

RELATED CORRESPONDENCE

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before Administrative Judges:
Ivan W. Smith, Chairperson
Gustave A. Linenberger, Jr.
Dr. Jerry Harbour



In the Matter of)

PUBLIC SERVICE COMPANY OF)
NEW HAMPSHIRE, ET AL.)
(Seabrook Station, Units 1 and 2))

) Docket Nos.
) 50-443-444-OL
) (Off-site EP)
) April 25, 1988
)

TESTIMONY OF THOMAS J. ADLER
ON BEHALF OF THE ATTORNEY GENERAL
FOR THE COMMONWEALTH OF MASSACHUSETTS
ON SHELTERING CONTENTIONS

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NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

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April 22, 1988

TESTIMONY OF DR. THOMAS J. ADLER ON BEHALF
OF JAMES M. SHANNON, ATTORNEY GENERAL FOR THE
COMMONWEALTH OF MASSACHUSETTS, CONCERNING VARIOUS
MATTERS RAISED IN THE "SHELTERING" CONTENTIONS

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I. IDENTIFICATION OF WITNESS

Q. What is your name and current occupation?

A. My name is Thomas J. Adler and I am President of Resource Systems Group of Norwich, Vermont.

Q. Are your professional qualifications as set forth in the testimony and attachments filed on September 14, 1987 in this case still accurate?

A. Yes, they are.

II. TESTIMONY

Q. Did *Resource Systems Group*, at the request of the Department of the Attorney General, perform additional runs of the I-DYNEV simulation model to determine evacuation times specifically for the beach population?

A. Yes, we did.

Q. Would you first describe the scenarios for which these analyses were performed?

A. We were asked to evaluate the times required to evacuate the beach population to an area outside a three mile radius from Seabrook Station. The evacuation scenario assumes that residents and employees within the EPZ are instructed to shelter in place and that 50% of those so instructed choose instead to evacuate. We ran KLD's I-DYNEV model, using the input files supplied to us by KLD, modifying only the description of the evacuation scenario and the estimated size of the beach population. Six situations were analyzed with the model and the results were graphed as shown in attached Figures 1 through 6.

Q. Would you please describe those graphs?

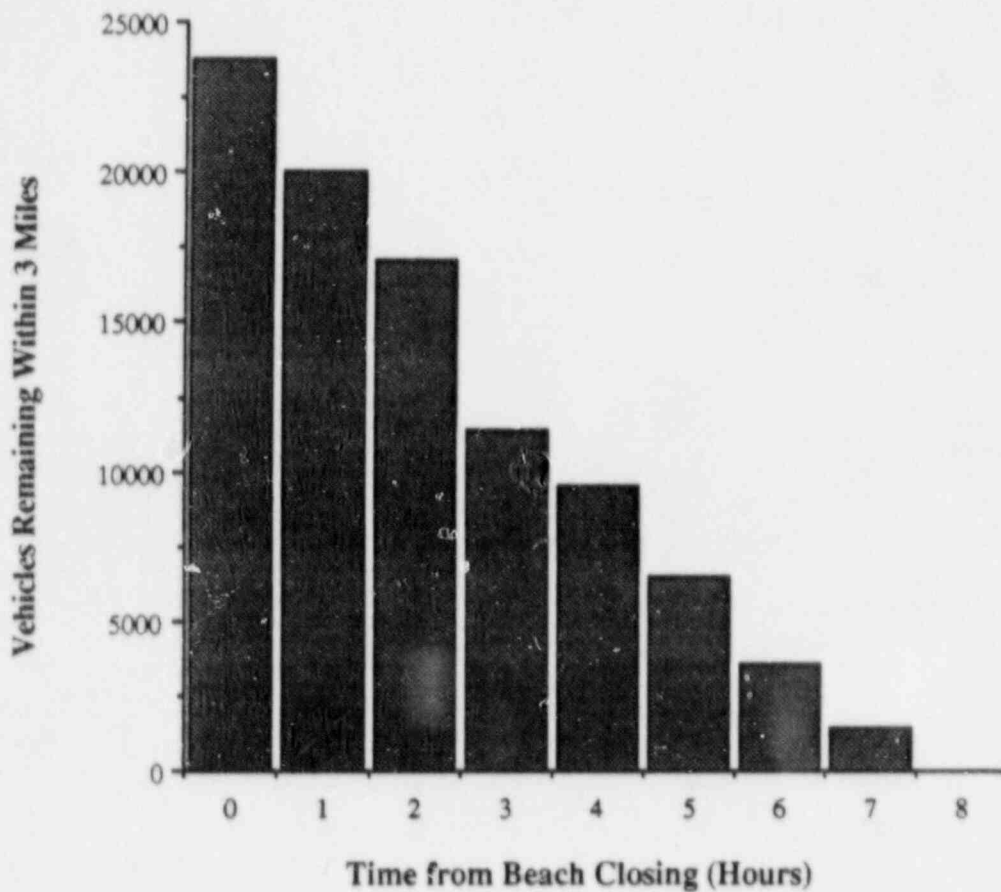
A. Each graph shows the number of evacuating vehicles remaining within approximately three miles of Seabrook Station during each hour following the start of evacuation. Figure 1, for example, shows that approximately 20,000 evacuating vehicles remain within three miles after one hour and 3,000 vehicles after 6 hours. The beach population estimate used for this calculation is based on the testimony of High, Adler and Befort filed by the Massachusetts

