What's at risk?

Dredging activity affects aquatic plants, fish and bottom-dwelling animals such as oysters, scallops, and juvenile lobsters. Dredging activities and the creation of confined disposal facilities can lead to habitat loss and habitat disturbance. Dredging activities are concentrated in three areas in New Jersey: New York Harbor, the Atlantic Coastal Basin, and the Delaware Bay and River.

What are the ecological impacts in New Jersey?

Over 80 million cubic yards of material is dredged annually in New Jersey. New York Harbor accounts for more than 90% and nearly all is disposed of in the ocean at the Historic Area Remediation Site (HARS). New dredging eliminates habitat, while maintenance dredging keeps habitat in a continually disturbed state. Where dredging has resulted in a decline in aquatic species populations, they tend to recolonize in a few years, and dredging has never been found to be the cause of a major population decline. Disposal of dredged material can have adverse effects due to high concentrations of pollutants in the material. Bioaccumulation of these contaminants often occurs in organisms inhabiting the disposal areas.

What are the socioeconomic impacts in New Jersey?

While there are costs associated with dredging, they are small in comparison to the billions of dollars in economic activity that dredging supports.

What's being done?

The amount of dredging per year has more than quadrupled in New York Harbor since the channel deepening project was initiated in 1999. Dredging in the Atlantic Coastal Basin and Delaware River and Bay regions is relatively constant. Dredging is extensively regulated at the state and federal levels of government to avoid or minimize impacts. There are increasing possibilities for beneficial disposal methods that virtually eliminate contamination and bioaccumulation problems associated with disposal of polluted sediments.

EHD virus in deer

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Epizootic Hemorrhagic Disease (EHD) is an infectious viral disease that kills wild animals, especially deer. There is no evidence that humans can become infected with the EHD virus. Most outbreaks in New Jersey have been documented in 20-year cycles.

What's at risk?

White-tailed deer populations statewide are at risk from EHD.

What are the ecological impacts in New Jersey?

EHD can have a significant effect on deer populations, but the disease does not wipe out entire herds, and does not affect domesticated animals. Historic documentation shows that up to 1,000 animals have been killed in a single year. New Jersey is currently experiencing a large overpopulation of deer, estimated at about 200,000 animals.

What are the socioeconomic impacts in New Jersey?

EHD poses minimal impacts, primarily associated with dead animal removal.

What's being done?

The New Jersey Department of Environmental Protection Division of Fish & Wildlife monitors the occurrence of EHD, and documents the cases in counties where it occurs.

Endocrine disruptors

Human Health Risk	M
Ecological Risk	M
Socioeconomic Risk	M

Endocrine disruptors are a subset of synthetic chemicals that interfere with the action of natural hormones in animals and humans. Chemicals with endocrine disrupting capability tend to be very persistent in the environment. Effects can vary from subtle to severe, and from temporary to permanent, depending on the chemical involved and the timing of the exposure with respect to normal hormonal activity. Resulting impacts are focused on adverse reproductive and developmental outcomes. Exposure to endocrine disrupting chemicals can occur directly from air, drinking water, or soil, and indirectly through the food chain, particularly for bioaccumumlating contaminants. A number of suspected endocrine disruptors have been evaluated independently; these include historically used pesticides, dioxin, PCBs, phthalates, and tributyltin.

What's at risk?

Because of the ubiquitous nature of endocrine disrupting chemicals, the entire population is exposed to some extent. As yet, unidentified subpopulations may be exposed to greater amounts due to geographic location or atypical dietary habits. Pregnant women and young children are especially sensitive to hormonally active agents. Endocrine disruptors can accumulate in breast tissue, potentially exposing nursing infants to elevated levels. Aquatic organisms, fish, and shellfish, and the birds and mammals that consume them are also exposed statewide. Wildlife in heavily polluted areas, such as Newark Bay and the Delaware River, is likely to be exposed to excessive levels of endocrine disruptors.

What are the human health impacts in New Jersey?

Scientists have only recently begun to study the effects of low doses of endocrine disrupting chemicals. Research thus far has focused on a small number of highly exposed subpopulations. The linkage between any particular exposure and these outcomes is unclear. There is also a lack of data quantifying the populations that may be at increased risk in New Jersey. Thus, the degree of uncertainty for this issue is large.

What are the ecological impacts in New Jersey?

All populations/ecosystems are at risk to some degree, and an estimated 20-40% of wildlife may be adversely affected. Because the limited amount of tissue sampling that has been done is typically associated with a suspected problem, it is difficult to accurately assess the risk to ecosystems statewide. Excessive concentrations are known to exist in polluted rivers and bays e.g., Delaware River, Newark Bay, but there are probably other areas where concentrations of endocrine disruptors exceed what is considered compatible with a healthy ecosystem. Ecological risks from PCBs and chlorinated pesticides such as DDT are described separately.

What are the socioeconomic impacts in New Jersey?

There are moderate psychological impacts linked to the effects of endocrine disruptors. Premature sexual development in girls may be linked to hormonally active chemicals in the environment. Premature development is known to have psychological effects for the girls, and creates significant worry for their parents. There continue to be many uncertainties regarding whether or not girls are maturing early, the extent to which endocrine disrupting chemicals are a cause, and the degree of harm induced by early sexual development.

What's being done?

Because of their abundance in consumer products and manufacturing processes, there are potentially significant amounts of endocrine disruptors that are released with little or no control. Current regulations that affect the production, use, and disposal of chemicals may not be effective in protecting ecosystems from the effects of very small quantities that subsequently magnify throughout the food chain. Research is being conducted to better assess the risks to human and wildlife populations from environmental concentrations of endocrine disruptors.

Extremely low frequency/ electromagnetic fields

Human Health Risk	L
Ecological Risk	L
Socioeconomic Risk	M - L

Electromagnetic fields (EMF) are produced by the generation, transmission, and use of electrical energy. United States' standards for delivering electrical current place these fields in the extremely low frequency (ELF) range of 3 hertz (Hz) to 3,000 Hz. Magnetic fields exist in conjunction with electric charges. Major sources of ELF magnetic fields are transmission and distribution lines, transformers, house wiring, appliances, train lines, and facilities that do electrogalvanizing, metal refining, induction heating, foundry work, and degaussing (demagnetizing recorded information). Magnetic fields have been hypothesized to be involved in promotion of cancer, specifically childhood leukemia and chronic lymphocyte leukemia in adults. This, however, remains highly uncertain.

Who's at risk?

Statewide, nearly all of the population is exposed to ELF/EMF via overhead power lines and household wiring. Electrical utility workers receiving greater exposure may be at increased risk for certain types of cancer. It is possible that children may be at a small, increased risk for certain types of cancers if their homes are near high voltage transmission lines or heavily-loaded distribution lines.

What are the human health impacts in New Jersey?

Studies to date have provided weak evidence connecting occupational exposure to magnetic fields (EMF) with adult chronic lymphocytic leukemia. Childhood exposures to magnetic fields might result in an additional 4-13 cases of leukemia statewide per year. However, the potential for any cancer from EMF is unclear and the number of attributable cancers may be zero.

What are the ecological impacts in New Jersey?

Studies involving birds, honeybees, wild animals, livestock, and fish have returned varying results. Most animals have not shown negative effects after exposure to high voltage power lines. Birds appear to be in greater danger of being electrocuted than of suffering from electromagnetic field exposure. The conflicting results shown from livestock studies may have been a result of stray ground voltage, rather than EMF. Honeybees have shown some decreased honey production and ability to survive in cold temperatures, however, researchers were unable to determine whether the results were due to EM fields or stray voltage. When the EM fields were shielded from the bees, their behavior returned to normal.

What are the socioeconomic impacts in New Jersey?

The socioeconomic impacts of EMF include the displeasure associated with viewing large metal structures along roadways and neighborhoods, concerns people have about unknown risk associated with EMF exposure, and concerns about reductions in property values. All New Jersey municipalities are affected by property value, worry, and aesthetic concerns. Approximately 240,000 acres of land are within 165 feet of overhead transmission wires. There is no quantifiable way to measure worry or aesthetic concerns. A general estimation of the reduction in property values due to close proximity of power lines is $1 to $2 billion. Costs of health care due to childhood leukemia may be several hundred thousand dollars.

What's being done?

Guidelines exist to restrict ELF electric fields at the edge of transmission line rights-of-way to 3 kilovolts per meter (kV/m).

Floatables

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	M - L

Floatables are solid wastes that litter waterways and beaches, degrading aesthetic quality and creating a hazard for wildlife. Plastic, wood, glass, metal, and styrofoam debris enter surface waters via storm drains, littering, and commercial transportation of garbage. Combined sewer outfalls are also a source of floatables, as increased flows during heavy rainfall overload the capacity of treatment plants and mixtures of storm water and sewage flow directly to waterways.

What's at risk?

Beach and bay communities bear most of the impacts from floatables, although inland rivers, lakes, and ponds are also affected. Birds and marine animals are at risk from injury or illness resulting from contact with litter. Residents of oceanside communities dependent on tourism are at increased risk for socioeconomic costs.

What are the ecological impacts in New Jersey?

Ingestion of or entanglement with floatables (e.g., plastic bags) can lead to strangulation, internal blockages, or other harm to birds, turtles, fish, marine mammals, or other wildlife. The impact on New Jersey ecosystems as a whole is judged to be small, particularly since the incidence of floatables has decreased in recent years and the trend is expected to continue. On the other hand, New Jersey does not conduct monitoring for impacts on aquatic life, thus these impacts are not fully understood.

What are the socioeconomic impacts in New Jersey?

In the 1980s, floatables were responsible for numerous beach closings in New Jersey. Oceanside communities dependent upon tourism lost hundreds of millions of dollars. Since that time, cleanup efforts have dramatically reduced the problem, and there have been no beach closings due to floatables since 1991.

What's being done?

Municipalities are required to remove floatables from sewage effluent. Following the beach closures of 1988, New Jersey initiated Operation Clean Shores in which prisoners remove debris from beaches. New Jersey also monitors floatables via aerial surveillance.

Formaldehyde

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	M - L

Formaldehyde is a chemical with industrial and commercial applications. Prior to 1980, it was present in urea formaldehyde insulating foam and levels of formaldehyde released from this product were high in some cases. It is also a by-product of combustion that leads to elevated outdoor concentrations. Mobile sources contribute 95% of the current outdoor releases. As a chemical pollutant, formaldehyde is an irritant and is considered a "probable" carcinogen.

What's at risk?

There are many individuals sensitive to the allergic effects of formaldehyde and levels inducing irritation are occasionally encountered in indoor environments. The cancer impacts from formaldehyde are the result of longer term chronic exposure that may be present in outdoor air and exposures are possible to the entire New Jersey population.

What are the human health impacts in New Jersey?

Cancer risks associated with average levels of formaldehyde in New Jersey are about 24 in a million, or about 2.5 additional cancer cases per year. The highest levels are found in Hudson County, where formaldehyde concentrations are four times the statewide median. At these higher exposures, the increased lifetime risk of cancer is about 1 in 10,000. The impacts from indoor exposure can be short term and acute, but the frequency of significant exposures is unknown although they are currently less than those in the period before 1980 when urea-formaldehyde foam was in regular use.

What are the socioeconomic impacts in New Jersey?

The medical costs associated with cancer cases attributable to formaldehyde exposure are expected to be about $250,000. There are no epidemiological studies available to estimate the number of cases of respiratory irritation or illness, but the impacts are unlikely to result in hospitalization. Thus, although formaldehyde exposure may be significant, there is no evidence that socioeconomic impacts (medical costs) are correspondingly so.

What's being done?

Indoor exposures have been reduced significantly as the result of the elimination of urea-formaldehyde use as insulating material. However, the use of formaldehyde in other products such as pressed wood furniture is still prevalent and not under current regulatory control. In the outdoor environment, formaldehyde is a by-product of combustion and subject to the general controls on automobile and stationary sources.

Geese

Risk	
Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	L

Suburban areas, with their expanses of short grass, make attractive habitat for Canada geese. In the 1980s, the population of geese living in New Jersey increased dramatically and has continued to rise. Overpopulation of geese creates a nuisance, reduces diversity of waterfowl, and may contribute to excess nutrient loadings in area waterways.

What's at risk?

Primary ecosystems at risk are urban and suburban lakes, parks, and golf courses. Atlantic (migrating) goose populations may also be at risk from the overabundance of year-round populations in New Jersey.

What are the ecological impacts in New Jersey?

The year-round goose population, estimated at about 100,000, may swell to as much as 280,000 in the winter as a result of migrating flocks. High populations of geese compete with other species of waterfowl for food and nesting sites, affecting species diversity. Resident geese are larger and better adapted to human environments, which favors their abundance relative to Atlantic (migrating) geese. At peak numbers, goose droppings may amount to more than 200 tons per day. In areas heavily populated by geese, their droppings increase nutrient loadings to streams and lakes, many of which are already overloaded from the effects of urban and agricultural runoff (see Phosphorus summary). This in turn can cause excessive algae growth, diminishing the aesthetic and ecological quality of the waterways. There is limited New Jersey-specific information on the ecological impacts of geese.

What are the socioeconomic impacts in New Jersey?

Goose droppings also create a nuisance on sidewalks, lawns, and golf courses. There have been two reports of individuals becoming sick from contact with goose droppings, but the effects appear to be minor as well as rare. Geese can also damage agricultural crops, but this is unlikely to be a significant concern in New Jersey.

What's being done?

Canada geese are protected under federal and state law. A winter harvest (i.e., hunting) has been recently allowed in New Jersey to help control resident populations. The U.S. Fish and Wildlife Service issues hunting permits to control local populations of resident geese. Short term deterrents include harassment with noise, dogs, or other means. Longer term strategies include modification of lake and pond shorelines to discourage geese.

Genetically modified organisms

Human Health Risk	
Ecological Risk	**L**
Socioeconomic Risk	**L**

For this report, genetically modified organisms (GMOs) are plants used in agriculture that are modified by applying laboratory techniques of biotechnology. The intent of their productions is to either increase yield, decrease pesticide use, decrease farm labor or increase nutritional value. Potential negative effects are cross pollination with wild species transferring unwanted genetic characteristics, and development of pest immunity to pesticides. There is also a general concern about unintended consequences of introducing species that have not evolved with natural controls in place to stop their spread.

What's at risk?

There may be human health impacts such as increased allergic responses or the encouragement of new bacteria and viruses. Economic impacts might be due to changes to agricultural and food processing industries. Ecological and psychological effects may arise if genetic material transfers to non-beneficial species. Non-target organisms may also be impacted by use of GMOs.

What are the ecological impacts in New Jersey?

The current effects in New Jersey are unknown due to lack of data. Potential ecological impacts include adverse effects on non-target organisms, development of pest immunity, and genetic exchange between transformed organisms and unaltered organisms. Information indicates low risk to tested species with the exception of butterfly species. These species may be at a low probability of risk near the edge or within corn fields. Overall, the risk from GMOs was deemed to be low. Data on the extent of GMO use in New Jersey should be collected and potential impact areas identified for study.

What are the socioeconomic impacts of GMOs in New Jersey?

The largest category of risk identified is currently psychological impacts. A 1993 poll revealed a minority of New Jersey citizens felt strong worry about GMOs. More recent national data suggest Americans are far less worried about GMOs than Europeans. There are no current large scale economic or ecological problems resulting from the use of GMOs but the potential exists for possibly devastating effects. There is significant disagreement regarding the likelihood of such problems.

What's being done?

The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture (USDA) reviews applications each year from biotechnology companies that wish to field-test new transgenic plants or to have a plant deregulated. EPA regulates plant-incorporated protectants (i.e., pesticidal substances); that is, EPA regulates the pesticide protein and its genetic material, but not the GMO plant itself.

Green/red tides

Risk	
Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Green and red tides are caused by excessive growth, or "blooms" of specific classes of single-celled plants in coastal waters. Blooms occur naturally under low flow conditions, and cause a red or green discoloration of the water. Blooms may result in fish and shellfish mortality, beach and shellfish bed closures, and mild to severe illness in humans. These can range from minor skin irritation associated with swimming in affected waters to serious illness associated with shellfish consumption.

What's at risk?

There have been chronic red tide blooms of various species in the Hudson-Raritan Estuary and New Jersey coastal waters for over three decades. Green tide has appeared as a greenish discoloration of the near shore coastal waters from Ocean City to Atlantic City during the summers of 1984-85. Algal blooms contribute to ecological problems in New Jersey, but there are few cases on record of human toxicity from algae in New Jersey waters, with the exception of moderate discomfort or illness reported from specific blooms.

What are the ecological impacts in New Jersey?

New Jersey has experienced chronic red tide blooms over many years, with green tide organisms appearing less frequently. Blooms are associated with reduced oxygen levels in the water, shellfish mortality, and fish kills.

What are the socioeconomic impacts in New Jersey?

The occasional appearance of discolored water may be considered a moderate aesthetic impact, but red and green tides have little impact on employment or property values, nor do the blooms impose any economic costs of significance.

What's being done?

The New Jersey DEP Bureau of Marine Water Monitoring monitors algae blooms throughout the summer. State and county officials have the authority to close beaches deemed unsafe because of algae. Harmful algal blooms are the subject of a national task force formed under the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998.

Greenhouse gases

Human Health Risk	L
Ecological Risk	M - L*
Socioeconomic Risk	M - L *

Global climate change is a gradual rise in average global temperatures caused by increasing amounts of "greenhouse gases" in the atmosphere. More than 80% are the result of the combustion of fossil fuels, and atmospheric concentrations of carbon dioxide have increased nearly 30% since pre-industrial times. The buildup of heat trapping gases in the atmosphere is linked to a gradual rise in sea level and an increase in intense storm activity.

What's at risk?

Should the hypothesized effects of climate change materialize, all of New Jersey's population would be susceptible to health problems related to an increase in heat waves and air pollution. The elderly, infants, and people with cardiovascular or respiratory diseases would be particularly vulnerable. Coastal wetlands and the forested Pine Barrens ecosystems would be most vulnerable to climate change effects. People living in coastal areas would be at a greater risk from the effects of violent storms and flooding. It is impossible to predict the extent of secondary effects related to increases in disease caused by poor water quality or by the northern migration of disease-carrying insects.

What are the human health impacts in New Jersey?

The impacts of global warming are relatively uncertain and long term in nature. There are five major concerns about impacts of global warming on human health:

> (1) increase in heat stroke and heat-related deaths due to hotter summers; (2) increase in respiratory diseases due to increase in air pollution; (3) increase in deaths from violent storm and flood activity; (4) increase in diseases carried by insects (e.g., malaria, and Lyme disease); and (5) illness related to poor water or food (e.g., fisheries) quality.

The total state population will be exposed; however, people near flood zones and coastal areas will be more susceptible to deaths from violent storm and flood activity. People in areas of the state that currently experience high levels of ground ozone might be increasingly exposed to respiratory diseases. The segments of the New Jersey population that might be particularly exposed are the elderly, infants and people with cardiovascular or respiratory diseases.

What are the ecological impacts in New Jersey?

Ecological impacts could be severe and irreversible, but they are very uncertain. Should sea levels rise to hypothesized levels, there is a potential for substantial damage to coastal ecosystems from saltwater intrusion and associated large impacts on biodiversity. Climate change may also influence the cycling of mercury in the environment, which would result in increased concentrations of mercury in fish.

What are the socioeconomic impacts in New Jersey?