Department of the Attorney General on September 14, 1987. Figures 2, 3 and 4 show analogous results for conditions involving evacuation of smaller fractions of the beach population; 75% (Figure 2), 50% (Figure 3) and 25% (Figure 4). Figure 5 is the result of an I-DYNEV run made using the applicants' "updated" beach population, based on their July 1987 vehicle counts. Finally, Figure 6 shows the effect of failure to staff the one major capacity-enhancing Traffic Control Post (TCP) specified in the New Hampshire Plan -- at the Rt. 51/I-91 interchange area.

Q. How are these runs different from those presented in your September 1987 testimony?

A. They are specifically designed to show the progress of a scenario involving ordered evacuation of the beach area only and to a distance of only three miles from Seabrook Station. There is a somewhat analogous figure shown in my earlier testimony (p. 16a) which compared the progress of a beach area evacuation as projected in the applicants' Volume 6 analyses and as calculated by our "new estimates." The Volume 6 estimates in that figure were based on beach population estimates which the applicants have since indicated are too low. The "new estimates" in that figure contained the effects of several important factors that we have maintained are not appropriately represented in the applicants' analyses. In the present testimony, we have reverted to using the applicants' assumptions to demonstrate the progress of what we believe is a "best case" evacuation for the given beach populations.

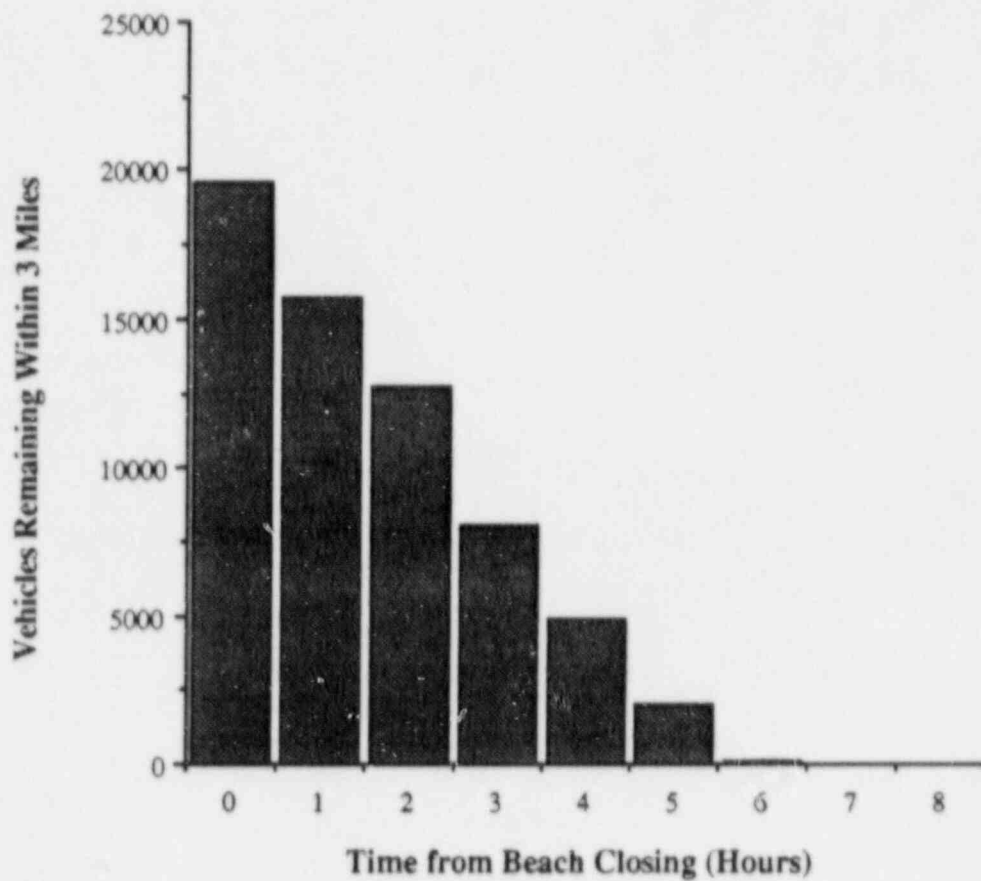
Beach Evacuation with 50% Voluntary Evacuation Entire Beach Population*



*Estimated as described in September 14, 1987 testimony of High, Adler and Befort.

Figure 1

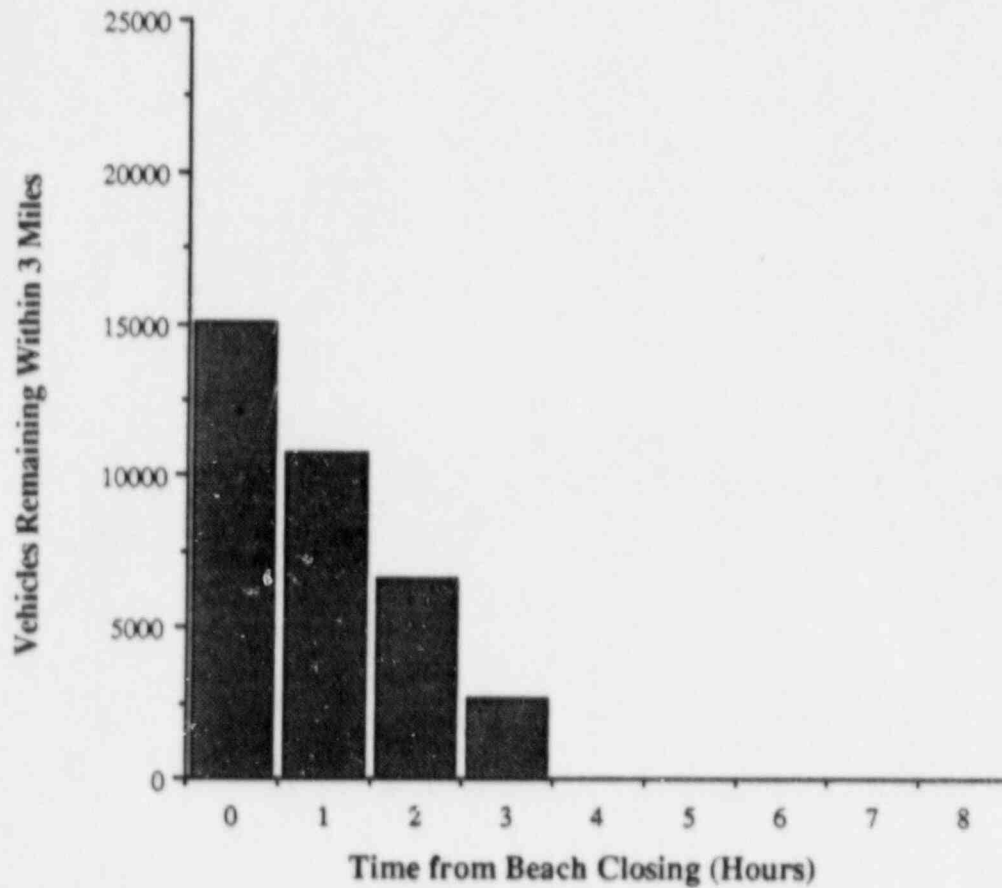
Beach Evacuation with 50% Voluntary Evacuation 75% Beach Population*



*Estimated as described in September 14, 1987 testimony of High, Adler and Befort.