Assessing the socioeconomic impacts associated with global warming is highly speculative. Should sea level rise as predicted, the economic costs associated with loss of property and tourism in coastal areas would likely be in the billions of dollars. Most people are aware of the potential for climate change impacts and this creates some degree of anxiety. However, major impacts are unlikely to occur within the next five years.

What's being done?

A treaty on greenhouse gas emissions may result in a slower warming trend, but most scientists agree that reducing emissions will not be enough to stop the increase in the greenhouse effect that will produce warmer temperatures in the coming decades. Impacts can be managed to some extent. Flood damage can be limited by controlling development in flood zones. New Jersey's existing health care system will, to some extent, be able to contain any major disease outbreaks.

*Note: Despite the potential for significant long-term human health and ecological impacts, the time frame over which such impacts may occur is longer than the five-year time frame encompassed by this comparative risk analysis. Over the shorter time frame of this analysis, few impacts are anticipated.

Habitat fragmentation

Human Health Risk	
Ecological Risk	**H**
Socioeconomic Risk	

Habitat fragmentation is the subdivision of habitat as land is converted from farms and forests to urbanized areas. While fragmentation is a frequent consequence of habitat loss, the ecological effects resulting in serious damage to ecosystems are distinct. Fragmentation results in the creation of "edge habitat" along the fragment border, which differs in microclimate and species composition from the original habitat. The continued expansion of urbanized areas and associated infrastructure interrupts watercourses, alters natural landscape patterns, and increases the proportion of edge habitat resulting in a number of ecosystem changes. Remaining habitat fragments support fewer species of plants and animals, and smaller populations of species that remain. Habitat fragmentation is often a contributing factor in the undesirable overpopulation of invasive plants and animals, as these species typically tolerate and even flourish in disturbed ecosystems.

What's at risk?

Virtually the entire state is at risk from the effects of habitat fragmentation. The New Jersey Pinelands and New Jersey Highlands are of particular importance because they still contain large tracts of critical wildlife habitat that are vulnerable to fragmentation and loss. The number and diversity of species present diminishes with forest size. Forest-breeding birds and other species that require moderate to large ranges of forested land are particularly at risk. Amphibian communities are severely impacted by fragmentation, especially by the presence of roads and other disturbances which can reduce or change their mobility patterns. Socioeconomic impacts of habitat fragmentation are included among the impacts discussed under Land Use Change.

What are the ecological impacts in New Jersey?

Studies have documented the effects of fragmentation in New Jersey. The habitat requirements of forest-breeding birds are relatively well studied, and a survey of New Jersey hawks and owls found that forest patches under 2,471 acres had no more than 4 different species, whereas forests up to 19,768 acres had up to 8 species. Data describing land use trends in New Jersey are also available. For example, between 1972 and 1988, the total amount of edge habitat increased 15% inside the Pinelands Reserve and 25% in neighboring areas outside. In the same time period, average mixed deciduous forest patch size decreased 21% inside the reserve, while outside the reserve forest patch size decreased 72%. Only 1% of the land area of the New Jersey Highlands consists of forest patches larger than 5,000 acres, and 75% of the land area is in forest patches smaller than 50 acres. Research suggests that 7,400 acres is the minimum forest patch size expected to retain all species of forest-breeding birds.

What's being done?

Major New Jersey land use and conservation plans identify habitat fragmentation as a management issue and New Jersey had 920,000 acres of permanently protected open space as of 1998. The Garden State Preservation Trust Act of 1999 establishes a stable funding source to preserve 1,000,000 acres of additional open space and farmland over the next ten years. Development is regulated in the 1.1 million acre New Jersey Pinelands National Reserve by the Pinelands Commission. Numerous other federal and state lands afford protection for areas already under public jurisdiction.

Habitat loss

Risk	
Human Health Risk	
Ecological Risk	H
Socioeconomic Risk	

Habitat loss is the conversion of land from one use to another, specifically the development of wild or agricultural lands to urban and suburban land uses. Habitat loss also includes the conversion of natural habitat to agriculture, the conversion of dunes to seawalls, and the modification of wetlands by dams and channelization. Habitat degradation is the leading cause of endangerment for all groups of organisms in the mainland Unites States, ranking ahead of exotic species, pollution, over-exploitation, and disease. In New Jersey, these changes affect thousands of acres per year, resulting in the reduction of available habitat for native plant and animal species and decreasing the resilience of ecosystems to accommodate other natural and human caused stressors.

What's at risk?

Habitat loss affects all terrestrial and aquatic plant and animal populations and ecosystems statewide, especially those found on undeveloped, unprotected land. Unprotected forests and wetlands are particularly at risk. Regions that still contain large tracts of critical wildlife habitat are especially vulnerable to the effects of habitat loss. These include the Pinelands region (1.1 million acres) and the New Jersey Highlands (640,000 acres). Socioeconomic impacts of habitat loss are included among the impacts discussed under Land Use Change.

What are the ecological impacts in New Jersey?

Most of the plants and animals listed as endangered or threatened in New Jersey are imperiled due to habitat loss. Endangered tree frogs native to the Pinelands are being displaced by more disturbance-tolerant bullfrogs. Pinelands plant communities have also been altered as native species are replaced by invasive exotics in more developed areas. Bird species diversity is also known to decrease as the proportion of urban land increases. New Jersey has lost 40% of its wetlands and 35% of the Pine Barrens since pre-settlement times, and has 50% less farmland than in 1950. Naturally vegetated shoreline areas provide habitat and perform critical ecosystem services. Only 29% of Barnegat Bay's shoreline, for example, remains undeveloped. Rates of development continue to increase. During 1984-1995, 11 of New Jersey's 21 counties experienced rates of development greater than 20%, and several grew by more than 30%. Developed acreage in Salem and Cumberland counties increased by 50% and 42%, respectively, during this time. In addition to the direct effects on species composition, land use change also compromises ecosystem functions such as nutrient cycling and water purification and storage.

What's being done?

Due to human population pressures, returning currently developed land to its former state is not practical on a large scale. Consequently, the primary management focus should be on preventing further impacts. As of 1998, New Jersey had 920,000 acres of permanently protected open space (29% of New Jersey's total 3.2 million acres). Development is regulated in the 1.1 million acre Pinelands National Reserve, and most of Barnegat Bay's remaining salt marshes and undeveloped shoreline are under some form of protection.

Hanta virus

Risk	
Human Health Risk	L
Ecological Risk	
Socioeconomic Risk	L

Hanta virus is an airborne viral pathogen generated from disturbed rodent saliva or droppings. It can be contracted by humans via inhalation of contaminated aerosols, or possibly through contact with broken skin or rodent bites. Once contracted, the infection may lead to pulmonary illness, which is often fatal.

What's at risk?

People can be exposed during activities (e.g., cleaning) which result in the generation of dusts or aerosols in indoor structures containing large numbers of deer or white-footed mouse nests. People who are occupationally exposed—grain farmers, field biologists, mill, construction, utility, and feedlot workers for example—may be at increased risk.

What are the human health impacts in New Jersey?

Risk is considered extremely low. There have been no known cases of hanta virus in New Jersey and a little over 200 cases in the Unites States since the disease was first characterized in 1993. In the northeastern Unites States, there have been 2 confirmed cases in New York, 2 in Pennsylvania, and 1 in Rhode Island.

What are the socioeconomic impacts in New Jersey?

There are no significant socioeconomic risks from hanta virus infection in New Jersey.

What's being done?

There are no regulations or controls in place. Hanta virus is a rare but serious disease with no known treatment, other than supportive care.

Hemlock woolly adelgid

Human Health Risk	
Ecological Risk	M - H
Socioeconomic Risk	M - L

The Hemlock woolly adelgid is an aphid-like insect pest that feeds on hemlock trees. Native to China and Japan, the insect was probably accidentally introduced in western North America in the 1920s and was first observed in eastern areas in the 1950s. It feeds at the base of the tree's needles, causing them to dry out and fall off. The trees become defoliated and heavy infestations can kill trees in about four years.

What's at risk?

All 26,000 acres of New Jersey hemlock forest are at risk. The loss of hemlock trees may also exacerbate other ecological risks by promoting the increased abundance of invasive exotic species, increasing fire hazard, and reducing shade necessary for maintaining stream temperatures.

What are the ecological impacts in New Jersey?

The pest poses a catastrophic threat to hemlock forests. All New Jersey counties have been infested, with more than 90% of hemlock forests exhibiting some degree of defoliation. Once it has occurred, defoliation is irreversible, and infested trees rarely recover. Indirect ecological impacts that may result from the decline or loss of hemlock stands include increased hazards from forest fire, changes in forest nutrient cycles, soil erosion, and loss of rare species habitat.

What are the socioeconomic impacts in New Jersey?

From a purely economic perspective, the loss of hemlock trees would be insignificant since they are a relatively small part of New Jersey's 1.8 million acres of forest. Similarly, any loss of recreational use of forests attributable to the loss of hemlock trees would likely be negligible. However, hemlocks are highly valued for their beauty. The loss of hemlock trees would probably be permanent. This must be considered a moderately serious socioeconomic impact.

What's being done?

There are no regulations concerning the transport of hemlock logs or trees in New Jersey. The state is experimenting with the introduction of exotic predators to control adelgid populations. If these prove successful, the risk to currently healthy stands (northwestern Sussex County) may be significantly reduced. However, there is little hope for hemlock stands that are already heavily infested.

Inadvertent animal mortality

Risk	
Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	M

Each year, animals are accidentally killed in large numbers due to traffic accidents, traps set for other animals, and as a result of nesting or other behaviors that are increasingly incompatible with human uses of their natural habitat. The risks associated with deer are discussed separately.

What's at risk?

Of particular concern is the diamondback terrapin, the only species of turtle in the United States that inhabits saltwater marshes. Once prized as a delicacy, terrapin numbers were so greatly depleted in the early 1900s that many states, including New Jersey, enacted protection policies that enabled terrapin populations to recover. No longer victims of overharvesting, terrapin populations are again threatened. Tens of thousands are unintentionally drowned in crab pots every year; another 1,500 are victims of traffic accidents.

What are the ecological impacts in New Jersey?

Excluding deer (addressed separately), there were about 18,000 animal-related traffic accidents in New Jersey during 1999. Shoreline development and associated erosion protection measures can destroy existing terrapin nests and force nesting females to venture into densely settled areas to lay their eggs. Hatchlings can become trapped in tire tracks in the sand and die before reaching the water.

What are the socioeconomic impacts in New Jersey?

Aesthetic and psychological impacts are likely, but they are expected to be fairly low. The costs associated with animal-related vehicle accidents are estimated at more than $16 million per year. Additional dollar costs are associated with terrapin rescue and management, but these have not been estimated.

What's being done?

Two promising management approaches may help combat the decline of terrapin populations. The "Life After Death" program rescues potentially viable eggs from freshly killed females; 30-50% of the rescued eggs become hatchlings. Another tactic is to increase the use of a "Bycatch Reduction Apparatus," a device that prevents 90% of terrapins from entering crab pots.

Increase in impervious surface

Human Health Risk	
Ecological Risk	M - H
Socioeconomic Risk	

Impervious surface is any material that prevents infiltration of water into soil. Roads, rooftops, and parking lots are examples of impervious surfaces. While the natural environment also contains impervious elements (e.g., bedrock surfaces), significant increases in the extent of developed areas have dramatically altered the proportion of impervious surfaces to natural vegetation. The resulting changes in the quantity and quality of storm runoff to receiving waterbodies creates adverse effects on ecosystem health by increasing erosion, degrading habitat, and altering natural stream flow patterns.

What's at risk?

Aquatic, wetland, floodplain, and upland animals and plants statewide are at some risk from increased imperviousness. Rare plant and animal species are likely at greater risk—particularly those that are directly impacted such as swamp pink and bog turtles. Approximately 36% of New Jersey's native plants and 7% of vertebrate species are in danger of becoming increasingly rare or extinct. Socioeconomic impacts of impervious surface are included among the impacts discussed under Land Use Change.

What are the ecological impacts in New Jersey ecosystems?

Major influences on stream quality for New Jersey include: increased human activity/density and paved surface; increased surface runoff and chemical use; and decreased base flow, forested area and wetlands—all factors which directly or indirectly relate to impervious surface cover. About one third of the land area in the state is already affected by an average impervious surface cover of over 10%, the threshold for impairments to benthic (bottom-dwelling) community structure. Sixty-five percent of monitored waterways in New Jersey have moderately to severely impaired benthic communities, and all but one small watershed with more than 25% impervious area showed moderate to severe impairment. Studies in New Jersey have also documented a relationship between storm water impacts such as erosion and decreasing or absent populations of the globally rare swamp pink and endangered bog turtle. Marine systems are similarly affected. Seventy-nine percent of near shore ocean waters were assessed as "threatened" based on dissolved oxygen levels. While there are multiple contributing factors, several, including river inputs and storm water runoff, are consistent with impervious cover.

What's being done?

There is a modest set of policy responses affecting the growth of impervious surface area. The Coastal Area Facility Review Act (CAFRA) limits development in coastal areas. New regulations for reducing storm water flows will apply to new developments. Stream encroachment and wetlands permits provide buffers for threatened and endangered species.

Indoor asthma inducers

Human Health Risk	M - H
Ecological Risk	
Socioeconomic Risk	M - H

Asthma is a complex condition affecting the small airways of the lungs. An initial exposure to allergens, viruses, pollution, or certain chemicals may induce the inflammation that leads to asthma symptoms in some individuals. Indoor asthma inducers include dust mites, animal/pet dander, mold, rodent protein, cockroach feces, and tobacco smoke. Asthma episodes may include lung inflammation, difficulty breathing, or in some cases, death. Episodes can be caused by inhalation of these same inducers, or other asthma triggers that may occur in either the indoor or outdoor environment, once an individual develops asthma.

STRESSOR SUMMARIES

What's at risk?

The risk is statewide, with certain occupational groups at higher risk, such as veterinarians or livestock workers. Children and adults in low-income communities are at increased risk, for reasons that are not entirely clear. African Americans are three to four times more likely than Caucasians to be hospitalized for asthma, and four to six times more likely to die from asthma. Individuals with atopic disease, an inherited tendency to get asthma, are more likely to develop asthma when exposed to these inducers. Estimates indicate that one third to one half of the United States population may be atopic.

What are the human health impacts in New Jersey?

Hospitalization and outpatient visits do not include all episodes, since many relatively mild episodes are self-treated with medication, but about 316,000 episodes of adult asthma and 123,000 episodes of asthma in children are estimated to occur in New Jersey in a given year (based on 2000 estimates). It is not known what fraction of these cases are the result of indoor asthma inducers.

What are the socioeconomic impacts in New Jersey?

Asthma has been determined to have significant health, societal, and economic consequences. The annual cost of asthma to New Jersey is $450 million. If one third of these costs are reasonably attributed to indoor allergens, this translates to a high socioeconomic risk. Persons with severe asthma account for 20% of the cases, and 80% of the costs associated with the disease. These chronic asthma sufferers may only be partially relieved by medication, and suffer from reduced quality of life.

What's being done?

Currently there are few controls placed on indoor air quality, with the exception of restrictions on smoking in some public areas.

Indoor microbial air pollution

Human Health Risk	L
Ecological Risk	
Socioeconomic Risk	M

Indoor microbial air pollution is caused by excessive growth of bacteria, fungi, or algae in warm, wet materials including lumber, ceiling tiles, books and papers, insulation, or hay. Microbes may also grow in central air systems and filters, or in humidifiers. A range of diffuse and often subjective symptoms known as "sick building syndrome" (SBS) may also result, in part, from indoor microbial air pollution. Health effects from airborne microbial pathogens include respiratory infection, ranging from flu-like, or pneumonia-like symptoms to possible neurologic damage, pulmonary hemorrhage, and even death.

What's at risk?

Airborne spores that cause no effect in some people may cause mild to severe effects in others. Persons with asthma, allergies, or weakened immune systems, and infants less than 6 months old are at increased risk, and may show more extreme reactions. At higher occupational risk are farmers, antique shop workers, greenhouse workers, or anyone occupying areas with excessive mold, or high moisture. Office workers in airtight buildings may be at risk for developing symptoms of sick building syndrome.

What are the human health impacts in New Jersey?

The population exposed to unsafe concentrations statewide is unknown, but it is estimated that hundreds of people are affected by indoor microbial air pollution each year. Incidence of severe symptoms, such as pulmonary hemorrhage, neurological effects, or death, is rare.

What are the socioeconomic impacts in New Jersey?

Indoor microbial air pollution is estimated to be responsible for 5-10% of the total costs of asthma in New Jersey, approximately $22 million to $45 million. Assuming that 10-20% of the total costs associated with sick building syndrome are attributable to indoor microbial pollution, New Jersey loses an estimated $230 to $460 million each year in direct health care costs and lost productivity.

What's being done?

Overall, indoor air pollution is increasing, but there are no regulations or standards for maintaining indoor air quality.

Invasive plants

Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	M

Plants termed "exotic" species were introduced in North America either accidentally or intentionally from other parts of the world. Because these tend to have few if any natural predators or parasites on this continent, they are aggressive competitors for space and nutrients, and often form dense stands or thickets that crowd out native vegetation. Other invasive plants, such as the common reed, are native species that have spread out of control as a result of land disturbances that altered the original ecological balance.

What's at risk?

In addition to the loss of plant biodiversity, wildlife that depend on the displaced native species as a food source are also affected. Most invasive species flourish in disturbed habitats statewide, though they tend to be somewhat less prevalent in the Pine Barrens and coastal plains regions.

What are the ecological impacts in New Jersey?

Common to all invasives is a tendency for prolific seed dispersal and/or vigorous spread via root or rhizome. They also share competitive advantages such as the ability to germinate in shady, overly dry, or overly moist conditions. The table below summarizes the threats from common invasive plants.

What are the socioeconomic impacts in New Jersey?

Because of the many uncertainties associated with quantifying the extent of impacts, the estimated costs associated with the control of invasive plant species range widely, from about $50 million to $150 million. Many people find these plants attractive, thus there are assumed to be no significant aesthetic or psychological costs incurred.

What's being done?

There are no regulations for curbing the spread of invasive plants. Moreover, many continue to be sold and planted as ornamentals. Large-scale control efforts are generally not feasible, and would require years of vigilant eradication and subsequent reseeding of native vegetation. New Jersey DEP is collaborating with the New Jersey Department of Agriculture on the development of effective biological controls—the introduction of a leaf-eating species of beetle has had promising results with reducing purple loosestrife.

Scientific/ Common name	Type	Key Threats
Ailanthus altissima Tree-of-heaven	Tree	Affects abundance of important wildlife food sources such as Black Cherry and Black Walnut.
Acer platanoides Norway maple	Tree	Still one of the most commonly planted street trees in New Jersey. Unlike most invasives, also invades undisturbed habitat. Outcompetes other species.
Rosa multiflora Multiflora rose	Shrub	Once championed for use as wildlife cover and erosion control, forms impenetrable thickets and outcompetes other species, reducing abundance of native vegetation.

Invasive plants (cont.)