Figure 2

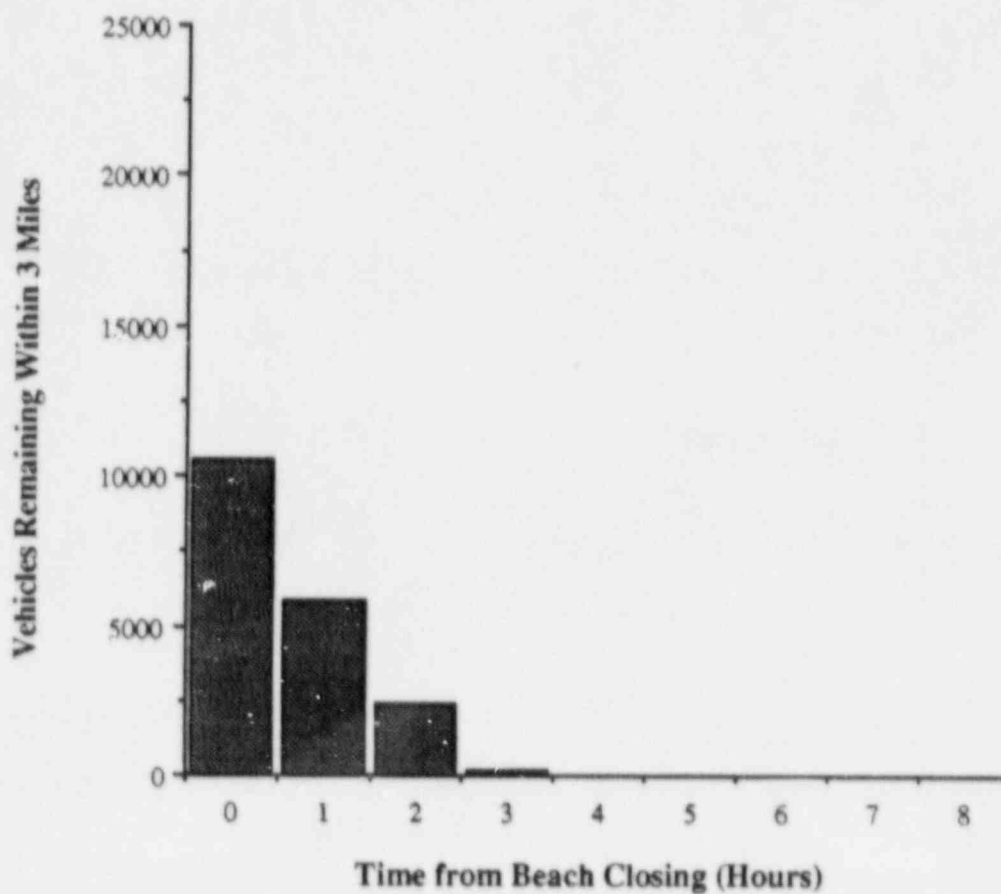
Beach Evacuation with 50% Voluntary Evacuation 50% Beach Population*



*Estimated as described in September 14, 1987 testimony of High, Adler and Befort.

Figure 3

Beach Evacuation with 50% Voluntary Evacuation 25% Beach Population*



*Estimated as described in September 14, 1987 testimony of High, Adler and Befort.

Figure 4

Beach Evacuation with 50% Voluntary Evacuation Applicants' Beach Population

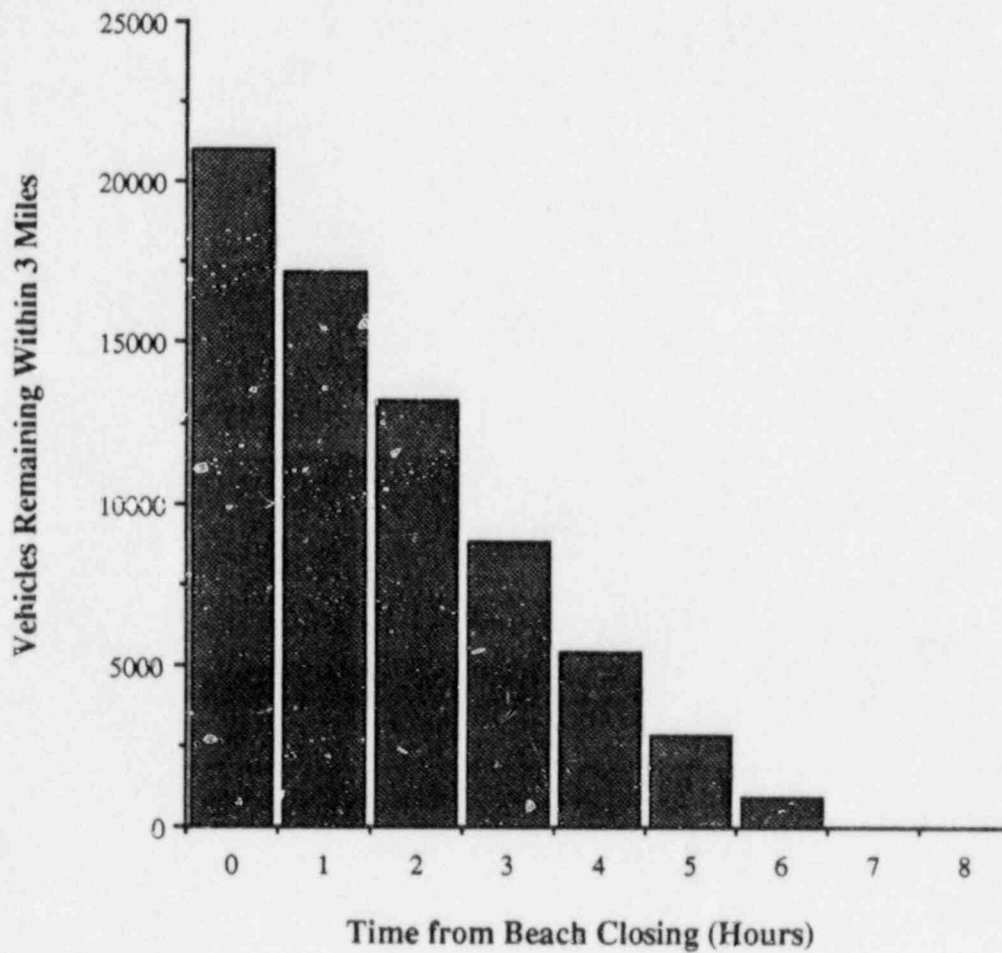


Figure 5

Beach Evacuation with 50% Voluntary Evacuation Applicants' Beach Population

No Staffing of Rt. 51/I-95 Intersection

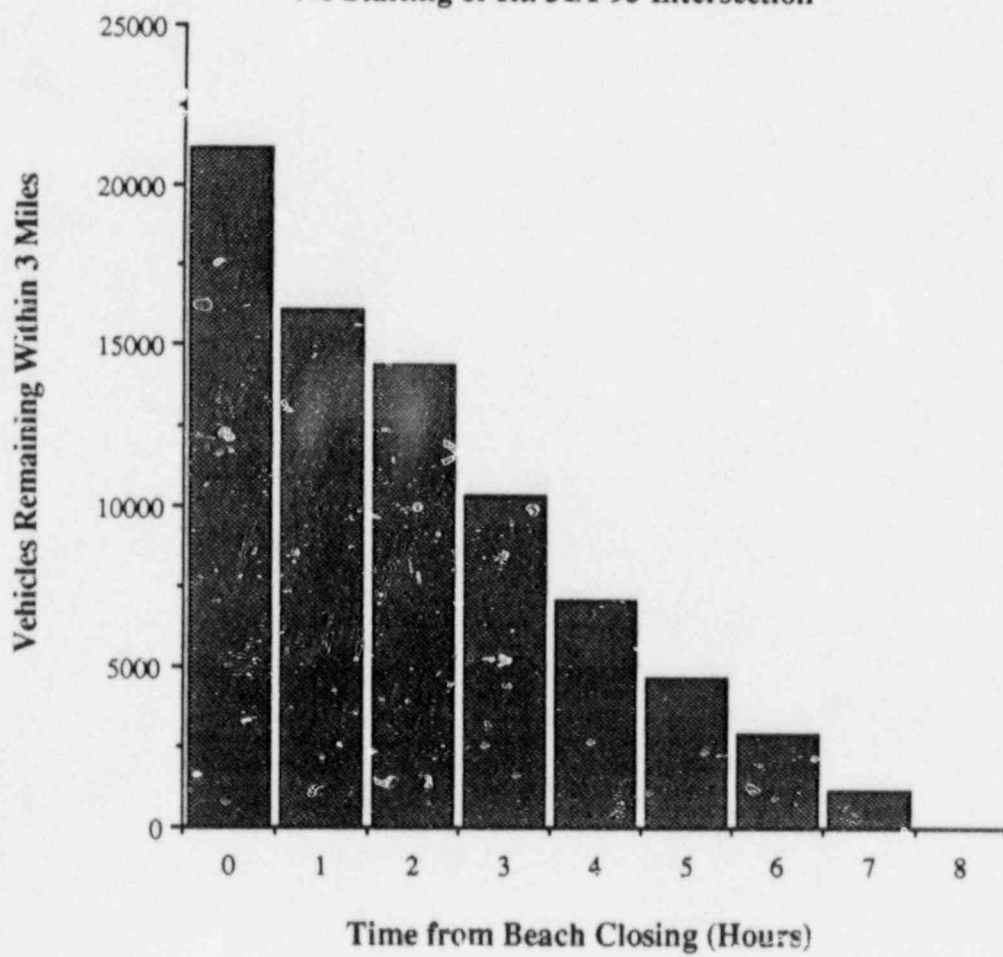


Figure 6

[Testimony of Sholly, and Beyea and Thompson on Sheltering]

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A. (Thompson) My name is Dr. Gordon Thompson. I am Executive Director of the Institute for Resource and Security Studies in Cambridge, Massachusetts.