Scientific/ Common name	Type	Key Threats
Berberis thunbergii Japanese barberry	Shrub	Still sold commercially as an ornamental shrub; can tolerate low light, thus invading deep into forests with closed canopies.
Celastrus orbiculatus Asiatic bittersweet	Woody vine	Native populations of American bittersweet are particularly at risk from competition and hybridization with *Celastrus*.
Lonicera japonica Japanese honeysuckle	Woody vine	Tolerates low light and forms dense stands in forest understory. Twining growth habit can damage/kill other plants, including rare species.
Alliaria petiolata Garlic mustard	Biennial	Rapid spring growth may preclude emergence of important food species. Primary spread is via human transport (hiking, mowing).
Lythrum salicaria Purple loosestrife	Perennial	Invades wetlands. Direct threat to several state and federally endangered species. All limestone fens in northern New Jersey are seriously impacted.
Microstegium vimineum Japanese stilt grass	Annual	Forms dense "lawns" on disturbed sites. Particularly invasive on fertile sites disturbed by flooding. Increasing in New Jersey at exponential rates.
Phragmites australis Common reed	Perennial	Native species, the invasive spread of which appears to be associated with land disturbing activity. Has catastrophic effect on salt hay farming.

Land use change

Human Health Risk	
Ecological Risk	
Socioeconomic Risk	H

The dramatic physical transformation of open, wooded, agricultural, and wetland areas to suburban development in recent decades has had significant impacts. Most obvious are ecological insults including habitat loss and fragmentation, and increased impervious surface cover that worsens flooding hazards and pollutant runoff into surface waters. There are also important distributional socioeconomic impacts, as urban and rural areas lose jobs, tax revenues, and social capital to suburban areas. Statewide, suburbanization appears to provide net gains in employment and property values, and net losses in aesthetic and psychological terms. Sprawl imposes large direct costs due to increased commuting distances, congestion, and inefficient infrastructure investment.

What's at risk?

Land use change occurs statewide. Ecological effects are discussed under Habitat Loss, Habitat Fragmentation, and Impervious Surface. Socioeconomic effects include the pain associated with a spatial redistribution of wealth and opportunity, plus statewide aesthetic and psychological impacts. Ecologists analyzed impacts of habitat fragmentation, habitat loss and increase in impervious surfaces, rather than on land use change as a whole.

What are the socioeconomic impacts in New Jersey?

From a statewide perspective, employment and property values have only increased as suburbanization has progressed. A majority of New Jersey residents are voting with their feet and saying that they prefer suburban to urban living. There is growing evidence that this vast dispersal of population has also been costly. Some costs are simple transfers, as suburban areas attract housing and commercial investment and jobs, while cities suffer from declining property tax bases and a spatial mismatch between housing and jobs. For example, the magnitude of the transfer in property values away from New Jersey cities to the suburbs is estimated at $3.5 billion to $7.1 billion. Although there is no associated statewide loss in property values, these transfers diminish the overall level of social capital within the state, by pitting new winners and losers against one another, and by weakening long-established social networks. There are also direct costs associated with sprawling land use patterns relative to centralized development patterns, most significantly the higher cost to provide transportation, utilities, schools, and other public services, recently estimated at about $400 million annually in New Jersey. Both opinion polls and public support for open space preservation indicate that New Jersey residents perceive significant social costs associated with long commute times, traffic congestion, reduced housing choices, unwalkable neighborhoods, and less varied scenery.

What's being done?

Local governments largely control the development of land in New Jersey, and some municipalities actively encourage compact development while others do not. The New Jersey State Development and Redevelopment Plan details a voluntary approach for managing growth, and the Governor's Smart Growth Policy Council is attempting to coordinate the efforts of state agencies in this regard. Federal government involvement in this issue includes substantial highway subsidies and home mortgage guarantees that encourage sprawl development, and minor mass transit and urban revitalization subsidies that discourage it.

Lead

Human Health Risk	H
Ecological Risk	M
Socioeconomic Risk	H

Lead is a naturally occurring metal used in a range of industrial and commercial applications. Two uses of lead, which have since been banned, have contributed to widespread environmental contamination: leaded gasoline and leaded paint. Small amounts of lead continue to be emitted in diesel exhaust, and the majority of ongoing industrial emissions are attributed to steel and iron works. Coal burning power plants also emit lead. In New Jersey, human health effects arise through exposure to historic concentrations of lead in the paint of older homes, and in the soils adjacent to roadways and lead-painted structures. These can range from neurological effects, such as a learning deficit, to anemia and life-threatening encephalopathy at higher exposures. There may also be a link between long term exposure and hypertension in adults. Lead accumulates in soils, surface waters, and sediments presenting a toxic hazard to fish, amphibians, reptiles, birds, and mammals.

What's at risk?

Lead's environmental pervasiveness means that exposure of people and wildlife occurs statewide. Children are far more likely than adults to ingest contaminated soil or peeling paint; their bodies absorb it more efficiently, and their developing nervous systems are more sensitive to its effects. Although contamination is often greatest in urban/suburban regions, elevated lead levels are found in soils, sediments, and surface waters statewide.

What are the human health impacts in New Jersey?

There are no requirements for testing the general population for lead exposure, but New Jersey requires testing of children under 7. The Centers for Disease Control considers child blood lead levels more than 10 micrograms per deciliter of blood to be elevated, and children with levels more than 20 ug/dl are considered lead poisoned. In 1999, there were a total of 802 cases of lead poisoning in children under 7 in New Jersey. Preliminary data for 2000 indicates 4% of children tested had elevated blood lead levels. Since 1993, New Jersey has documented more than 15,000 cases of lead poisoning in children.

What are the ecological impacts in New Jersey?

Birds and mammals are at risk, due to bioaccumulation of lead up the food chain. While lead can cause death, chronic exposure is the more serious problem because of the irreversible reproductive and developmental effects. Limited sampling in New Jersey suggests that sediments in urban areas may contain lead at more than three times the ecological health benchmark. Lead levels in surface waters and sediments adjacent to contaminated sites have been sampled at extremely high levels—more than 200 times the benchmark. It is difficult to characterize the risks absent sufficient monitoring.

What are the socioeconomic impacts in New Jersey?

Based on national estimates, lead-related medical costs in New Jersey may reach $774 million annually. There are additional costs associated with lead abatement (removal of lead paint hazard in older homes) increasing the total economic cost. Urban parents and residents in older housing may suffer a moderate amount of worry regarding the risks from lead paint. Environmental justice activists have criticized the pace of lead removal from housing in minority areas.

What's being done?

Phasing out leaded gasoline has drastically reduced lead emissions to the air. Regulations restrict the amount of lead in air, drinking water, and consumer products. Laws also govern the cleanup of contaminated sites. Public health education, along with statewide pediatric screening, has also contributed to reductions in blood lead levels.

Legionella

Risk	
Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	L

Legionella is a specific group of bacteria, some of which are known to be pathogenic to humans. Under natural conditions, *Legionella* bacteria do not pose a threat. In certain (primarily indoor) conditions, they can multiply to unsafe levels. Humans may become exposed via inhalation of contaminated aerosols that arise from stagnant warm water found in indoor air handling systems. Inhalation of high numbers of these bacteria can cause a flu-like disease called Pontiac fever, or a more serious and sometimes fatal type of pneumonia called *Legionnaire's* disease, first recognized in 1977 following an outbreak of pneumonia at an American Legion convention in Philadelphia.

What's at risk?

Anyone has the potential to become exposed, but most healthy individuals will not become ill. People with an existing illness are more likely to become ill as a result of exposure. Smokers, the elderly, chemotherapy patients, and individuals with weakened immune systems are examples of more susceptible groups. Most cases have occurred in the 40-70 age group.

What are the human health impacts in New Jersey?

Reported cases of legionellosis in New Jersey from 1993-1996 averaged 33 cases per year. However, it is likely that only 5-10% of cases are reported. Based on Centers for Disease Control statistics, an estimated 237-533 people may contract legionellosis each year in New Jersey, with potentially 12-15 deaths resulting. Fatality rates are highest for immune-suppressed patients, or those with underlying disease. The occurrence of Pontiac fever is estimated to be 2 to 10 times more frequent than legionellosis.

What are the socioeconomic impacts in New Jersey?

Socioeconomic risks from *Legionella* infection in New Jersey include medical costs and the psychological impacts associated with the threat, which was widely publicized in New Jersey due to the proximity of the Philadelphia outbreak. Costs associated with the treatment of the disease may be several million dollars per year.

What's being done?

Growth of the bacteria can be controlled through the implementation of preventative procedures. Indoor air quality regulations apply to air handling equipment, and address microbial contamination specifically.

Light pollution

Risk	
Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	M - L

Concerns relate to vehicle safety (glare), energy efficiency, privacy, and aesthetics. Communications towers and other tall structures that are illuminated at night for aviation safety pose a threat to New Jersey birds.

What's at risk?

The proliferation of nighttime lighting has dramatically decreased the number of stars visible in New Jersey. While there are no health or ecological impacts that can be directly attributed to light pollution, the night sky seems to resonate deeply with people statewide. New Jersey bird populations statewide are at risk from collisions with towers, and regional biodiversity may be affected as migrating birds change flight patterns in relation to towers.

What are the ecological impacts in New Jersey?

Birds in flight can become disoriented near the light source and collide with the tower itself. Nationally, an estimated one million to five million birds are killed annually in collisions with towers. Lighted towers also affect migratory patterns, which could affect regional biodiversity. A number of studies outside the state have documented birds altering their flyways relative to lighted towers. More research is needed in order to determine whether light towers pose significant risks in New Jersey, but any existing impacts are likely to worsen as more and taller towers are constructed.

What are the socioeconomic impacts in New Jersey?

Economic costs, while impossible to quantify, would have to include the wasted energy used to produce unwanted light. The aesthetic impact of light pollution is not trivial, as evidenced by the growing number of night sky activists. There are likely some degree of aesthetic impacts and maintenance costs associated with the deaths of birds near light towers, but these are relatively insignificant.

What's being done?

At least one New Jersey community, Eatontown, in Monmouth County, has passed an ordinance declaring misdirected or unnecessary light to be a public nuisance. In 1997, the New Jersey Light Pollution Study Commission issued recommendations for reducing unwanted light on the basis of safety, privacy, efficiency, and preservation of the night sky. Widespread concern about the degradation of the natural nighttime environment has resulted in the growth of international advocacy for the control of inappropriate outdoor lighting.

Lyme disease

Human Health Risk	L
Ecological Risk	
Socioeconomic Risk	

Lyme disease is a multi-systemic, inflammatory disease caused by the spirochete *Borrelia burgdorferi* transmitted through the bite of infected black-legged ticks, *Ixodes scapularis*. Diagnosed and treated early, the effects are generally mild and transient. Misdiagnosed or undiagnosed/untreated cases may result in more severe complications, including cardiac, neurologic, or arthritic conditions. White-tailed deer (also evaluated as a biological stressor) are known to carry the tick that spreads the disease.

Who's at risk?

Specific populations at risk are those living or working in wooded suburban or rural environments in New Jersey. However, Lyme disease cases have been reported in all New Jersey counties. A large proportion of cases occur among children, presumably because of increased exposure and infrequent use of preventive measures.

What is the extent of human health problem in New Jersey?

Approximately 2,000 cases are reported annually (approximately 24 cases per 100,000 population). New Jersey consistently ranks among the top 5 states with respect to the number of confirmed cases reported each year.

What's being done?

Effective public education and surveillance are the extent of current intervention. No organized tick assessment or management programs have been established.

Mercury

Human Health Risk	M
Ecological Risk	M - H
Socioeconomic Risk	M - L

Mercury is a naturally occurring element that has been used in a variety of industrial and commercial applications. The primary source of mercury in the environment is air deposition—quantities of mercury are released from waste incinerators, manufacturing processes, and as a by-product of coal-burning power plants. Mercury emissions may travel hundreds of miles before precipitating out of the atmosphere and depositing on land. Thus, a portion of New Jersey's mercury deposition originates out of state. In aquatic environments, deposited mercury will react with bacteria to form methylmercury, an organic form that accumulates in biological (e.g., fish) tissue. It is this organic form of mercury that presents the greatest human and ecological hazards.

What's at risk?

Children whose mothers consume mercury-contaminated fish during pregnancy are at risk for neurological-developmental effects. A small number of private wells in New Jersey may also contain unsafe concentrations of mercury. Individuals with large numbers of dental fillings may be at increased risk, as are people who intentionally use mercury in their homes for folk/cultural reasons. Atmospheric deposition of mercury affects ecosystems statewide. Wildlife, particularly fish-eating species near the top of the food chain, are also at risk for adverse chronic effects. Areas at higher risk would include low pH systems such as the Pine Barrens, and near hazardous waste sites.

What are the human health impacts in New Jersey?

A child exposed to methyl mercury *in utero* may exhibit subtle cognitive deficits. About 10-20% of pregnant women in New Jersey who consume fish may expose their children to unsafe levels; thus an estimated 11,000-24,000 infants may be exposed each year. Adults who consume large amounts of fish with elevated levels of mercury may also experience neurological symptoms including tremors, weakness, and motor difficulties. Of 2,239 private wells tested in Ocean and Atlantic counties, 59% had detectable levels of mercury, and 14% had levels that exceeded the Maximum Contaminant Level (MCL). These percentages, however, cannot be generalized to New Jersey or to Ocean and Atlantic County residents. There are no reliable estimates of the numbers of people using mercury intentionally, or how many may be at greater risk as a result of dental work.

What are the ecological impacts in New Jersey?

Mercury may cause adverse impacts on aquatic and terrestrial species including reproductive, behaviorial and growth effects. Fish and wildlife at the top of aquatic food chains (fish-eaters) are especially at risk to the toxic effects of mercury, and because monitoring is limited, actual risks to aquatic species may be underestimated. Based on the samples that have been collected at some locations, mercury concentrations in soils, sediments, water, and fish tissue appear to exceed ecological benchmarks a significant portion of the time.

What are the socioeconomic impacts in New Jersey?

Statewide, the costs of mercury pollution are estimated at $2 million to $113 million per year. This includes medical costs for 1% of exposed infants, along with the costs of remediation for contaminated wells in the Pinelands area.

What's being done?

Fish consumption advisories are intended to limit consumption of mercury-contaminated fish, and increased education and public awareness should help reduce human health risks. Mercury in some consumer products has been reduced. Controls on emissions further reduce atmospheric concentrations. Assistance is provided for households with private wells exceeding the MCL.

Methyl tertiary butyl ether (MTBE)

Human Health Risk	L
Ecological Risk	
Socioeconomic Risk	M - L

Methyl tertiary butyl ether, or MTBE, is a fuel additive that reduces the generation of carbon monoxide and ozone-forming compounds when burned in automobiles. The chemical is water-soluble, and when spilled migrates readily through soil and into ground water supplies. Inhalation of high concentrations of MTBE can cause nervous system depression, and animal studies have shown long term exposure can result in kidney toxicity.

What's at risk?

MTBE can be inhaled during automobile refueling and ingested via contaminated drinking water. Therefore, the entire population is generally exposed, with some increased risks for those relying on well water that could potentially be contaminated with MTBE and for service station attendants.

What are the human health impacts in New Jersey?

Personal exposures, such as during refueling at service stations, can exceed the Reference Dose (i.e., the "safe dose"), but ambient concentrations are several hundred-fold lower. There are anecdotal reports of individuals suffering from acute symptoms, including headache, eye irritation, and dizziness. There are several wells contaminated with MTBE in New Jersey, but only one public water supply has exceeded the Maximum Contaminant Level (MCL). Contamination of private wells occasionally results in MTBE levels that exceed the MCL as set by the state.

What are the socioeconomic impacts in New Jersey?

No individual socioeconomic factor poses a large risk in New Jersey although psychological and aesthetic risks may be noticeable. MTBE does add a taste and odor to drinking water at concentrations less than those yielding a health concern.

What's being done?

The use of MTBE is being phased out to reduce its negative environmental impacts, particularly well contamination.

MSX parasite in oysters

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	M - L

MSX refers to a disease of oysters caused by the protozoan organism *Haplosporidium nelsoni*. MSX (which stands for "multinucleated sphere X") is also known as Delaware Bay disease. The protozoa were introduced to East Coast waters by an unknown source but have colonized oyster fisheries from Maine to Florida. MSX causes rapid death in highly susceptible oysters, and resulted in massive mortalities in Lower Delaware Bay estuary in 1957. Native populations in Delaware Bay have since grown quite resistant, although their numbers remain severely depleted relative to fifty years ago (see report on *Dermo* disease in oysters). Pollution does not appear to be a factor in the incidence or spread of the disease.

What's at risk?

Populations of the Eastern (aka American) oyster found in the Delaware Estuary and Atlantic coastal bays are at risk.

What are the ecological impacts in New Jersey?

Since the 1990s, the prevalence and severity of MSX disease has been very low in the Delaware Bay, even though the infectious organisms continue to be present. It is hypothesized that the current native population, having been descended from oysters that survived the 1957 event, is highly resistant. The general decline of native oyster populations due to periodic catastrophic infection events over the past fifty years remains a concern; current harvests indicate about a 90% loss since 1950. Oyster population decline significantly reduces the filtration of suspended particles in estuaries such as Delaware Bay.

What are the socioeconomic impacts to New Jersey?

Returning the oyster industry to historic levels would restore hundreds of jobs and contribute an estimated $40 million to New Jersey's economy. (Dermo parasites are included in this analysis.)

What's being done?

Control measures that are effective for Dermo disease are not generally effective for MSX. The best control for MSX is to culture resistant seed oysters in hatcheries, and to avoid seeding of wild oysters during the early summer, when risk of infection is highest.

Nickel

Human Health Risk	L
Ecological Risk	M - L
Socioeconomic Risk	L

Nickel is a naturally abundant metallic element that is ubiquitous in the environment. It is also used industrially for a variety of purposes. As an alloy, nickel is combined with other metals to form consumer products such as kitchen utensils, coins, and jewelry. Some nickel compounds formed as by-products from industrial processes using nickel as a catalyst are human carcinogens, but are of little concern for non-occupational exposures in New Jersey. Nickel is also a common skin allergen, and inhalation of low concentrations of nickel can contribute to asthma and respiratory infections.

What's at risk?

Because of the ubiquitous nature of nickel and its use in everyday household items, the statewide population is exposed on a daily basis. Risks to human and non-human populations will be greater in areas of increased nickel release (manufacturing facilities, oil and coal combustion sources, sewage sludge incinerators). Smokers and occupationally-exposed individuals are also at increased risk. Individuals with skin allergies to nickel may constitute 2-5% of the population.

What are the human health impacts in New Jersey?

Assuming that New Jersey ambient air concentrations of nickel are of the carcinogenic form, total air releases for New Jersey could be expected to add 5.1 lifetime cancers per million population, which is equivalent to a total of 40 excess cases, or less than one additional cancer per year. This assumption, however, is highly uncertain and is likely to result in a large overestimation of cancer risk. There have been no exceedences of the Maximum Contaminant Level (MCL) for nickel in New Jersey public drinking water supplies. Individuals with skin allergies to nickel may experience contact dermatitis, symptoms of which (e.g., itching) are mild and reversible.

What are the ecosystem impacts in New Jersey?

Nickel occurs regularly in river, marine, and estuarine sediments at levels greater than benchmark values but the impacts from these concentrations are not known. At toxic levels, nickel affects photosynthesis and/or growth in aquatic plants and animals. However, average concentration of nickel in surface waters are generally below levels of concern.

What are the socioeconomic impacts in New Jersey?

Medical costs associated with the additional cancer burden attributable to nickel are estimated at about $30,000 per year. There are no hypothesized impacts to property values, employment, aesthetics, or psychological well being.

What's being done?

Quantities of nickel in drinking water are regulated by federal law, with a Maximum Contaminant Level set at 0.1 milligrams per liter. Workplace exposures are regulated by OSHA. DEP has established that residential-use soils contain less than 50 parts per million of nickel.