Q. Briefly summarize your experience and professional qualifications.

A. (Sholly) I received a B.S. in Education from Shippensburg State College in 1975 with a major in Earth and Space Science and a minor in Environmental Education. I have seven years experience with nuclear power matters. In particular, for four and one-half years I was employed by the Union of Concerned Scientists where I worked on matters related to the development of emergency plans for commercial nuclear power plants and the application of probabilistic risk assessment (PRA) to the analysis of safety issues related to commercial nuclear power plants. I have been a consultant with MHB Technical Associate for two years, during which time I have been involved in a variety of projects related to the safety and economics on nuclear power plants, including the evaluation of severe accident issues for light water nuclear power plants generally, and for the Seabrook Station, Unit 1, specifically.

I have testified as an expert witness in proceedings before the U.S. Nuclear Regulatory Commission (NRC) and other bodies, including the safety hearings on Indian Point Units 2 and 3 (Docket Nos. 50-247-SP and 50-286-SP), the licensing hearings on Catawba Nuclear Station, Units 1 and 2 (Docket Nos. 50-413 and 50-414), and the licensing hearings on the Shoreham Nuclear

Power Station, Unit 1 (Docket No. 50-322-OL-3). I have also provided expert testimony before the Sizewell B Public Inquiry in the United Kingdom. I have served as a member of a peer review panel on regulatory applications of PRA (NRC report NUREG-1050), as a member of the Containment Performance Design Objective Workshop (NRC report NUREG/CP-0084), as a member of the Committee on ACRS Effectiveness, and as a panelist at the Severe Accident Policy Implementation External Events Workshop, Annapolis, Maryland (presentation on seismic risk assessment, 1987; forthcoming Lawrence Livermore National Laboratory report). The details of my education, experience, and professional qualifications are included in my resume, which is contained in attachments to this testimony.

(Beyea) I received my doctorate in nuclear physics from Columbia University in 1968. Since then I have served as an Assistant Professor of physics at Holy Cross College in Worcester, MA; as a member for four years of the research staff of the Center for Energy and Environmental Studies at Princeton University; and, as of May 1980, as the Senior Energy Scientist for the National Audubon Society.

While at Princeton University, I worked with Dr. Frank von Hippel to prepare a critical quantitative analysis of attempts to model reactor accident sequences. The lessons learned from this general study of nuclear accidents and the computer codes written to model radioactivity releases were then applied by me

to specific problems at the request of governmental and non-governmental bodies around the world. I have written major reports on the safety of specific nuclear facilities for the President's Council on Environmental Quality (TMI reactor), for the New York State Attorney General's Office (Indian Point), for the Swedish Energy Commission (Barsebeck reactor), and the state of Lower Saxony (Gorleben Waste Disposal Site). I have also examined safety aspects of specific sites for the California Energy and Resources Commission, the Massachusetts Attorney General's Office and the New York City Council.

While at Princeton, I wrote a computer program useful for reactor emergency planning for the New Jersey Department of Environmental Protection. This program, appropriately modified, has been used for some of the calculations presented in this testimony.

After joining the National Audubon Society, I continued to work as an independent consultant on nuclear safety issues. I participated in a study, directed by the Union of Concerned Scientists at the request of the Governor of Pennsylvania, concerning the proposed venting of krypton gas at Three Mile Island. The U.S.C. study, for which I made the radiation dose calculations, was the major reason the Governor gave for approving the venting.

I participated in the international exercise on consequence modelling (Benchmark Study) coordinated by the Organization for Economic Cooperation & Development (O.E.C.D.). Scientists and

engineers from fourteen countries around the world calculated radiation doses following hypothetical "benchmark" releases using their own consequence models. Participants from the United States, in addition to myself, included groups from Sandia Laboratories, Lawrence Livermore Laboratory, Batelle Pacific-Northwest, and Pickard, Lowe and Garrick, Inc. I also served as consultant from the environment community to the N.R.C. in connection with their development of "Safety Goals for Nuclear Power Plants."