Nitrogen oxides (NO_X)

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	L

Nitrogen oxides (NO_x) are by-products of combustion, with nitrogen dioxide (NO_2) being the most prevalent. Major sources of NO_2 in outdoor air are utility boilers and vehicles. Indoors, gas stoves and kerosene heaters also contribute to NO_2 exposures. Health effects are primarily to the respiratory system, although there are also immune system and cardiovascular impacts associated with exposure. Nitrogen dioxide is also a precursor to ozone as well as a constituent of acid precipitation; the effects of those are described separately.

What's at risk?

Virtually the entire population is exposed to NO_x and residents of urban areas are exposed to somewhat higher levels. As with other air pollutants, NO_x can accumulate to higher concentrations indoors and pose greater risk. At particular risk are asthmatics and children.

What are the human health impacts in New Jersey?

The concentration of NO_2 in New Jersey is below federal regulatory standards, but there is some evidence that the concentrations that do exist in New Jersey can increase the susceptibility of children to respiratory disease. There is some evidence of increased numbers of asthma episodes among the approximately 54,000 asthmatics that live in the three New Jersey counties with highest ambient NO_2 levels. For both children and asthmatics, indoor exposures increase the risk.

What are the socioeconomic impacts in New Jersey?

Any impacts are expected to concern medical costs, but even these are uncertain and likely to be low.

What's being done? .

New Jersey is required to reduce NO_x emissions to comply with federal regulations. These reductions have been effective in the past for industrial sources and to a lesser degree with mobile sources. Increasing use of automobiles makes it more difficult to keep emissions from increasing.

Nitrogen pollution (water)

Human Health Risk	L
Ecological Risk	M
Socioeconomic Risk	L

The natural nitrogen cycle is disrupted by the use of nitrogen fertilizers and by the production of nitrogen oxides (NO_x) during combustion. Excess nitrogen from fertilizers enters aquatic ecosystems, causing algal blooms and reducing oxygen levels and other ecological effects. Additionally, NO_x are present in precipitation, adding to the ecological impacts caused by fertilizer runoff. High nitrate levels in drinking water can contribute to "blue-baby syndrome," which reduces the ability of blood to carry oxygen. Atmospheric NO_x is considered separately, as are the impacts of ozone and acid precipitation, stressors to which NO_x are an important contributing factor.

What's at risk?

All freshwater and coastal ecosystems are exposed to excess nitrogen, but impacts are primarily to estuarine and coastal ecosystems. In the form of ammonia, nitrogen is toxic to fish, particularly trout.

What are the human health impacts in New Jersey?

No cases of "blue-baby syndrome" have been attributed to drinking water in recent years. Most drinking water in New Jersey meets the public health standard, and no cases of this syndrome have occurred at or below that level. Perhaps 10 to 20 infants a year, minus those who are breast-fed, would be at risk for exposure to clinically significant levels of nitrates in water from private wells in New Jersey.

What are the ecological impacts in New Jersey?

The effects of excess nitrogen in aquatic systems are most noticeable in marine and estuarine systems. Freshwater systems are more affected by excessive amounts of phosphorus (considered in a separate report). Ammonia can be toxic to fish, and its conversion to nitrate can result in oxygen depletion in aquatic systems. Low dissolved oxygen, or hypoxia, often occurs in coastal waters during summer, with severe ecological effects. High nitrogen levels contribute to the growth of problematic algae, resulting in the loss of submerged vegetation and fish and shellfish mortality (see reports on brown tide, red/green tide, pfiesteria). Ammonia levels exceeding water quality standards are found in about 10% of trout habitats.

What are the socioeconomic impacts in New Jersey?

Socioeconomic impacts were judged to be minor and associated with the potential for localized employment impacts.

What's being done?

Fertilizer use is not regulated, but efforts to reduce the incidence of excessive use are important in watershed management efforts.

STRESSOR SUMMARIES

Noise

Human Health Risk	L
Ecological Risk	M - L
Socioeconomic Risk	M

While noise is generally described as "unwanted" sound, excessive exposure to sound, regardless of desirability, can produce various physiological and psychological effects in both humans and animals. Workplace exposures to noise and personal exposures that are at least partially within the control of the individual are excluded from this analysis. As a result, the primary sources of concern are vehicle, railroad, and aircraft traffic noise, along with airports and highways.

What's at risk?

The entire population is exposed to some extent. Individuals living along transportation corridors or near airports constitute a population of concern, but these numbers have not been quantified. People with irregular sleeping habits, such as shift workers, and those with medical conditions that affect sleep are particularly vulnerable. Nesting shorebirds in the vicinity of heliports and airports are also impacted by excessive noise. Overflight noise affects special use lands, river corridors, beaches, forests, and wetlands totaling approximately 1.5 million acres.

What are the human health impacts in New Jersey?

There is a lack of data regarding the number of people exposed to excess noise and the magnitude of health effects that may be experienced as a result of exposure. Human health effects potentially include hearing loss, sleep disturbance, and effects on the cardiovascular system (e.g., blood pressure). The number of people exposed to excessive transportation noise has not been quantified. Likewise, the number of sleep-compromised individuals or otherwise vulnerable subgroups would be extremely difficult to estimate reliably. Excluding workplace and voluntary exposures, the remaining effects from environmental noise are minor and reversible.

What are the ecological impacts in New Jersey?

Animals also suffer from the effects of loud noise. Nesting birds exposed to heavy aircraft and helicopter traffic have been observed evacuating their nesting sites and fighting among themselves—abnormal behaviors that can affect reproductive success. There is little research that describes the extent of exposure or magnitude of effects in wildlife, including on the bird and aquatic wildlife impact of oceanic (ships; underwater broadcasts) and jet-ski noise. (The Ecological TWG produced two noise analyses, for overflights and watercraft, respectively.

What are the socioeconomic impacts in New Jersey?

Negative perceptions associated with noise are reflected in lower property values near airports. Estimated loss of property value due to the NY/NJ air transportation hub alone is nearly $25 billion. Additional property damages due to ground sources of traffic noise may bring the total to as much as $38 billion statewide.

What's being done?

There are significant controls in place to curb noise levels. Vehicles are required to comply with noise standards, noise ordinances are intended to keep environmental sources of noise down to acceptable levels, and New Jersey is second only to California in spending on noise barrier walls along its highways.

Off-road vehicles (ORVs)

Risk	Rating
Human Health Risk	
Ecological Risk	M- L
Socioeconomic Risk	L

The use of all-terrain vehicles (ATVs), snowmobiles, and jet skis is controversial. While resource managers claim moderate to severe impacts to terrestrial and aquatic ecosystems, use of motorized recreational vehicles continues to increase, creating conflict between ORV enthusiasts and non-motorized visitors to beaches, parks, and forests.

What's at risk?

Terrestrial and aquatic ecosystems where the use of ATVs, snowmobiles, and jet skis are used are at risk from the impacts of ORVs. Impacts appear to be more severe on sensitive ecosystems including wetlands and streams, but limited data prevents quantification at this time.

What are the ecological impacts in New Jersey?

Environmental impacts from ORVs include soil compaction and erosion, habitat degradation and/or wildlife harassment, loss of vegetation, noise, and air pollution. Jet skis also discharge quantities of unburned fuel which can be harmful to fish and marine mammals.

What are the socioeconomic impacts in New Jersey?

Motorized vehicles are considered a nuisance by non-users, and jet ski noise drives away significant numbers of tourists, costing an estimated $1 billion in lost revenue nationally.

What's being done?

Because of environmental concerns and negative public comments, the use of ORVs has been banned in many state and federal areas, including all New Jersey state parks. New Jersey has at least one park for off-road vehicles located in the Pine Barrens in Chatsworth. Operations such as this potentially reduce impacts by focusing activity to one area and reducing use in other areas/habitats.

Overharvesting (marine)

Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	L

Harvesting of species such as clams, crabs, eels, and tuna at a greater rate than they can replace themselves is known as overharvesting. Overharvesting has been blamed for a decline in commercial fishing yields. Harvesting of horseshoe crabs was used as an example of overharvesting marine resources.

What's at risk?

Groups at risk include species with commercial value, such as horseshoe crab, tuna, clam, and eel. A critical aspect of overharvesting crabs is the annual reliance of more than a million migratory shore birds on horsehoe crab eggs as a food source to sustain the trip to their Arctic breeding grounds.

What are the ecological impacts in New Jersey?

Horseshoe crab eggs help maintain a healthy ecosystem by being a source of food for migratory shore birds, raccoons, foxes, turtles, and moles. Reduced availability of food for these species may result in decreased numbers, and a decline in ecological complexity and quality.

What are the socioeconomic impacts in New Jersey?

Employment impacts include the loss of several hundred commercial fishing jobs and declines in tourism income from birdwatching and recreational fishing. Aesthetic impacts of decreased bird nesting at Cape May are also notable, although very difficult to measure.

What's being done?

New Jersey requires a horseshoe crab permit and mandatory monthly reporting. Harvest by trawling or dredging is prohibited, and only hand harvesting is allowed. The harvest season has also been limited to April 15 to August 15. In addition, the National Marine Fisheries Service has recently established a horseshoe crab sanctuary off the mouth of Delaware Bay.

Ozone (ground level)

Human Health Risk	H
Ecological Risk	L
Socioeconomic Risk	M

Ozone is one of a class of compounds called photochemical oxidants that result from chemical reactions between various nitrogen oxides (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight. Stationary sources and motor vehicles are the primary source of NO_X and VOCs. Inhalation of ground level ozone has been associated with a variety of respiratory problems, especially asthma, but also including acute and chronic bronchitis, chronic obstructive pulmonary disease (COPD), reduced lung function, and premature death. Ozone is also linked to various types of damage to agricultural crops, domestic plants, forests, and other plant life.

STRESSOR SUMMARIES

What's at risk?

All residents statewide are potentially exposed during the summer months. Children may be at increased risk of exposure because they are active outside during the summer, when ozone levels are at their highest. Adults and children with respiratory illnesses, such as asthma, bronchitis and emphysema, and adults who are active outdoors during the summer are also at higher risk. Ecosystems at risk include agricultural areas and urban vegetation, which are exposed to somewhat higher levels of ozone.

What are the human health impacts in New Jersey?

Studies on ozone exposure suggest that there is no minimum threshold for triggering respiratory responses and a significant proportion of hospital visits for asthma can be associated with exposure to elevated ozone levels. Federal health-based standards for ozone are set at 80 ppb measured over an 8-hour period, and 120 ppb for a 1-hour period. In 1999, one or more locations in New Jersey were in violation of the 8-hour standard on 46 days, and the 1-hour standard on 10 days. On an average day in 1999, peak 1-hour concentrations were in the range of 50-65 ppb. In New Jersey, there are more than 440,000 asthmatics and 430,000 persons with chronic bronchitis, who may be adversely affected by ozone levels.

What are the ecological impacts of ground level ozone in New Jersey?

Exposure to ground level ozone can suppress the growth of crops, trees, shrubs, and other vegetation, and increase susceptibility to insects and diseases. Agricultural crops are considered to be at increased risk, because of the economic impacts associated with reduced growth. New Jersey ozone levels are unlikely to have a visible impact on forest ecosystems, although ozone exposure may negatively affect individual tree species, such as the eastern white pine and black cherry, as well as urban vegetation.

What are the socioeconomic impacts of ground-level ozone in New Jersey?

Ground level ozone has been linked to a variety of respiratory problems, and agricultural crop and other plant damage. Socioeconomic impacts include costs associated with that damage, as well as worry due to respiratory illness, and reduced visibility on high-smog days. Minimum cost estimates of ground level ozone's contribution to respiratory illness total more than the $59 million, and crop damage to corn, winter wheat, and soybean crops are estimated at $1 million to $2 million.

What's being done?

During the 1980s, the 1-hour ozone standard was exceeded in New Jersey more than 30 times per year. In recent years, the standard is exceeded much less often—less than 20 times per year. This overall reduction in ozone levels can be attributed to reductions in allowable emissions from automobiles and industrial sources, and by controlling releases at fuel pumps.

Particulate Matter

Human Health Risk	H
Ecological Risk	
Socioeconomic Risk	M - H

Particulate matter is solid particles or liquid droplets from smoke, dust, ash, or condensed vapor that can remain airborne for long periods of time. Particulate matter results from all types of combustion, materials abrasion, and re-suspension of dust. Bioaerosols, which include plant pollen, animal dander, molds and yeasts, bacteria, and viruses, may be particularly high indoor contributors to particulate matter exposures. Particulates are usually measured in two size ranges. Coarse particles (between 2.5 and 10 microns in diameter) are formed as a result of crushing or grinding (e.g. mining operations), and natural weathering, and include the bioaerosols. Fine particles (less than 2.5 microns) result from condensation of volatile combustion products and reactions between atmosphere pollutants. Fossil fuel combustion (vehicles, power utilities, and industry), burning of vegetation, and metal smelting are sources of fine particulates. Inhalation can aggravate existing respiratory and cardiovascular disease, damage lung tissue, and interfere with lung function. Increases in particulate matter exposure are also associated with increased daily mortality, although the exact cause is uncertain.

What's at risk?

Groups most widely affected include young children, asthmatics, the elderly, smokers, and individuals with chronic lung or cardiovascular disease. Asthmatics show increased response to acid aerosols and bioaerosols. Smokers constitute approximately 80% of individuals with chronic obstructive pulmonary disease and a portion of cardiovascular disease patients. Children and adolescents may be at increased risk because they have higher respiration rates.

What are the human health impacts in New Jersey?

The entire state is currently in compliance with federal standards for coarse particles (PM 10). Recent studies have shown that fine particles (PM 2.5) may be of greater concern. Fine particulates are inhaled deeply into the lungs, where they become lodged and interfere with lung function. In contrast, PM 10 are cleared fairly rapidly from the nose and upper airways by sneezing and coughing. New standards for PM 2.5 are being developed. The average American person spends about 20 hours per day indoors. Cooking, smoking, dusting, vacuuming, and walking on carpets are all sources of particulates to which people are exposed daily. For most individuals, the effects are small and difficult to attribute to specific environmental conditions. Typically, the effect is a worsening of an existing health problem.

What are the socioeconomic impacts in New Jersey?

Damage costs associated with the soiling of homes are estimated at over $160 million. Health care costs cannot be quantified, because of the tendency of particulate matter to worsen existing conditions. Aesthetic impacts from reduced visibility in New Jersey attributed to particulate matter can be assigned a dollar cost using established "willingness to pay" rates for improved visibility in recreational and residential areas. These costs are estimated at $45 million, however there are significant uncertainties associated with this estimate.

What's being done?

Recent research focused on the significance of smaller (PM 2.5) particles, and their relation to illness. Controls are in place on large industrial facilities, and new standards for auto fuels have been released, which are expected to further reduce PM 2.5. There are indoor particulate matter standards for the workplace, but no regulations control residential exposures.

Pesticides, present use

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. Approximately 600 substances are registered as pesticides—this analysis focuses on the risks associated with a subset commonly used in New Jersey. Aquatic herbicides such as copper sulfate are applied directly to surface waters to control weeds and nuisance insects. Oxamyl is an insecticide used on a variety of crops, typically apples, potatoes, and tomatoes. Diazinon is a versatile insecticide used widely on both croplands and turfgrass. Resmethrin is another broad-spectrum insecticide commonly used in mosquito control.

What's at risk?

Aquatic ecosystems throughout the state are at risk from unintended effects of weed and nuisance insect control pesticides. Atlantic, Burlington, Cumberland, Gloucester and Salem counties typically record the heaviest agricultural pesticide use in the state. Foraging birds, mammals, fish, and beneficial insects, such as honey bees, are at risk.

What are the ecological impacts in New Jersey?

Even when used in an appropriate and legal manner, commonly used pesticides create adverse impacts on non-target species. Oxamyl is typically applied to a variety of crops during critical periods of bird and mammal reproduction, increasing the risk of reproductive effects. Bird kills associated with diazinon application are well documented, as are its toxic effects on honey bees, fish, and aquatic invertebrates. Incidents of wildlife mortality associated with diazinon have been steadily increasing, with the majority occurring on turf sites, such as lawns. The use of resmethrin has increased in response to health concerns associated with mosquito-borne illness (West Nile virus) along with a corresponding increase in the risks to non-target populations.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

There are controls on where oxamyl, diazinon, and resmethrin may be applied and by whom. The DEP Pesticide Control Program licenses professional pesticide applicators and conducts monitoring for ecological impacts in New Jersey. Outreach programs help to educate the public on the safe and responsible use of pesticides. Acute and chronic impacts to non-target organisms are occurring under legal uses; further exploration is needed to determine whether allowable uses are protective of ecological integrity.

Pesticides, food

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. Approximately 600 substances are registered as pesticides, each having different chemical, physical, and toxicological characteristics. Many of these are used in growing and producing food crops for human consumption. Food monitoring studies have documented the consistent presence of many different pesticide residuals in foods, and because of the presence of long lasting pesticides in soils, there are no crops grown that can be guaranteed completely pesticide free.

What's at risk?

The general population is exposed as persistent pesticide residues continue to be detected in virtually all types of food products. Because of their immature systems, infants and children are more susceptible to the effects of pesticides. They also consume more food relative to body weight. Exposure to even trace amounts at crucial times in fetal or infant development may disrupt or damage developing hormonal, reproductive, neurological, or immune systems. The elderly, nursing mothers, and women and men of childbearing age are also more susceptible.

What are the human health impacts in New Jersey?

There are national estimates for residue content in selected foods: pesticides have been found in about 40% of grain samples, 55% of fruits, and 30% of vegetable samples. Only a small percentage of samples violate established tolerances, however, and this percentage has been decreasing over time. While DEP has recently initiated a pilot program to evaluate food grown in New Jersey, there are currently no data available to quantify exposures to residues from food grown in New Jersey. In addition to the difficulties in quantifying exposure, health effects associated with residues have not been systematically assessed even for particular chemicals. There are large data gaps hindering a valid assessment of the impacts that may result from chronic exposure to the myriad of pesticide residues on food.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

The federal Food Quality Protection Act requires a reassessment of the underlying risks from pesticides in food. National efforts are under way to reevaluate tolerances to reflect residues in all types of food, to include risks other than cancer, and to factor in aggregate exposures from diet, drinking water, and other nonoccupational exposures. Over 9,000 commodity/pesticide combinations with existing tolerances will be reassessed by 2006. The limitation and regulation of the use of pesticides on food crops minimizes the risks of acute effects or poisoning.

Pesticides, historic use

Human Health Risk	
Ecological Risk	M - H
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. The widespread use of chlorinated pesticides such as DDT and chlordane began with the use of DDT during World War II as a highly effective, long lasting, and inexpensive insecticide. It was the most widely used agricultural insecticide from 1946 to 1972. Chlordane, also introduced in the 1940s, was used extensively throughout the 1960s and 1970s to control lawn and garden pests. Recognition of the ecological and human health hazards of chlorinated pesticides led to a United States ban on DDT in 1972, and chlordane in 1988. Because these compounds remain stable for long periods of time, residues continue to be detected in New Jersey soils, sediments, surface, and ground water.

STRESSOR SUMMARIES

What's at risk?

Since DDT, chlordane, and other chlorinated pesticides were used extensively, they continue to be detected throughout the state. Because these chemicals accumulate in animal tissue, species at the top of the food chain, especially fish eaters, are at greatest risk. Examples include osprey, bald eagle, and river otters.

What are the ecological impacts in New Jersey?

DDT and its metabolites (DDD, DDE) are found in soil samples throughout the state. Bald eagle and peregrine falcon eggs have been found to contain up to 30 parts per million of DDE in their eggs. High pesticide concentrations reduce eggshell thickness, making them vulnerable to breakage, thus impacting reproductive success for the population. Chlordane has been linked to large-scale bird poisonings in certain areas of New Jersey. During a 3-week period in 1997, chlordane-contaminated beetles, consumed by insectivorous songbirds, and ultimately birds of prey, resulted in a significant poisoning event that killed over 400 birds. Whether similar conditions exist throughout New Jersey is unknown, but sampling indicates the hazard may be restricted to suburban areas where chlordane was used on lawns in the 1960s and 1970s.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

Bans on the use of chlorinated pesticides have decreased their presence over time, but as much as 50% of these persistent compounds may remain in the environment. Federal and state regulations control the levels of chlorinated pesticides permitted in drinking water and food. Contaminated sites requiring cleanup must meet federal and state requirements for chlorinated pesticide concentrations.

Pesticides, indoor

Human Health Risk	M - H
Ecological Risk	
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. Approximately 600 substances are registered as pesticides, each having different chemical, physical, and toxicological characteristics. Indoor exposure to pesticides results from their direct use as disinfectants or pest control as well as indirectly as a result of drifting or tracking in from outdoors. Rugs and floors are a major source of pesticide residues; household dust has been found to contain higher pesticide levels than the surrounding outdoor soils in a number of studies. Chemicals used for termite control, some of which have been banned for residential use, may continue to persist in indoor air years later. Pesticides that degrade readily in soils may persist for longer periods in indoor environments.

What's at risk?

Virtually everyone is exposed to some degree and infants and children are especially at risk from ingesting pesticide residues on floors and objects. Asthmatics or other sensitive individuals may also be at increased risk. Residents of older homes treated for termites and urban residents with persistent pest control problems may have elevated indoor levels. Suburban residents and homes in agricultural areas where large quantities of chemicals are applied outdoors may also have correspondingly higher indoor levels.

What are the human health impacts in New Jersey?

According to EPA data, many people receive 80% to 90% of their exposure to pesticides indoors. Exposure occurs via inhalation of residues in the air, skin contact, and ingestion of residue carried by dust or particles. Pesticide residues may be found in homes many years after chemical use has been discontinued—some of the most persistent pesticides such as DDT are still detected. The exposure level to specific populations in New Jersey cannot be quantified, but according to national estimates, 75% of American households used at least one pesticide indoors during the year. While it is unknown what percentage of these households are adversely affected by indoor pesticide levels, there is concern about the chronic impacts of low doses on the endocrine, reproductive, and neurological systems, immune response, and on learning and memory. There is also a potential for acute effects resulting from misuse or accidental poisoning. Several thousand calls related to pesticides are placed annually to the New Jersey Poison Information and Education System.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

A number of the most persistent pesticides have been banned from use, but continue to be detected in indoor environments. Regulations govern the professional pest control industry. Product labeling and education efforts contribute to increasing consumer safety. There are currently no regulations pertaining to the safe storage of pesticides where they are sold to the general public.

Pesticides, outdoor

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. Approximately 600 substances are registered as pesticides, each having different chemical, physical, and toxicological characteristics. Pesticides of every major chemical class may be detected in New Jersey ground and surface waters, a result of widespread use on croplands, lawns, gardens, golf courses, rights-of-way, and parks. Pesticides that have long been banned, such as DDT, are still detected in New Jersey surface water samples. The presence of pesticides in surface and ground water supplies poses risks to human health when these sources are used for drinking water. Most New Jersey residents obtain drinking water from public water supplies, about half rely on surface water sources, and half on ground water sources for raw water. In rural areas in the southern part of the state, many people rely on private wells that tap into ground water. There is a potential for any of these drinking water supplies to become contaminated with pesticides.

What's at risk?

The general population is potentially exposed. Because private wells are not monitored, households with private wells are at increased risk. Particularly vulnerable to contamination are shallow wells located in areas with high pesticide use. Infants, children, and the elderly may be at increased risk from the effects of pesticide contamination. Individuals with compromised immune systems or chronic lung disease or nervous system dysfunction are also at increased risk.

What are the human health impacts in New Jersey?

More research is needed to address the data gaps that make it impossible to quantify exposure levels and impacts of that exposure for the New Jersey population. There are currently no estimates regarding the incidence of pesticide-related illness, nor a means for assessing the severity of health effects. However, hundreds of thousands of pounds of chemicals are applied commercially in New Jersey, with the additional volume of usage by private citizens going unreported. Most pesticides have not been fully evaluated with respect to the potential for endocrine disrupting effects at low, chronic levels of exposure (see summary on Endocrine Disruptors), rather, evaluations for potential health effects have been heavily based on high dose animal studies. Pesticide use also carries a risk for acute effects resulting from misuse or accidental poisoning. Several thousand calls related to pesticides are placed annually to the New Jersey Poison Information and Education System.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

Pesticide use is regulated, but current levels of contamination are occurring as a result of legal use. Reducing the risks associated with pesticides in drinking water will require changes in regulations controlling their use, as well as changes in agricultural practices that reduce application rates and control runoff.

Pesticides, water

Human Health Risk	M
Ecological Risk	
Socioeconomic Risk	

Pesticides include any compounds employed to destroy, prevent, or control pests. By their very nature, these chemicals present some risk of environmental harm. Approximately 600 substances are registered as pesticides, each having different chemical, physical, and toxicological characteristics. Outdoor herbicides are widely used for lawn care, rights-of-way, and golf courses in New Jersey. Pesticides of every major chemical class may be detected in New Jersey ground and surface waters, a result of widespread use on croplands, lawns, gardens, golf courses, rights-of-way, and parks. Pesticides that have long been banned, such as DDT, are still detected in New Jersey surface water samples. The presence of pesticides in surface and ground water supplies poses risks to human health when these sources are used for drinking water.

What's at risk?

The general population is exposed to pesticides through the ingestion of drinking water coming from public and private supplies. Because private wells are not monitored, households with private wells are at increased risk. Particularly vulnerable to contamination are shallow wells located in areas with high pesticide use. Infants, children and the elderly may be at increased risk from the effects of pesticide contamination. Individuals with compromised immune systems are also at increased risk.

What are the human health impacts in New Jersey?

There are currently no estimates regarding the incidence of pesticide-related illness, nor a means for assessing the severity of health effects. However, hundreds of thousands of pounds of chemicals are applied commercially in New Jersey, with additional use by private citizens going unreported. If only 1-5% of the applications reach surface water via run off, then a large quantity of the pesticide will be available through drinking water. Monitoring both surface and ground water shows a large percentage is vulnerable to pesticide contamination, although exceedances of health based limits are not currently observed. Most pesticides have not been fully evaluated for endocrine disrupting effects at low, chronic levels of exposure (see summary on Endocrine Disruptors). Evaluations for potential health effects have been heavily based on high dose animal studies. Pesticide use also carries a risk for acute effects from misuse or accidental poisoning. Several thousand calls related to pesticides are placed annually to the New Jersey Poison Information and Education System.

What are the socioeconomic impacts in New Jersey?

The socioeconomic TWG estimated impacts from pesticide exposures from all sources. Using national estimates, at least $8 million in medical costs may be expected as a result of increased childhood cancers and accidental poisonings related to pesticide exposures. Studies have shown that most people worry about pesticide residues in food. Potential loss of biodiversity may also contribute to an aesthetic impact. Overall, socioeconomic risks from pesticides are considered high, but there are significant uncertainties.

What's being done?

Drinking water is monitored for pesticide contamination. A number of the most persistent pesticides have been banned from use, but continue to be detected wherever samples are taken. Risks from current use pesticides are controlled in part by labeling requirements and EPA registration. The DEP Pesticide Control Program has responsibility for licensing and certification of commercial pesticide applicators. Applications for mosquito control increased in response to the 1999 West Nile virus outbreak (see related summary).

Petroleum Spills

Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	M - H

Spilled oil and gas products can pose a threat to aquatic ecosystems in a number of different ways. Catastrophic oil spills on the order of the Exxon Valdez, while unlikely to occur, would have devastating effects on a marine or riverine environment. Minor oil spills, which happen much more frequently, can have significant cumulative impacts. Recreational vehicles such as jet skis release a significant portion of their fuel into the water. Finally, underground storage tanks may leak, allowing the contents to seep into the soil and ground water, eventually contaminating surface water systems.

What's at risk?

Fish, shellfish, and birds are most directly affected by oil spills. Most spills occur in Newark Bay, Arthur Kill, Kill Van Kull, and the Delaware River.

What are the ecological impacts in New Jersey?

The severity of the impacts will vary depending on (1) the properties of the specific product spilled, (2) natural conditions such as water temperature, wave action, and weather at the time of the spill, and (3) the feeding habits of affected wildlife—shore birds versus waterfowl for example. About 600 spills occur each year, averaging less than 10 gallons each. Major spills of more than 500 gallons occur much less frequently—11 occurred in New Jersey between 1997 and 2000.

What are the socioeconomic impacts in New Jersey?

Millions of dollars are spent by polluters, DEP, and tank owners for emergency clean ups. Additionally, the threat of a catastrophic tanker accident along with the unsightly appearance and odor associated with degraded ship channels creates moderate levels of psychological and aesthetic impacts.

What's being done?

The United States Coast Guard, EPA, and Department of Environmental Protection share responsibilities for helping to prevent, monitor, and clean up accidental oil spills in New Jersey waterways. EPA and DEP regulate the repair and closure of underground storage tanks. Despite regulations and programs aimed at reducing the risk of accidental oil spills, the volume of petroleum-related activity ensures that spills will continue to pose a threat as long as oil is transported, stored, and processed in New Jersey. There are no restrictions on the use of jet skis and other marine engines that routinely release quantities of fuel and engine oil to the water.

Pets as predators

Risk	
Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Free ranging cats and other household pets that are allowed to roam outdoors can pose a threat to birds and other wildlife. Housecats are abundant predators, responsible for killing over a billion small mammals and hundreds of millions of birds in the United States each year. To a lesser extent, unleashed dogs can also harm wildlife, particularly beach nesting birds. Suburbanization has the compound effect of increasing the incidence of pets, while decreasing preferred habitat for prey species.

What's at risk?

Birds, mammals, and small reptiles including at least 18 endangered or protected species are at risk. Small perching birds and beach nesting species such as piping plover and tern are particularly vulnerable to pet predation in New Jersey. Cats also outnumber and outcompete some native predators such as hawks and weasels.

What are the ecological impacts in New Jersey?

There have been no studies done in New Jersey to quantify the problem. As a reference, data from other states have found that cats kill nearly 40 million birds per year (Wisconsin), averaging up to 91 birds per year apiece (Virginia). Predators are cited as the major cause of piping plover decline in New Jersey, but management for cats and dogs has been recommended at only 8 of 34 monitored breeding sites.

What are the socioeconomic impacts in New Jersey?

Predation of birds by pets could potentially have negative impacts for birdwatchers. Interest in birdwatching has grown in recent years, and more than 100,000 birdwatchers now visit the Cape May region each year. The economic impact associated with birdwatching has risen from $10 million in 1991 to $31 million in 1997. Since expenditures in New Jersey are rising, it appears that pets have not yet taken a measurable economic toll. If cats were to threaten the survival of enough species of birds, there could be a negative effect on birdwatching, but this is unlikely to occur within five years.

What's being done?

There are currently no regulations protecting wildlife from household pet predation. Non-profit groups such as the American Bird Conservancy work to raise awareness among pet owners about the risks to birds and other wildlife when their pets roam freely.

Pfiesteria

Risk	
Human Health Risk	L
Ecological Risk	L
Socioeconomic Risk	L

Pfiesteria is a type of algae that occurs naturally in New Jersey coastal waters. Generally harmless, *Pfiesteria* can become toxic under specific environmental conditions, notably the presence of large schools of fish. *Pfiesteria* has been associated with fish kills in Maryland, Delaware, Virginia, and North Carolina, but there have been no confirmed reports of *Pfiesteria*-type fish kills in New Jersey waters. *Pfiesteria* is not a source of human illness through seafood consumption, but it can cause adverse effects in individuals who come in direct contact with toxic-stage *Pfiesteria* during an outbreak. While the toxic stage lasts only a few hours, toxic effects (*e.g.,* fish kills) may persist for days or weeks afterward.

What's at risk?

There has never been a confirmed outbreak in New Jersey. Areas with large concentrations of fish (menhaden for example) where there is a potential for *Pfiesteria* outbreaks include the Navesink and Shrewsbury rivers in the Atlantic region and in estuaries along the shoreline of the Lower Delaware. Given the isolated and short-term nature of the organism's toxic stage, potential human exposure is very small—perhaps a few dozen individuals could become exposed.

What are the human health impacts in New Jersey?

Should an outbreak ever occur in New Jersey, the potential for human health impacts is likely to be very low, given the short duration and isolated nature of these events. Exposures in other states were limited to a few lab workers handling Pfiesteria cultures, and commercial fisherman who were exposed during fish kill events. These individuals experienced a wide range of symptoms, including lesions, respiratory problems, stomach distress, behavior changes, and memory loss.

What are the ecological impacts in New Jersey?

Under specific environmental conditions, such as high nutrient levels and the presence of large schools of fish, *Pfiesteria* populations may increase or "bloom" and become toxic to fish, causing lesions that are often fatal. Of 32 locations sampled for the presence of the organism, it was found at only one site, the Tuckahoe River near Corbin City. There are no confirmed reports of *Pfiesteria*-type fish kills in New Jersey waters.

What are the socioeconomic impacts in New Jersey?

New Jersey is unlikely to experience a *Pfiesteria*-related fish kill. Even worst-case estimates yield a very low level of socioeconomic impact due to the short term, isolated nature of the problem.

What's being done?

New Jersey wastewater treatment approaches tend to reduce the potential for nutrient overload which is thought to be a contributing factor. Secondary treatment, along with discharge pipes that extend far offshore, help keep nutrient loads low. In the unlikely event of a *Pfiesteria*-related fish kill, the Departments of Health and Senior Services and Environmental Protection have a contingency plan for emergency response.

Phosphorus

Human Health Risk	–
Ecological Risk	M
Socioeconomic Risk	M - H

Phosphorus, or phosphate, is an essential nutrient required for plant growth. Natural concentrations of phosphorus in freshwater environments support an ecologically balanced aquatic community. Excessive amounts of phosphorus result in an overabundance of plant and algae growth in lakes, a condition known as eutrophication. Phosphates enter New Jersey lakes from incoming streams which have been affected by fertilizer runoff from farms and lawns, discharges from sewage treatment plants and septic systems, and possibly other sources. Eutrophic lakes are characteristically cloudy and choked with weeds and algae, making them less able to support healthy populations of fish and other wildlife. Recreational and aesthetic value is also affected, potentially affecting lakeshore property values.

What's at risk?

Freshwater ecosystems statewide are at risk, although lakes are typically more vulnerable than streams or rivers. More than 100 lakes in New Jersey are classified as eutrophic, potentially affecting property values and local recreation opportunities.

What are the ecological impacts in New Jersey?

Eutrophic lakes are found throughout the state, and it is difficult to reverse a eutrophic trend once it has become established. Excess phosphorus stimulates plant growth, changing the ecological balance of plants and animals living in and near an affected lake. Eutrophication occasionally results in serious damage to ecosystems, with significant changes in habitat and wildlife populations. More frequently, habitats remain intact, but the distribution and abundance of some species are reduced. Increasing rates of development have the potential to increase phosphorus input, but there is also a potential for decreased phosphorus levels if regulatory efforts are strengthened or if agricultural and residential uses of fertilizers decline in the future.

What are the socioeconomic impacts in New Jersey?

The loss of water clarity and negative impacts on the overall health of lakes is considered a moderate aesthetic impact. Economic models suggest that the loss of amenities suffered as a result of eutrophication in New Jersey could be valued at approximately $20 million. Reductions in lakefront property values, should they materialize, would not create much of an impact at the state level, but could be locally significant where a large proportion of property is located on an affected lake. Eutrophication could also affect jobs in the tourism or recreation sectors, but even worst-case estimates demonstrate that this would be a very small impact.

What's being done?

Phosphates were banned from detergents in 1972. The federal Clean Water Action Plan specifies that states establish water quality standards for nutrients based on the characteristics of water bodies and the ecoregions where they are located. Department of Environmental Protection monitors nutrient levels in lakes and coordinates water quality planning for achieving state water quality goals, including reducing nutrient loads to streams, rivers, and lakes.

Phthalates

Risk	
Human Health Risk	M
Ecological Risk	L
Socioeconomic Risk	

There are a number of manufactured chemicals that can mimic or inhibit the action of natural hormones in humans and wildlife (*see also the report on endocrine disruptors*). Phthalates are a category of these substances used in the production of a variety of consumer goods including many plastics and lubricants. Because of their widespread use, phthalates have become one of the most abundant industrial pollutants in the environment. Phthalates concentrate in body fat, and have been associated with adverse effects to the reproductive organs.

What's at risk?

Because of their abundance in the environment, virtually all populations are exposed to some extent and phthalates are detected in ground water, rivers, and drinking water. Human subpopulations may be exposed to greater amounts due to geographic location or atypical diets. Phthalates move easily in aqueous systems, placing a particular stress on aquatic systems.

What are the human health impacts in New Jersey?

The risks from phthalates in New Jersey is unknown. Several phthalates are known testicular toxicants. While virtually everyone is exposed, the severity of effects at given environmental levels has not been established. Subpopulations exposed to high concentrations may experience a wide range of developmental effects from mild and temporary to severe and life long. Effects depend on the properties of the specific chemical as well as the timing of the exposure relative to developmental stages. There are substantial uncertainties associated with the effects of endocrine disrupting chemicals in general.

What are the ecological impacts in New Jersey?

Sampling conducted for phthalates in or near contaminated sites during 1996-1999 documented sediment concentrations at levels far greater than benchmark values established for ecological health. There has been very little research on the effects of phthalates on environmental systems. Potential ecological impacts implied by observed phthalate levels include changes in reproductive capacity, which is critical to biological integrity, biodiversity, habitat and ecosystem health.

What's being done?

Because of their abundance in consumer products and manufacturing processes, there are potentially harmful quantities of phthalates released with little or no control. Current regulations that affect the production, use, and discard of chemicals may not be effective in protecting ecosystems from the effects of very small quantities that subsequently magnify throughout the food chain. Research is being conducted to better assess the risks to human and wildlife populations from environmental concentrations of endocrine disruptors.

Polychlorinated biphenyls (PCBs)

Human Health Risk	H
Ecological Risk	M
Socioeconomic Risk	M - H

There are many structurally similar polychlorinated biphenyls (PCBs) formerly manufactured for use in transformers and electrical components. They are chemically stable, which was a benefit for their industrial application but has become an environmental problem because of their persistence in the environment. PCBs enter the environment largely through accidental spills and historic disposal practices. Currently the greatest source of exposure to PCBs results from their presence in aquatic systems where they are taken up and concentrated through the food chain by aquatic organisms. Humans and wildlife may become exposed to PCBs through the diet. PCBs are probable human carcinogens and cause developmental and reproductive problems in humans as well as several species of wildlife.

What's at risk?

PCBs bioaccumulate in the food chain. For humans, the primary exposures are via the ingestion of meat products. For some species, exposure has its roots in aquatic systems. Therefore, consumers of large, fatty fish and shellfish, particularly from areas with elevated concentrations of PCBs in the sediment, are the most likely to be exposed. In New Jersey, PCB contamination is most evident in the Hudson River system and New York Harbor, primarily due to upstream sources and to a lesser degree in the Delaware River system resulting from several smaller sources.