At the request of the Three Mile Island Public Health Fund, I supervised a major review of radiation doses from the Three Mile Island Accident. This report, "A Review of Dose Assessments at Three Mile Island and Recommendations for Future Research" was released in August of 1984. Subsequently, I organized a workshop on TMI Dosimetry, the proceedings of which were published in early 1986.

In 1986, I developed new dose models for the Epidemiology Department of Columbia University. These models are being used to assess whether or not the TMI accident is correlated with excess health effects in the local population. The new computer models account for complex terrain, as well as time varying meteorology (including changes in wind direction). Insights gained from this project have been applied to the Seabrook situation.

In addition to reports written about specific nuclear facilities, an article of mine on resolving conflict at the

Indian Point reactor site, an article on emergency planning for reactor accidents, and a joint paper with Frank von Hippel of Princeton University on failure modes of reactor containment systems have appeared in The Bulletin of the Atomic Scientists.

I have also prepared risk studies covering sulfur emissions from coal-burning energy facilities. And I have managed a project that analyzed the side effects of renewable energy sources.

I regularly testify before congressional committees on energy issues and have served on several advisory boards set up by the Congressional Office of Technology Assessment.

I currently participate in a number of ongoing efforts aimed at promoting dialogue between environmental organizations and industry.

I was assisted in the early stages of my studies of Seabrook by Brian Palenik, who has worked with me on other reactor studies in the past. In subsequent answers to questions, I will use the pronoun, "we," to describe our collective efforts. However, all work was carried out either by me or under my direct supervision.

Brian Palenik received his Bachelor of Science in Civil Engineering degree with honors from Princeton University. While an undergraduate at Princeton, Mr. Palenik worked with me on "The Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island"--my report to the President's Council on Environmental Quality.

After graduation, Mr. Palenik joined the staff of National Audubon's Policy Research Department. While there, he and I wrote, "Some Consequences of Catastrophic Accidents at Indian Point and Their Implications for Emergency Planning," as part of our testimony before the Nuclear Regulatory Commission Atomic Safety and Licensing Board, July 1982.

Mr. Palenik is currently a graduate student in the Civil Engineering Department at M.I.T.

A complete resume is included in the attachments to this testimony.

(Thompson) I received a Ph.D in applied mathematics from Oxford University in 1973. Since then I have worked as a consulting scientist on a variety of energy, environment, and international security issues. My experience has included technical analysis and presentation of expert testimony on issues related to the safety of nuclear power facilities.

In 1977, I presented testimony before the Windscale Public Inquiry in Britain, addressing safety aspects of nuclear fuel reprocessing. During 1978 and 1979, I participated in an international scientific review of the proposed Gorleben nuclear fuel center in West Germany, this review being sponsored by the government of Lower Saxony.

Between 1982 and 1984, I coordinated an investigation of safety issues relevant to the proposed nuclear plant at Sizewell, England. This plant will have many similarities to

the Seabrook plant. The investigation was sponsored by a group of local governments in Britain, under the aegis of the Town and Country Planning Association. This investigation formed the basis for testimony before the Sizewell Public Inquiry by myself and two other witnesses.

From 1980 to 1985, first as a staff scientist and later as a consultant, I was associated with the Union of Concerned Scientists (UCS), at their head office in Cambridge, MA. On behalf of UCS, I presented testimony in 1983 before a licensing board of the US Nuclear Regulatory Commission (NRC), concerning the merits of a system of filtered venting at the Indian Point nuclear plants. Also, I undertook an extensive review of NRC research on the reactor accident "source term" issue, and was co-author of a major report published by UCS on this subject (Sholly and Thompson, 1986).

Currently, I am one of three principal investigators for an emergency planning study based at Clark University, Worcester, MA. The object of the study is to develop a model emergency plan for the Three Mile Island nuclear plant. Within this effort, my primary responsibilities are to address the characteristics of severe reactor accidents.

My other research interests include: the efficient use of energy; supply of energy from renewable sources; radioactive waste management; the restraint of nuclear weapons proliferation; and nuclear arms control. I have written and made public presentations in each of these areas.

At present, I am Executive Director of the Institute for Resource and Security Studies, Cambridge, MA. This organization is devoted to research and public education on the efficient use of natural resources, protection of the environment, and the furtherance of international peace and security.

A detailed resume is included in the attachments to this testimony.

II. CONTENTIONS

Q. To what contentions does your testimony refer?

A. (All) Town of Hampton revised contention VIII, SAPL revised contention 16 and NECNP contention RERP-8. These contentions and their bases are set out in full in Attachment 4. Our testimony also addresses matters raised in the Federal Emergency Management Agency (FEMA) June 4, 1987 "current" position on these contentions. In addition, our testimony bears on aspects of other contentions in this proceeding.