What are the human health impacts in New Jersey?

As many as 2,000 to 2,500 cases of cancer per year may be attributed to PCBs in New Jersey. This is approximately one third to one half of the total incidence of breast, pancreatic, and non-Hodgkins lymphatic malignancies in the state. There are, however, significant uncertainties in this assessment. Current rates of PCB ingestion may reduce neurological development of children.

What are the ecological impacts of in New Jersey?

Species exposed to PCBs in contaminated sediments face levels in excess of benchmark values. Benthic invertebrates may suffer some effects in reproduction and development; fish species have higher body burdens and may also suffer reproductive challenges. But most obvious impacts are observed in raptors with significant portions of their diet resulting from fish ingestion. When PCB levels were higher, these birds had extreme difficulty reproducing. Current levels of PCB contamination still have some significant effects.

What are the socioeconomic impacts in New Jersey?

The socioeconomic risks from PCBs are moderate, with some increased psychological impacts because of general awareness of problems associated with contamination. Dollar costs associated with the health impacts from PCB contamination are significant and may exceed $100 million per year.

What's being done?

PCB production and use has been banned since 1979. Contaminated site clean up is taking place slowly and there are efforts to dredge contaminated sediments, including the large source that exists upstream on the Hudson River.

Polycyclic Aromatic Hydrocarbons

Human Health Risk	L
Ecological Risk	M - L
Socioeconomic Risk	M

Polycyclic Aromatic Hydrocarbons (PAHs) are chemical compounds containing hydrogen and carbon that result from incomplete burning of organic material, such as cigarettes, wood, food, and fossil fuels. PAHs are found nearly everywhere in the environment, both naturally and as a result of human activities. There are many individual PAHs; of particular concern are those that cause cancers, including skin, bladder, lung, and possibly gastrointestinal tract cancers. Other effects of long term exposure may include eye irritation and light sensitivity. Exposure to PAHs may occur via inhalation, ingestion of smoked or charbroiled foods, or as a result of skin contact with contaminated soils, coal tars in shampoos, or psoriasis treatment.

What's at risk?

All New Jersey residents and ecosystems have been and continue to be exposed to PAHs, however, the degree of exposure from these sources can vary greatly from region to region, with higher levels in urban areas. In addition, personal lifestyle choices such as smoking and ingestion of smoked and charbroiled foods contribute to an individual's body burden. PAHs must be acted upon by the body's metabolic processes in order to become carcinogenic. Children and adolescents may be at increased risk due to higher rates of metabolism. Additional groups at risk include roofers and coke oven workers, and individuals living near creosote and coal tar manufacturers.

What are the human health impacts in New Jersey?

There are insufficient exposure data available to quantify the number of illnesses in New Jersey.

What are the ecological impacts in New Jersey?

PAH levels above the normal background amounts may cause acute or chronic toxicity, leading to changes in the composition, diversity, and function of normal plant and animal populations and communities. There is little data on the effects of PAHs on amphibians and reptiles, but tests on earthworms have shown toxicity, as do tests on fish and benthic macroinvertebrates, the bottom-dwelling animals that are a food source for fish and other animals. PAHs have been shown to reduce plant health and reproduction, and increase illness and death in bird embryos. Benthic macroinvertebrates in urban and industrial areas or adjacent to PAH-contaminated sites are at increased risk, as are plant and animal communities near these sites.

What are the socioeconomic impacts in New Jersey?

The health care costs of cancers associated with PAHs are difficult to determine, in part because exposure to tobacco smoke contains a number of carcinogens, including PAHs. Over 10,000 cases of bladder cancer were diagnosed in New Jersey in 1997, and the contribution of PAHs to that number is unknown. Other socioeconomic impacts include a reduction in property values near hazardous waste sites, and worry about living near the sites, but again, PAHs are present with other toxic materials, and the direct effect of PAHs on property values and worry is unknown. While PAHs do have some ecological impact, it is unlikely that significant job losses will occur as a result.

What's being done?

Emissions from industrial facilities are regulated, industrial hazardous waste sites are undergoing mandatory cleanup, and protective clothing is being used in occupational settings to reduce risk.

QPX parasite shellfish

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

QPX stands for "Quahog Parasite X", meaning an unknown parasite. QPX kills quahog or hard clams and was first discovered in New Jersey in Barnegat Bay in the 1970s. Infections with the QPX parasite may be associated with conditions that are stressful to the clams, such as low temperatures and densely populated beds.

What's at risk?

Hard clam populations in Barnegat Bay Estuary (and possibly other estuaries) are at risk.

What are the ecological impacts in New Jersey?

New Jersey surveys have detected the presence of QPX in association with clam mortality in 1996 and 1997. The impact of these infections on New Jersey ecosystems has thus far been minimal, but infections may become increasingly severe with time. There is little known about the relationships among the QPX parasite, environmental conditions, and mortality rates in hard clam populations.

What are the socioeconomic impacts in New Jersey?

Quahog harvesting contributes about $7.6 million and about 250 jobs to the New Jersey economy. Since 1978 there has been a general upward trend in quahog harvests, so there has not yet been a demonstrable impact as a result of QPX infection. Should quahog harvests begin to decline in the future, the relatively small size of the industry limits the potential for more than a negligible impact on the New Jersey economy.

What's being done?

QPX itself is not regulated, but the National Shellfish Sanitation Program classifies shellfish harvesting beds according to the presence of potential sources of contamination. Good husbandry should minimize the potential for problems, and based on the historical trend, the threat of major impacts from QPX is unlikely.

Radionuclides (from Nuclear Power Plants)

Human Health Risk	L
Ecological Risk	
Socioeconomic Risk	

Radionuclides are radioactive products from nuclear reactions. Radiounclides are a source of ionizing radiation that can cause biological impacts in humans and other species. For this analysis, the focus is on radionuclides from the routine operations of nuclear power plants in and adjacent to New Jersey. Iodine-131 is of particular interest because it is the most abundant radioactive isotope measured at nuclear power plants. While this analysis evaluates the risks from nuclear power plants, there are many other sources of radionuclides and ionizing radiation. The New Jersey Comparative Risk Project has separate analyses for Radium and Radon and for Catastrophic radioactive releases from nuclear power plants.

What's at risk?

All species are at risk from the effects of ionizing radiation although this report focuses on the impacts to human populations. The populations at greatest risk of exposure to radionuclides from nuclear power plants are those living closest to the facilities. There is one nuclear power plant in Ocean County (Oyster Creek) and three in Salem County (Salem I and II, and Hope Creek). New Jersey is also in close proximity to nuclear power plants in other states.

What are the human health impacts in New Jersey?

Ionizing radiation is most notably associated with the induction of cancer. Other health effects include genetically associated disorders, developmental abnormalities and some degenerative diseases. While humans are exposed to levels of ionizing radiation that may result in these health affects, nuclear power plants contribute only about 0.1% of the total exposure (most exposures are from natural and medical sources) and national studies show no evidence of increased cancer or other radiation impacts in those populations living near nuclear facilities. Even accidental releases such as occurred at Three Mile Island in 1980 did not result in notable increases in health affects associated with ionizing radiation.

What's being done?

Radiation releases from nuclear power plants are monitored by the DEP Environmental Surveillance and Monitoring Program. The data includes monitoring for specific radionuclides in the immediate vicinity of each facility. In addition, the operations of nuclear power plants, including releases, are regulated by the Nuclear Regulatory Commission. The releases from New Jersey facilities are far below allowable standards set to protect human health.

Radium

Human Health Risk	M - H
Ecological Risk	
Socioeconomic Risk	L

Radium is a naturally occurring radioactive element that exists in rocks, soil, and groundwater. The main route of exposure to humans is via drinking water, although certain foods accumulate radium and may pose a significant source. There are also contaminated sites where historical use of radium has resulted in the potential for small populations to receive additional exposures.

What's at risk?

The risk varies with geographic region, mainly related to the level of radium in drinking water. The main risk to humans at exposures likely to be encountered in the New Jersey environment is cancer, including bone, lung, and stomach cancer. Drinking water with the potential for elevated radium levels appears to be confined to ground water sources.

What are the human health impacts in New Jersey?

In some areas of the state more than 50% of drinking water wells exceed health based standards. The total number of individuals with significant exposure depends not only on the particular source of the drinking water, but also on the extent and type of water treatment. It is estimated that 100,000 – 300,000 individuals statewide use water which exceeds the drinking water standard. In many cases ground water provides only a portion of the drinking water supply, with the remainder from surface water. Calculations of average exposure suggest that the risks from radium in drinking water can be expected to result in 21 additional lifetime cancers, which is less than one per year for the New Jersey population. However, there are significant uncertainties in these calculations and the actual numbers could be higher or lower. Individuals living near hazardous waste sites may be exposed to higher levels, but the additional population risk should be small.

What are the socioeconomic impacts in New Jersey?

The Socioeconomic Technical Work Group considered the risks from radium together with the risks from radon. Most of the socioeconomic risk is associated with health care costs and property damage, and most of that risk can be attributed to radon, therefore the socioeconomic risk attributed to radium should be small.

What's being done?

There are regulations in place to monitor the levels of radium in drinking water from public water supplies. Exceedances of standards lead to action to reduce exposure. Private water supplies are not monitored or regulated.

Radon

Human Health Risk	H
Ecological Risk	
Socioeconomic Risk	M

Radon is a radioactive gas that is emitted during the decay of uranium, a naturally occurring mineral found in New Jersey rocks and soil. While radon gas is not a threat in the ambient (outdoor) air, it can become concentrated in buildings where it enters and collects in basements. At these concentrated levels, radon is a human carcinogen. When radon is inhaled, small radioactive particles are retained in the lungs, increasing the risk of lung cancer. Radon may also be present in drinking water, and exposure via ingestion of contaminated water increases the risk of stomach cancer.

Who's at risk?

Some individuals are exposed to greater concentrations of radon because of the location and/or construction of their homes or businesses. Houses and other structures contain varying concentrations of radon gas due to differences in the radon content of underlying soils and rocks, and because of differences in ventilation. Smokers are at an increased risk because there is a synergistic effect from the combined exposures.

What are the human health impacts in New Jersey?

The total number of lung cancers resulting from radon exposure may be as high as 1700 per year. The number of stomach cancers attributable to radon may total 10 per year.

What are the socioeconomic impacts in New Jersey?

While total socioeconomic impacts are modest, economic costs may be significant. When combined with radium exposures, health care costs for the excess cancers may be as high as $90 million annually. In addition, there are costs for remediating homes with known high levels of radon. These costs add up to between $14 million and $70 million per year.

What's being done?

Legislation requires minimum standards for new home construction, and a federal rule has been proposed for mitigation of drinking water risks, in areas with elevated radon levels. New Jersey citizens are encouraged to monitor their homes for radon.

Road Salt

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Various salt compounds are used to melt ice and snow that accumulates on roadways in winter. Salt-contaminated runoff from streets and highways can damage nearby trees and shrubs, and can also affect aquatic ecosystems when it reaches streams and other surface waters. There have been isolated instances of salt contamination of drinking water in New Jersey in recent years. Road salt also damages road surfaces, bridges, vehicles, and electrical fixtures.

What's at risk?

Areas along roadways statewide, particularly those adjacent to water bodies, are at risk. Areas next to highways and major routes, urban areas, and areas in the northern part of the state receiving greater snowfall are at increased risk because of greater salt application rates. Roadside vegetation and trees, birds, and aquatic life (especially young fish) are at risk for acute or chronic impacts. Elevated salt concentrations in the Oradell Reservoir in Bergen County can pose a health hazard for water customers with high blood pressure.

What are the ecological impacts in New Jersey?

In terms of water quality impacts, observable effects have not been documented in any New Jersey waterbodies. Screening data has indicated that 4 of 136 monitoring stations had concentrations of chloride above the EPA benchmark for the protection of aquatic life. These areas exceeded the benchmark at least once during the period from 1997-2000: Rahway River near Springfield, Cooper River at Haddonfield, Green Brook at Plainfield, and Ramsey Brook at Allendale. The potential impacts to New Jersey roadside vegetation and birds were not quantifiable with available information.

What are the socioeconomic impacts in New Jersey?

There have been isolated and unsubstantiated claims of road salt contamination of private wells resulting in a loss of property value. The cost of remediating salt contamination in Bergen County has been estimated at $300,000. Road salt causes substantial damages to roads, bridges, and motor vehicles; these costs have been estimated at nearly $8 million. Overall, however, the socioeconomic impacts attributable to the use of road salt are comparatively low.

What's being done?

Some of the salts and salt alternatives are less harmful than others and these may be used effectively to protect sensitive areas. Road salt in runoff has been included in local and regional plans in New Jersey; Bergen County's Hackensack and Hudson watershed plans include efforts to reduce quantities of road salt contaminating the Oradell Reservoir. There are significant opportunities to improve road salt storage and application techniques, thereby minimizing quantities available for runoff to the environment.

Secondhand tobacco smoke

Human Health Risk	H
Ecological Risk	
Socioeconomic Risk	M - H

Secondhand tobacco smoke is a complex mix of chemicals generated during the burning and smoking of tobacco products that can affect those nearby who are not smoking. It is also known as passive or environmental tobacco smoke. Over 4,000 chemicals, including 40 known or suspected carcinogens, have been identified in cigarette smoke. Exposure to secondhand tobacco smoke can cause or contribute to middle ear infections, asthma, bronchitis and pneumonia, ischemic heart disease, low birth weight, lung cancer, Sudden Infant Death Syndrome (SIDS), and Acute Lower Respiratory Tract Illness (LRI) in children up to eighteen months. All of the compounds found in the smoke inhaled by the active smoker are also found in secondhand smoke.

What's at risk?

Children are more susceptible to the harmful effects of secondhand tobacco smoke than adults, although all persons breathing in secondhand smoke are at risk. In infants and young children up to three years old, exposure to secondhand tobacco smoke causes an approximate doubling in the incidence of pneumonia, bronchitis, and bronchiolitis. There is also strong evidence of increased middle ear infection, reduced lung function, and reduced lung growth.

What are the human health impacts in New Jersey?

There is clear evidence that it can cause cancer in humans. There is no evidence that any particular group of individuals will remain unaffected. It is estimated that the following number of cases/ deaths occur in New Jersey annually:

- Middle ear infection, 14,000-32,000 cases
- Asthmatic episodes, 8,000-20,000 cases
- Bronchitis and pneumonia, 3,000-6,000 cases
- New asthma cases, 160-520 cases
- Ischemic heart disease, 700-1,240 deaths
- Low birth weight, 194-372 cases
- Lung cancer, 60-80 deaths
- Sudden infant death syndrome, 38-54 deaths
- Acute lower respiratory tract inf., 2-4 deaths

In New Jersey, 53% of all effects from secondhand tobacco smoke exposure manifest as middle ear infections, occurring mostly in children. An additional 33% of all effects from secondhand tobacco smoke exposure are due to exacerbation of asthma. Ischemic heart disease, which usually ends in death, accounts for the majority of deaths associated with secondhand tobacco smoke exposure, followed by deaths due to lung cancer.

What are the socioeconomic impacts in New Jersey?

The health care costs of secondhand tobacco smoke are of greatest impact. Costs associated with secondhand tobacco smoke-related ailments are estimated at $186 million to $332 million. These costs do not include lawsuits, accidental death or property destruction through fires started by cigarettes, or cleaning cigarette odor out of fabrics.

What's being done?

Most restrictions on exposure to secondhand tobacco smoke have occurred at the municipal level, where restaurants, workplaces, and public places may have smoking bans. Commercial daycare centers are required to be smoke-free. State regulations do not restrict smoking in bars, shopping malls, hotels, or enclosed arenas.

Starlings

Risk	
Human Health Risk	
Ecological Risk	M
Socioeconomic Risk	L

The European starling is an exotic species introduced to North America in the late 1800s. Within 60 years, starling populations had expanded as far as the West Coast. Starlings are highly adaptable, and have flourished in urban and suburban landscapes where they outcompete other native birds for food and nesting sites.

What's at risk?

Overpopulation by starlings affects bluebirds, great-crested flycatchers, common flickers, and other New Jersey native bird species.

What are the ecological impacts in New Jersey?

Much like invasive plant species, the ability of starlings to flourish in disturbed or human-altered landscapes has led to a dominant presence in a variety of habitats. Starlings exhibit a broad range of food habits, raise up to three broods per year, and aggressively defend their nest sites. Roosting flocks may number in the thousands to millions of birds. The primary impacts involve outcompeting other native birds, potentially changing the diversity of species inhabiting an area. Risks are lowest in already developed areas, higher in areas such as the Highlands that are relatively undeveloped.

What are the socioeconomic impacts in New Jersey?

Although many people may be annoyed by large flocks of starlings, there is no evidence of negative socioeconomic impacts associated with them.

What's being done?

The ability of the starling to successfully adapt to a variety of conditions has confounded attempts to control populations. In other parts of the country attempts have been made to reduce starling populations, but these efforts have not met with much success. The North American population has been estimated at over 200 million birds, and it is unlikely that future control efforts will be successful. Moreover, since a good deal of the success of the starling is related to widespread conversion of diverse habitats to urban and suburban landscapes, there are significant barriers to restoring the ecological balance that existed prior to the starling's introduction.

Sulfur oxides (SO_x/Sulfates)

Human Health Risk	M - L
Ecological Risk	
Socioeconomic Risk	M

Sulfur dioxide(SO_2) is the primary component of the class of air pollutants known as oxides of sulfur (SO_x). It is a product of fossil fuel combustion, primarily coal, and is a by-product of several chemical processes such as paper manufacture and smelting. This issue summary focuses on the human health impacts from sulfur dioxide.

What's at risk?

SO_x is a respiratory irritant. Elevated concentrations of SO_x cause respiratory problems. At particular risk are asthmatics and children. For asthmatics, exposure to SO_x increases incidence of asthmatic attacks. For children, there is evidence of increased incidence of respiratory disease and some evidence that SO_x exposure reduces their ability to respond to infection. SO_x also causes decreases in visibility which is of particular interest in recreation areas with important viewsheds.

What are the human health impacts in New Jersey?

The concentration of SO_x in New Jersey is below federal health-based regulatory standards, but concentrations are slightly elevated in some counties, possibly decreasing the ability of approximately 100,000 children who live in these counties to respond to infection. Throughout the state there is a slight chance that children will have increased incidence of respiratory disease as a result of SO_x exposure.

What are the socioeconomic impacts in New Jersey?

The greatest impacts are due to aesthetic degradation. A national study showed significant visibility benefits from reductions of sulfur dioxide, of which New Jersey should gain a part.

What's being done?

Federal regulations have reduced the emissions from most point sources significantly. Additional regulations are pending which may further reduce sulfur emissions.

Thermal pollution

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Thermal pollution refers to elevated water temperatures that result from industrial discharges to streams, rivers, or other waterbodies. Elevated temperatures can have negative effects on aquatic organisms, and accordingly, temperature is one of the required parameters included in New Jersey state water quality standards. Thermal shock, such as when power plants shut down in winter, can also lead to impacts (e.g., fish kills).

What's at risk?

Based on the most recent information collected by New Jersey DEP, less than 1% of documented impairments to New Jersey waters are attributable to thermal pollution. Watersheds affected include the Middle Delaware-Musconetcong, Raritan, Hackensack-Passaic, Middle Delaware, Lower Delaware, and Cohansey-Maurice basins.

What are the ecological impacts in New Jersey?

Elevated water temperatures in these basins may increase metabolic and respiration rates, altering behavior patterns of aquatic organisms. Although rising temperatures may enhance the growth rate of some organisms, eventually higher temperatures can adversely affect reproduction and survival. The extent of damage depends on the rate of temperature change, duration of the exposure, and where the ambient temperature lies in relation to the tolerance range of a given species. Compared with other stressors, thermal pollution does not represent a significant category of water quality impairments in the state.

What are the socioeconomic impacts in New Jersey?

Given the relative insignificance of thermal pollution as compared with other water quality stressors and the fact that less than 1% of New Jersey's documented impairments are due to temperature, it is unlikely that thermal pollution would have any socioeconomic ramifications.

What's being done?

Stringent requirements on industrial discharges will continue to limit the potential for adverse impacts associated with thermal pollution of aquatic ecosystems. Nevertheless, New Jersey water quality status is updated every two years, affording an ongoing opportunity to monitor the extent of thermal pollution over time.

Tin

Risk	
Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	L

Tin is a naturally occurring element that is used in a wide variety of applications. In its inorganic (metallic) form, tin is used in products such as food cans, alloys (brass, pewter, bronze, and solder), and toothpaste (stannous fluoride). Organic tin compounds or organotins are synthesized for use in the manufacture of antioxidants and biocides, including marine paints. Tin is relatively benign in its metallic form and does not accumulate to harmful levels in either humans or ecological systems. Many organotins, however, are toxic to aquatic organisms, causing impaired behavior and reduced growth, reproduction, and survival. Tributyltin, an anti-fouling agent added to marine paint and regulated as a restricted-use pesticide, is markedly toxic to aquatic organisms, and is a suspected endocrine disruptor.

What's at risk?

Aquatic ecosystems are primarily at risk, particularly marine waters with large vessel traffic, marinas, and shipyards. The primary sources of tributyltin (TBT) to the aquatic environment include paint leaching from boat hull surfaces, runoff from sites where boats are painted, and accidental spills. The greatest impacts would be expected in high ship usage areas such as New York-New Jersey Harbor and commercial docks along the Delaware River.

What are the ecological impacts in New Jersey?

Aquatic biota in proximity to heavy usage areas (e.g., commercial docks and berths) are at increased risk from observed concentrations of organotins in the sediments. Evidence of organotin residues in blue mussels may indicate increased risk for mollusk populations in Upper New York Bay. Low concentrations of TBT have resulted in abnormal sexual development in snails, reducing the number of young and reducing the size of the breeding population. These populations will continue to be exposed as organotins leach from incoming ship traffic, release from sediments, and bioaccumulate in the food chain. Currently there is no comprehensive or regular monitoring of TBT levels in biological tissues in New Jersey. Ecosystem-level effects are poorly understood, and additional research is needed to better characterize the long-term and chronic effects of TBT discharge to the environment. However, exposure is expected to decrease over time as a result of an anticipated international ban on the application of organotins to marine vessels.

What are the socioeconomic impacts in New Jersey?

The socioeconomic risks associated with environmental concentrations of tin were judged to be low.

What's being done?

TBT is regulated as a restricted use pesticide under state and federal laws. In New Jersey, TBT paint can only be applied by certified applicators to vessels 25 meters or larger, or to aluminum hulls. In 1999, the International Maritime Organization passed a resolution banning the application of organotin compounds beginning in 2003.

Ultraviolet radiation

Human Health Risk	M
Ecological Risk	M - H
Socioeconomic Risk	M - H

Ultraviolet (UV) radiation is a form of electromagnetic energy whose only significant natural source is the sun. Stratospheric ozone absorbs harmful forms of ultraviolet light and depletion of the ozone layer results in increased UV radiation reaching the Earth's surface. Ultraviolet radiation is divided into categories based on wavelength; the impacts noted here are associated with ultraviolet radiation known as UV-B. UV-B damages biological systems by causing chemical changes at the molecular level and its effects are evident in animals, plants, and microorganisms. In humans, UV-B exposure is known to be associated with various skin cancers, accelerated skin aging, cataract and other eye diseases, and may reduce a person's ability to resist infectious diseases.

What's at risk?

Virtually the entire population of New Jersey is exposed to some level of naturally occurring UV-B daily. People with fair skin are more susceptible to burns and skin cancers than darker skinned individuals. However, eye damage can occur in all populations. Beachgoers and other outdoor enthusiasts are at increased risk. Ecologically, all species in all parts of the state are exposed and potentially susceptible to the damage caused by UV-B radiation. More research is needed to document the extent and severity of UV exposure and effects in human and ecological populations.

What are the human health impacts in New Jersey?

In New Jersey, several thousand persons are diagnosed with malignant skin melanomas. Available information documents an increase each year in the rate of melanoma for the years 1993 through 1996. While individual behaviors are a factor in exposure to UV radiation, the reduction in stratospheric ozone may also be contributing to increases in the numbers of cases of melanoma. Other forms of skin cancer (i.e., basal and squamous cell) may also be increasing in response to increased UV radiation, but since these are not reportable diseases, no data are available. The extent of health effects other than skin cancers (e.g., eye problems, immune disorders) attributable to UV radiation is not known.

What are the ecological impacts in New Jersey?

Ultraviolet radiation poses one of the greatest potential risks to New Jersey ecosystems. In aquatic ecosystems, UV radiation has adverse effects on the growth and photosynthesis of phytoplankton, thus affecting food webs, which in turn can damage the ecosystem's ability to function. In terrestrial systems, increasing amounts of UV-B may be causing a number of subtle changes in the competitive balance among plants. Specific exposures and effects are dependent upon site-specific variables such as cloud cover, reflection, and proximity to industrial areas. Species-specific traits also determine the severity of effects.

What are the socioeconomic impacts in New Jersey?

Economic costs and psychological impacts from UV radiation are significant. Medical costs associated with skin cancer treatments may total over $50 million annually. Cataract treatment for problems resulting from UV radiation may total an additional $31 million. People do worry about and avoid sun exposure, and parents are concerned about the exposure of their children.

What's being done?

The international "Montreal Protocol" agreement was intended to reduce and eventually eliminate the emissions of man-made substances that deplete stratospheric ozone. The federal Clean Air Act was subsequently amended to include provisions for the protection of the ozone layer. These regulations include a schedule that is currently being implemented for reducing the production and use of ozone depleting chemicals. Education efforts focused on reducing human exposures to ultraviolet radiation help to reduce human health risk.

Volatile organic compounds (VOCs)

Volatile organic compounds, or VOCs, are a class of compounds characterized by having high vapor pressure, meaning they readily volatilize from solid and water surfaces to the air. Dozens of these compounds are present in the environment as a result of fuel combustion, chemical manufacturing, and their use in consumer products. Exposure to these chemicals via inhalation, or presence in drinking water can lead to a variety of health effects ranging from irritation of mucus membranes to cancer. To help in distinguishing between the many kinds of VOCs, the Technical Work Groups divided VOCs into different categories. For this report, there are two categories of VOCs summarized: those VOCs causing cancer (p. 183) and those VOCs not thought to cause cancer (p. 184). Separate analyses were also conducted for the following specific VOCs: acrolein (p. 104), benzene (p. 108), 1,3-butadiene (p.102), formaldehyde (p. 127), MTBE (p. 148), and polycyclic aromatic hydrocarbons (p. 170). VOCs that originate as by-products of the drinking water treatment process itself (e.g., chloroform) are covered in the report for disinfection by-products (p. 121). VOCs contribute to the formation of ground level ozone, also the subject of another analysis (p. 156).

Volatile organic compounds (VOCs), carcinogenic

Human Health Risk	M - H
Ecological Risk	L
Socioeconomic Risk	M - L

This summary focuses on the risks from VOCs found in New Jersey ambient air and groundwater that are known or suspected to cause cancer. The chemicals of concern in both air and drinking water are: 1,3 dichloropropene, ethylene dibromide, ethylene dichloride, p-dichlorobenzene, trichloroethylene, vinyl chloride, acetaldehyde, acrylonitrile, hydrazine, ethyl acrylate, and ethylene oxide. Chemicals included in this summary based on risks from exposures through the air (drinking water exposures are covered within the Disinfection By-products report), are carbon tetrachloride, chloroform, methyl chloride, and methylene choride.

What's at risk?

The general population is exposed primarily as a result of the use of VOCs in chemical manufacturing. Residents of urban counties with industrial activity are at increased risk. Individual exposures vary depending upon proximity to industrial sources, workplace exposures, use of volatile consumer products, and source of drinking water. Plants and nesting birds near highways and industrial areas are also at increased risk.

What are the human health impacts in New Jersey?

Modeled and measured New Jersey concentrations of the carcinogenic VOCs considered in this analysis may result in 252 excess lifetime cancer cases, or 3.6 additional cases annually. Almost one-half of this risk is attributable to background levels of carbon tetrachloride and ethylene dibromide, which are found statewide with little local variation. Indoor concentrations may reach 100 times outdoor levels, but vary widely making statewide risks difficult to estimate. Drinking water exposures may contribute one additional lifetime cancer statewide.

What are the ecological impacts in New Jersey?

VOCs typically volatize before causing a long-term impact on an ecosystem. Potential effects on ecological systems are more likely to result from accidental exposures to high concentrations rather than continual exposure. VOCs will dissolve in water, and thus may cause short-term impacts to aquatic organisms, but evaporate quickly from water surfaces.

What are the socioeconomic impacts of VOCs in New Jersey?

Apart from the specific compounds reported on separately, the residual socioeconomic risk associated with VOCs generally is low. Health care costs may total as much as $1 million to $2 million annually when indoor exposures are considered. Aesthetic concerns related to the odors from indoor concentrations of VOCs are also possible.

What's being done?

Most consumer uses of halogenated VOCS have been phased out and industrial releases have been reduced significantly over the past 20 years. Concentrations of some compounds (e.g., carbon tetrachloride) reflect global background concentrations rather than New Jersey sources. Public drinking water suppliers are required to monitor for, and report the presence of carcinogenic VOCs.

Volatile organic compounds (VOCs), non-carcinogenic

Human Health Risk	M - L
Ecological Risk	L
Socioeconomic Risk	M - L

This summary focuses on the risks associated from a subset of VOCs that are suspected of having some health impacts and are found in New Jersey indoor and outdoor air. None of these compounds are suspected of causing cancer. The compounds included in this analysis are glycol ethers, methanol, methyl ethyl ketone, toluene, and xylene.

What's at risk?

The general population is exposed to low levels throughout the state, but exposure varies significantly due to local variations in industrial and transportation emissions. Certain populations may be sensitive to low concentrations of VOCs and exhibit symptoms of neurological distress. Plants and nesting birds in industrial areas may also be at greater risk.

What are the human health impacts in New Jersey?

Non-cancer effects—which may include irritation to mucous membranes, neurological effects, and liver damage—are negligible at concentrations likely to be encountered in non-occupational settings. A lack of certainty regarding the specific level of exposure and the inability to include all possible VOCs in the analysis resulted in the ranking of Low/Medium.

What are the ecological impacts in New Jersey?

VOCs typically volatize before causing a long-term impact on an ecosystem. Potential effects on ecological systems are more likely to result from accidental exposures to high concentrations rather than continual exposure. VOCs will dissolve in water, and thus may cause short-term impacts to aquatic organisms, but evaporate quickly from water surfaces.

What are the socioeconomic impacts of VOCs in New Jersey?

The residual socioeconomic risk associated with VOCs generally is low. Health care costs may total (including carcinogenic VOCs) as much as $1-2 million annually when indoor exposures are considered. Aesthetic concerns related to the odors from indoor concentrations of VOCs are also possible.

What's being done?

Industrial emissions are regulated via the permit process, and pollution prevention efforts are resulting in a general decrease in the use and release of VOCs. While many VOCs decreased in ambient concentrations during the 1990s, there is evidence that ethylene oxide increased by about 10% between 1990 and 1996.

Waterborne pathogens

Human Health Risk	recreational water	M	drinking water	L
Ecological Risk				
Socioeconomic Risk		M - L		

Bacteria, viruses, and parasites that are present in the feces of infected individuals can contaminate surface waters that may be used as sources of drinking water or for primary contact recreation (such as swimming). Waterborne pathogens contributing to disease outbreaks in the United States include the bacteria Shigella, Salmonella, Leptospira, and Campylobacter; viruses caliciviruses, adenoviruses, and hepatitis A; and the parasite Giardia (*Cryptosporidium* and *legionella* are addressed separately.) The health effects from waterborne pathogens are generally mild, and may include diarrhea, cramps, nausea, and vomiting. Infections can sometimes result in more serious illness, or even death, particularly among sensitive populations.

What's at risk?

Everyone in New Jersey is potentially exposed via either contaminated drinking water or accidental ingestion while participating in water sports. While no more likely to become exposed, some individuals may be at increased risk for more serious health effects. These include people with weakened immune systems or underlying disease, pregnant women, infants, and the elderly. This sensitive population is estimated at 1.6 million to 2 million individuals.

What are the human health impacts in New Jersey?

Taking Unites States Centers for Disease Control (CDC) data for the United States as a whole, and apportioning cases among states according to population, suggests that waterborne pathogens in New Jersey may result in approximately 28,000 illnesses and 27 deaths annually. However, many of these go largely undetected, because symptoms are typically not serious or distinguishable from other potential sources of illness. New Jersey has not had a documented drinking-water-related disease outbreak since 1989, when 8 individuals were infected as a result of a contaminated well at a campsite. There have been 6 incidences of waterborne disease as a result of recreational exposures. There is a low risk of a large-scale disease outbreak in the event of a treatment breakdown at any of New Jersey's large drinking water facilities. If this should occur during a pathogen contamination event, a large number of people could be infected.

What are the socioeconomic impacts in New Jersey?

The vast majority of cases are undiagnosed, so it is difficult to estimate the number of actual cases, let alone the costs associated with them. Medical costs and lost wages due to waterborne illness in New Jersey may range from $10 million per year (using the above CDC estimate for cases) to $70 million per year or more if other estimation techniques are used.

What's being done?

Disinfection and filtration of water supplies derived from surface water sources eliminate all but very low levels of most pathogens. Testing requirements vary from once every 3 months up to 480 tests per month depending on the size of the facility. New legislation requires testing of private wells for indicator bacteria upon the sale of a residence, and landlords will be required to test every five years. Recreational waters are sampled for indicator bacteria on a weekly basis for designated swimming areas, or as part of the state surface water monitoring program for lakes and streams that are designated as primary contact recreational waters.

Water Overuse

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	M

When more water is used than can be replenished through precipitation, a water supply deficit occurs. As ground water levels are depleted, the risk of salt water intrusion increases, which can contaminate drinking water. Depletion of underground aquifers can also affect stream flows and lake levels, resulting in decreased water quality and associated impacts to the ecological community. Eight of the 21 water planning regions in New Jersey are currently experiencing water supply deficits and while there is not yet a statewide deficit, one is projected to develop by 2040 if population growth continues.

What's at risk?

Water supply deficits are experienced in several portions of the state. Areas include Camden/ Delaware tributaries, Mullica River, South River, Metedeconk Creek/Toms River, Maurice River, Hackensack River, Cape May coastal area, and lower Passaic/Rahway rivers. Deficits range from less than 10 million gallons per day (MGD) to 56 MGD in the Mullica River region. Both marine (estuarine) and freshwater systems are at risk, and wetlands are particularly vulnerable to ecological impacts.

What are the ecological impacts in New Jersey?

Water overuse can lead to loss or reduction in stream flow, saltwater intrusion, and changes in estuarine salinities. Consumptive use or diversions of water impact downstream ecosystems as freshwater stream flows are reduced from natural levels. Flow conditions and salinity levels greatly influence the suitability of habitat for amphibians and aquatic organisms, and the magnitude of the impact varies depending on the duration of the reductions. Potential impacts include loss of specific habitat (such as pools), along with changes in the ecological community that result from the differential abilities of various species to adapt to changes in flows or salinities. Data documenting direct impacts to New Jersey ecosystems are limited—a survey of instream flow requirements and comparison with seasonal flows is needed to assess the impacts of water use on New Jersey streams.

What are the socioeconomic impacts in New Jersey?

Costs required for capital improvements to address current and projected shortages are expected to total over $300 million. Major improvements are planned for the Raritan/South River region ($128 million), Camden/Delaware ($170 million), and Cape May ($10 million). Higher water rates could potentially affect property values, but there is little evidence to demonstrate this. Water scarcity could also have a localized impact on employment in sectors such as agriculture which are highly dependent on water. Again, there is little evidence available to evaluate this possibility. If left unremediated, large-scale saltwater intrusion could create additional impacts. Since 1940, more than 120 wells in Cape May County have been abandoned because of saltwater intrusion.

What's being done?

The New Jersey State Water Supply Plan was formulated to guide water use management over the next 20 years. In addition to capital improvement projects designed to increase available supplies, the Plan also calls for water conservation and sustainable use. Water diversion is regulated by DEP, however, there are currently no requirements to protect ecological quality. Policies designed to encourage conservation could reduce long-term demand for water, and such measures could potentially be more cost effective than new construction. Research is currently underway to develop ecological flow goals and methodologies for New Jersey streams.

West Nile Virus

Human Health Risk	L
Ecological Risk	M - L
Socioeconomic Risk	L

West Nile virus is transmitted by mosquitoes and found throughout Africa, the Middle East, West Asia and Europe. In 1999, West Nile virus was identified in North America for the first time, during an epidemic in the New York metropolitan area. The virus has emerged as a significant threat to human, equine, and wild bird health in New Jersey and the entire northeastern United States. All human cases in the Unites States have resulted from mosquitoes biting humans after feeding on infected birds. There is no risk of human-to-human transmission of West Nile virus.

What's at risk?

Everyone in the state is potentially exposed to the bite of an infectious mosquito. The elderly are at increased risk of developing severe illness as a result of infection. Horses are at relatively higher risk than humans, and susceptible wild bird populations include crows, blue jays, hawks and falcons.

What are the human health impacts in New Jersey?

Infection with West Nile virus can cause a form of encephalitis or meningitis. Most infections produce no symptoms in people, or are mild or moderate. More severe infections may lead to death. In New Jersey in 2000, there were six confirmed cases of severe West Nile virus, from five counties including one death. The fatality rate is less than 1%.

What are the ecological impacts in New Jersey?

In 1999, West Nile virus was detected in birds from 16 of 21 New Jersey counties, with the majority in the north central area of the state. In 2000, 496 crows tested positive in similar areas, and infected mosquito pools were detected in Bergen County.

What are the socioeconomic impacts in New Jersey?

Socioeconomic risks from present incidences of West Nile virus were judged to be low, but it is impossible to predict the course that the disease will take over the next five years. It is clear that the virus is still spreading throughout the north-eastern U.S.

What's being done?

New Jersey has set up monitoring systems and mosquito control operations to track and manage the threat.

Zebra mussels

Human Health Risk	
Ecological Risk	L
Socioeconomic Risk	L

Zebra mussels are thumbnail-sized freshwater mollusks that are native to western Asia. After accidental introduction in the Great Lakes via ballast water in ships, colonies of zebra mussels have invaded 20 states east of the Mississippi since 1986. Zebra mussels infest and devastate native mollusk populations and dramatically affect the food web because of their efficiency as filter feeders. In the Hudson River zebra mussels filter all the water in the tidal-freshwater part of the river every two to three days. Prior to the invasion all other filter feeders combined filtered the water about once every 50 days. Zebra mussels have not yet been detected in New Jersey waters, but it is probable that invasion will occur in the near future.

What's at risk?

Native freshwater mollusks are in danger of extinction if zebra mussels become established in New Jersey. All inland freshwater ecosystems would be at risk from severe and dramatic changes in habitat structure and food web dynamics. Socioeconomic costs would extend to all waterworks and utilities in the state with freshwater intake and outflow pipes.

What are the ecological impacts in New Jersey?

Based on the assumption that the zebra mussel does not currently exist in New Jersey, the risks are now low. Should the mussel become established in New Jersey waters, and this is likely, zebra mussels will pose a significant threat to freshwater ecosystems. All aquatic organisms which are subject to attachment by zebra mussel colonies would be at risk. Phytoplankton, which have declined by 90% in the Hudson River, would also be at risk statewide, as would the entire ecosystems that depend on them.

What are the socioeconomic impacts in New Jersey?

Massive colonies of zebra mussels clog water intake and outflow pipes used by water companies and other utilities. In affected areas, these costs exceed $5 billion annually. If zebra mussels invade New Jersey waters, and the costs are proportional, then this would result in annual costs of $336 million. However, these costs are hypothetical, as the zebra mussel has not yet been detected in New Jersey. Other socioeconomic impacts are harder to evaluate. While it seems reasonable to assume there would be socioeconomic consequences associated with the adverse impacts to native aquatic communities, there are also potential benefits. For example, zebra mussels are thought to have increased populations of yellow perch and other fish. Similarly, dramatic increases in water clarity have resulted in improved aesthetics and recreation use in affected waters.

What's being done?

New Jersey has a Zebra Mussel Watch program that depends on public assistance in reporting zebra mussel sightings. The New Jersey Department of Environmental Protection has formed a task force to manage and mitigate potential infestations.

Zinc

Human Health Risk	
Ecological Risk	M - L
Socioeconomic Risk	L

Zinc is a naturally occurring metallic element and a necessary nutrient for mammal metabolism. Meat, seafood, dairy products, nuts, legumes, and whole grains are dietary sources of zinc. Dietary deficiencies can result in health problems ranging from decreased immune response to skin problems and mental disturbances. Zinc is also used industrially for a variety of purposes—as a coating and alloy, and in the manufacture of tires. Industrial releases, combined with rubber tire wear, result in quantities of zinc discharged to the environment. This leads to high concentrations in nearby (typically urban) soils and sediments, which can cause toxic ecological effects.

What's at risk?

High concentrations of zinc can limit plant growth and inhibit reproduction in animal populations. Zinc is toxic to sensitive organisms living in soils and aquatic sediments. Bottom dwelling organisms in Newark Bay are at risk from high levels of zinc, as are organisms living in contaminated industrial areas.

What are the ecological impacts in New Jersey?

Background levels of zinc in New Jersey range from concentrations of 34 milligrams per kilogram (mg/kg) in rural soils to 162 mg/kg in urban soils. Concentrations in Newark Bay can reach 1900 mg/kg, with an average concentration of 532 mg/kg. Organisms in contact with contaminated sediments may experience negative effects on growth and organ function. Determining the extent of ecological impacts at given concentrations is complicated by the fact that soil and sediment properties greatly influence the degree to which organisms are affected, and it is difficult to isolate the effects of zinc from other contaminants outside of laboratory studies. Most of the risk attributed to zinc is associated with aquatic systems, with potentially substantial effects on benthic (bottom) habitat in Newark Bay. While zinc levels in terrestrial soils may also exceed benchmark levels for plant toxicity, these impacts are less well understood.

What are the socioeconomic impacts in New Jersey?

Though negative effects of large quantities of zinc have been observed in laboratory animals, there is no evidence that environmental levels of zinc pose a risk to humans. Its use as a dietary supplement and in the synthesis of drugs provides further evidence of its relative innocuousness. Thus it is unlikely that zinc produces measurable economic or psychological impacts.

What's being done?

Water, soil, and sediment criteria exist for industrial discharges and guidelines for contaminated site cleanup. Zinc loadings from non-point sources (particularly transportation-related), are not regulated.

ACRONYMS

ACRONYMS

Acronyms

Air pathogens	Airborne pathogens
AL beetle	Asian longhorned beetle
ATVs	All-terrain vehicles
CAFRA	Coastal area facility review act
CDC	Centers for Disease Control
CO	Carbon monoxide
COPD	Chronic obstructive pulmonary disease
CR radiation	Catastrophic radioactive release
Crypto	Cryptosporidium
DBPs	Disinfection byproducts
Dermo	Dermo parasite in oysters
Dioxins	Dioxins/furans
EDs	Endocrine disruptors
EHD	Epizootic hemorrhagic disease - virus in deer
ELF/EMF	Extremely low frequency electromagnetic field radiation
EQTWG	Ecological Quality Technical Working Group
ETS	Environmental tobacco smoke
GGs	Greenhouse gases
GMOs	Genetically modified organisms
HAAs	Haloacetic acids
HARS	Historic area remediation site
HWA	Hemlock woolly adelgid
HHTWG	Human Health Technical Working Group
Hz	Hertz
Indoor microbes	Indoor microbial air pollution
Impervious surface	Increase in impervious surface
KV/m	kilovolts per meter
LRI	Lower respiratory tract illness
MCL	Maximum contaminant level
MCS	Multiple chemical sensitivities
MGD	Million gallons per day
MSX	Multinucleated sphere X parasite in oysters
MTBE	Methyl tertiary butyl ether
NEPPS	National Environmental Performance Partnership System
NJCRP	New Jersey Comparative Risk Project
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
NO_x	Nitrogen oxides
ORVs	Off-road vehicles
OSHA	Occupational Safety and Health Administration
Overharvesting	Overharvesting (marine)
Ozone	Ozone (ground level)
PAHs	Polycyclic aromatic hydrocarbons
Particulates	Particulate matter
PCBs	Polychlorinated biphenyls
Pets	Pets as predators
PM	Particulate Matter
ppb	parts per billion
ppm	parts per million

Acronyms

QPX	Quahog parasite X in shellfish
SBS	Sick building syndrome
SC	Steering committee
SETWG	Socioeconomic Technical Working Group
SO_x	Sulfur oxides
TBT	Tributyltin
THMs	Trihalomethanes
TICs	Tentatively identified compounds
TWG	Technical working group
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet radiation
VOCs	Volatile organic compounds
Water pathogens	Waterborne pathogens

APPENDICES

APPENDICES

Appendix I
NJCRP Participants

Steering Committee

The Steering Committee (SC) was intended to provide diverse representation of New Jersey viewpoints on environmental issues, and to shape the agenda of the NJCRP. A wide range of individuals were invited, either initially by the Commissioner of DEP or upon the recommendation of SC members, to become part of this effort. Some were active participants throughout the process; some participated actively early in the process, but withdrew once substantive work began for various reasons (other priorities; personal life). Active members are listed below, followed by a list of those who were invited but did not participate, either at all or after the first few meetings.

Several environmental organizations were invited to be members of the Steering Committee. Representatives of some of these groups became active members of the SC; others attended initial meetings of the SC to discuss the Project's mission, scope and procedures, but then chose to withdraw from the process. Most of the environmental groups which withdrew emphasized the low priority of NJCRP participation relative to their other initiatives and responsibilities; some groups said that DEP should be taking action to reduce known environmental impacts, not conducting more studies. Because these groups withdrew from the process, they should not be held responsible for the project's work, findings or recommendations. However, the project benefited from their brief participation in the initial planning stage.

Special note should be given to the contributions of Charlie Yates, who tragically died in a small airplane accident mid-way through the project. His enthusiasm, acuity and humor were vital to the SC's structuring of the project's mission and procedures, and will be sorely missed. May this project report stand in a small way as a memorial to him.

Active Members

Co-Chair: Daniel I. Rubenstein, Professor and Department Chair, Ecology & Evolutionary Biology, Princeton University

Co-Chair: Sheryl Telford, PSE&G (later E.I. du Pont de Nemours & Company, Corporate Remediation Group)

Candace Ashmun, President, Association of New Jersey Environmental Commissions

Dorothy Bowers, Vice President (Retired), Merck & Co.

James Brownlee, Director, Department of Health & Senior Services, Consumer and Environmental Health Services

Joseph Della Fave, Ironbound Community Corporation

Gus Elsner, Manager, Safety, Environmental and Risk Management, Infineum USA

Peter J. Furey, Executive Director, New Jersey Farm Bureau

John Gaston, Executive Director, Stony Brook Regional Sewerage Authority (deceased)

Keith V. Hamilton, Mercer County Freeholders, and Avaya Corp.

Gary Lord/Laura Swartz (sequential members), Isles, Inc.

Leslie McGeorge, DEP, Assistant Commissioner, Environmental Planning & Science (later Administrator, Water Monitoring Management), NJ Department of Environmental Protection

Michael McGuinness, New Jersey Chapter of the National Association of Industrial and Office Properties

Linda Morgan, Vice President, OENJ Cherokee Realty Holdings, LLC

Martin Robins, Transportation Policy Institute, Edward J. Bloustein School of Planning & Public Policy, Rutgers, The State University of New Jersey

Jessica Rittler Sanchez, Office of State Planning (later Delaware River Basin Commission)

Dave Shelton/Annette Giuseppi-Elie (sequential members), E.I. du Pont de Nemours & Company, Chambers Works Division

Randy Solomon/Tim Evans (sequential members), New Jersey Future

Nancy Wittenberg, New Jersey Builders Association

Charles Yates, Farmers & Mechanics Bank (deceased)

Carolyn Whittaker/Junfeng (Jim) Zhang (sequential members), Environmental & Occupational Health Sciences Institute (EOHSI), UMDNJ

Also Invited to be SC Members

New Jersey Office of Legislative Services

Somerset Alliance for the Future

New Jersey Environmental Federation

Pinelands Preservation Alliance

Regional Clean Water Action

Project Coordinating Team

This team was responsible for providing technical and logistical support to the Steering Committee, and coordinating SC and Technical Working Group activities, as well as producing the project's final report.

Martin G. Rosen, Director, Division of Science, Research and Technology (DSRT), New Jersey Department of Environmental Protection (DEP); Project Manager

Branden B. Johnson, Ph.D., DSRT, DEP; Associate Project Manager

Clinton J. Andrews, Ph.D., Professor, Edward J. Bloustein School of Planning & Public Policy, Rutgers, The State University of New Jersey (plus graduate students John Posey, Jun Bi, Jason Lien, Eric Powers and Ana Baptista)

Suzanne Shannon, DSRT, DEP

(Contractor) **Ken Jones,** Ph.D., Director, Green Mountain Institute for Environmental Democracy, Montpelier, Vermont

Gary A. Buchanan, Ph.D., Chair, Ecological Quality Technical Working Group (TWG)

Alan Stern, Ph.D., Chair, Human Health TWG

Terri Tucker, DSRT, DEP

Technical Working Groups

TWGs were responsible for the details of the analytic structure and process, including writing of the stressor-specific analyses, agreeing on overall relative rankings, and conducting peer review (internal and/or external).

Human Health TWG

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<u>Ecological Quality TWG</u>

(Note: Several Rutgers graduate students wrote one or more analyses under Prof. Casey's direction: David Bart, Christopher T. Martine, Matt Palmer, Denise Royle, and Michael Van Clef. Assistance also was provided by the following DEP staff: Ernie Hahn, Office of Natural Resource Damages; Bob Soldwedel, Freshwater Fisheries; and Larry Thornton, Geographic Information and Analysis.)

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Socioeconomic TWG

(Note: Most analyses were written under the direction of Prof. Andrews, by John Posey and by members of a planning class, all graduate students at Rutgers University. TWG members' primary role was to decide the method for systematic socioeconomic impact analyses, and to act as internal reviewers of analyses produced by course members.)

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Appendix 2
Templates for Stressor Analyses

APPENDIX II

Human Health

Risk Assessment Framework	Findings
Hazard Identification	
stressor	
description of stressor (including etiology)	
stressor-specific impacts considered including key impacts	
Exposure Assessment	
exposure routes and pathways considered (include indoor air as appropriate)	
population(s)/ecosystem(s) exposed statewide	
quantification of exposure levels statewide, including populations at significantly increased exposure (include indoor air as separate category as appropriate)	
specific population(s) at increased risk	
quantification of exposure levels to population(s) at increased risk (i.e., susceptible sub-populations) (include indoor air as separate category as appropriate)	
Dose/Impact-Response Assessment	
quantitative dose/impact-assessment employed for each population considered	
Risk Characterization	
risk estimate(s) by population at risk including probability and number of cases/occurrences (specify risk metric employed , e.g., mean population risk upper percentile population risk, etc.)	
assessment of severity, persistence, irreversibility, frequency of effect(s) (categories as appropriate)	
size of population(s) affected	
assessment of uncertainties in this assessment (H,M,L) and brief description, and data gaps	
potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description	
potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, ?=,? where + is improvement)	
potential impact from catastrophic (low probability) events (H,M,L) and brief description of likelihood	

potential impact from catastrophic (low probability) events (H,M,L) and brief description of likelihood	
extent to which risks are currently reduced through in-place regulations and controls	
Relative Contributions of Sources to Risk (H,M,L)	
Allocation of stressor-specific risk to primary NJ sources	
large business/industry	
small business industry	
transportation	
residential	
agriculture	
recreation	
resource extraction	
government	
natural sources	
contaminated sites	
diffuse and non-NJ sources	
sediment	
soil	
non-local air sources (including deposition)	
biota sinks	

Severity of specified health effects at current levels of exposure (H,M,L) (also 1-5 with 1 being least severe)	Size of population at significant risk for each health effect (H,M,L) (also 1-5 with 1 being smallest)	Are there discrete communities at elevated risk? (Y,N) (also 1-5 with 1 being the lowest probability that there are discrete communities at elevated risk)	Overall risk ranking (as a function of severity and population effected integrating across health effect) (H,M,L) (also 1-5 with 1 being the lowest overall risk)

APPENDIX II

Ecological Template

Issue:
Author:
Version:

Hazard Identification	
Stressor	
Description of stressor	
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	
Key impacts selected (critical ecological effects)	
Exposure Assessment	
Exposure routes and pathways considered	
Population(s)/ecosystem(s) exposed statewide	
Quantification of exposure levels statewide	
Specific population(s) at increased risk	
Quantification of exposure levels to population(s) at increased risk	
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	
Risk Characterization	

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		**Score**
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure		
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)		

APPENDIX II

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)		
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		
	Total	
Assessment of uncertainties in this assessment (H,M,L) and brief description		
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)		
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, −, =, ≡; where + is improvement), and brief description.		
Potential for catastrophic impacts (H,M,L) and brief description		
Link to other Work Groups (e.g., socioeconomic impacts)		
Extent to which threat is currently regulated or otherwise managed		
Barriers to restoration		
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		
NJ Primary Sources		
Large business/industry		
Small business industry		
Transportation		
Residential		
Agriculture		
Recreation		
Resource extraction		
Government		
Natural sources/processes		
Orphan contaminated sites		
Diffuse Sources		
Sediment sinks		

Non-local air sources incl. deposition	
Biota sinks	

Summary Statement:

(This statement should include a brief description of the stressor, exposure pathway(s), populations/ecosystems exposed, effects/impacts, and reason for the score given).

Statewide Analysis of Threat Threat =

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters				
Marine Waters				
Wetlands				
Forests				
Grasslands				
			Total Score	
			Average Score (Total ÷ 8)	

Risk by Watershed Management Region

THREAT =	*ECOSYSTEM*							
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands	Agro-ecosystems	Recreational Ecosystems	Urban
Upper Delaware		NA						
Passaic								
Raritan								
Atlantic								
Lower Delaware								
Region/Watershed (secondary)								
Urban								
Suburban								
Rural								

H=high, M=medium, L=low, NA = not applicable

APPENDIX II

potential impact from catastrophic (low probability) events (H,M,L) and brief description of likelihood	
extent to which risks are currently reduced through in-place regulations and controls	
Relative Contributions of Sources to Risk (H,M,L)	
Allocation of stressor-specific risk to primary NJ sources	
large business/industry	
small business industry	
transportation	
residential	
agriculture	
recreation	
resource extraction	
government	
natural sources	
contaminated sites	
diffuse and non-NJ sources	
sediment	
soil	
non-local air sources (including deposition)	
biota sinks	

Severity of specified health effects at current levels of exposure (H,M,L) (also 1-5 with 1 being least severe)	Size of population at significant risk for each health effect (H,M,L) (also 1-5 with 1 being smallest)	Are there discrete communities at elevated risk? (Y,N) (also 1-5 with 1 being the lowest probability that there are discrete communities at elevated risk)	Overall risk ranking (as a function of severity and population effected integrating across health effect) (H,M,L) (also 1-5 with 1 being the lowest overall risk)

APPENDIX II

**Socioeconomic
Template**

Author's Name | Date
Socioeconomic Risk Assessment Framework | **Findings/Notes**

Hazard Identification		
Stressor		
Description of stressor		
Ecological/Human Health Risks (including their relationship to socioeconomic impacts)		
Stressor-specific impacts considered (including direct socioeconomic impacts and those caused by ecological and human health risks):		
Key impacts selected (critical socioeconomic effects)		
Exposure Assessment		
Socioeconomic entities exposure routes and pathways considered		
Quantification of exposure levels statewide		
Specific socioeconomic entities at increased risk		
Quantification of exposure levels to entities at increased risk		
Dose/Impact-Response Assessment		
Quantitative/Qualitative impact-assessment employed		
Risk Characterization		
Risk estimate(s) by socioeconomic entities at risk		*Score*
Property Values	***a)*** Severity:	
	b) Duration/irreversibility:	
	c) Scale:	
	d) Uncertainty:	
Employment	***a)*** Severity:	
	b) Duration/irreversibility:	
	c) Scale:	
	d) Uncertainty:	
Costs Incurred	***a)*** Severity:	
	b) Duration/irreversibility:	
	c) Scale:	
	d) Uncertainty:	
Aesthetic Levels	***a)*** Severity:	
	b) Duration/irreversibility:	
	c) Scale:	
	d) Uncertainty:	
Psychological Impacts	***a)*** Severity:	
	b) Duration/irreversibility:	
	c) Scale:	
	d) Uncertainty:	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)		

Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, -, --, --- where + is improvement), and brief description	
Potential for catastrophic impacts (H,M,L) and brief description	
Incidence of impacts (affected sub-groups, variability, equity issues)	
Extent to which threat is currently regulated	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	
Small business industry	
Transportation	
Residential	
Agriculture	
Recreation	
Resource extraction	
Government	
Natural sources/processes	
Orphan contaminated sites	
Diffuse Sources	
Sediment sinks	
Soil sinks	
Non-local air sources incl. Deposition	
Biota sinks	
References	
Current Policy and Regulatory Framework	
Federal	
State & Local	

Stressor Summary:

APPENDIX II

Non-local air sources incl. deposition	
Biota sinks	

Summary Statement:

(This statement should include a brief description of the stressor, exposure pathway(s), populations/ecosystems exposed, effects/impacts, and reason for the score given).

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Region/Watershed (secondary)								
Urban								
Suburban								
Rural								

H=high, M=medium, L=low, NA = not applicable

Cover Photos

Photos by: Bruce Ruppel, DSRT

Top left:	Purple flowers
Top middle:	Canistear Reservoir
Top right:	Farm - Griggstown
Middle:	Princeton
Bottom left:	Island Beach State Park
Bottom right:	Arthur Kill

Photo by: Terri Tucker, DSRT

Bottom Center: Green Frog