Q. What is the purpose of your testimony and how does it relate to the specific contentions cited here?

A. (All) These three interrelated contentions and the FEMA position on them all concern the issue of protection from radiological releases of the beach populations in the vicinity of the Seabrook Plant. Our testimony first describes the

standard guidance used by the Nuclear Regulatory Commission (NRC) and FEMA for the initiation and duration of radiological releases to be considered in emergency planning. Then, and using postulated accidents at Seabrook consistent with the spectrum of accident scenarios called for in the NRC guidance, the testimony estimates and describes the radiation dosages which could affect the beach populations near the Seabrook Plant site.

The testimony as a whole demonstrates that NHRERP Rev. 2 is fundamentally flawed and is of no real or practical use because the beachgoing public in the vicinity of the Seabrook plant will not be adequately protected in the event of an emergency. In particular, this testimony shows that because of the size of the beach population in the immediate vicinity of the plant site, the long evacuation times, and the lack of effective sheltering, many thousands of individuals will die, suffer serious injuries or face the prospect of increased likelihood of cancer if one of any number of the accidents required to be planned for by the NRC occurs. Thus, because of the radiation dosages that would reach the beach population, there is no reasonable assurance that NHRERP Rev 2 can and will be implemented to provide adequate protection to the public in the event of an accident.

III. OVERVIEW

Q. Please summarize your portion of this testimony.

A. (Sholly) My testimony describes the technical basis for the current NRC emergency planning rules. The testimony

discusses the use in the NRC reports NUREG/CR-1311, NUREG-0396, and NUREG-0654, of the risk assessment results for the Surry Unit 1 plant (as set forth in the NRC report WASH-1400) to derive dose-distance relationships for a spectrum of accidents, including severe accidents beyond the design basis of light water nuclear power plants. The testimony further describes the nature of that spectrum of accidents, including release characteristics, release frequencies, and uncertainties. Finally, the testimony describes how the risk-based insights from the Surry Unit 1 risk assessment were utilized by the NRC to arrive at the generic emergency planning zone distances and other guidance contained in the rules and in the applicable NRC guidance documents (including NUREG-0654, Rev. 1).

A. (Beyea) The situation around the Seabrook Nuclear Power Plant is unusual in the context of emergency planning for nuclear plants, because large populations make use of nearby beaches in the summertime. In order to determine the extent of protection afforded the summer beach population by current emergency plans, we have modelled the radiation doses to the population that would follow releases of radioactivity from the Seabrook plant. A range of releases has been studied, patterned after the range used in the NRC's report, NUREG-0396.

In NUREG-0396, a set of generic accident sequences (PWR1-PWR9) were defined that apply to pressurized water reactors like the Seabrook plant. These sequences span the entire range of physically-plausible release scenarios, making them useful for assessing, at least on a theoretical basis, the

effectiveness of emergency plans. For my testimony, we have chosen accident sequences that are similar to the NRC's generic versions, but which take into account reactor-specific differences at Seabrook.

In order to understand the conditions under which the population would not be protected from "early death" (death within 60 days of the release), doses were modelled for these release categories using a range of weather parameters, plume rise heights, and dose contribution assumptions. The results indicate that the potential consequences of severe accidents increase greatly during the summer months, due to the increased population in the area and the unique conditions of a beach release: Beach-goers caught in the open would not be shielded from radiation, and could be expected, by our calculations, to receive doses as much as five times higher than generally considered in nuclear emergency planning. This means that certain accident releases, not normally projected to cause early fatalities, are projected to do so in the Seabrook case.

As a result, it is necessary to consider a range of accident scenarios, from those with very small releases to those with very large releases.

In addition to the risk of early death, we have considered other potential accident consequences, including delayed cancer incidence. These potential outcomes dominate the risk for accident releases in classes PWR4-PWR9.

The proximity of the reactor to an unshielded summer beach population makes the Seabrook case a special and difficult one

for emergency planning. The doses that would be received following a range of releases at the Seabrook site, with emergency plans in effect, are higher than doses that would be received at most other sites in the complete absence of emergency planning.

Our results demonstrate that, with current plans, the immediate safety of the beach population is threatened for a wide range of releases and meteorological conditions. For the accidents studies in our testimony, many thousand of people could receive life-threatening doses.

A. (Thompson) The issues I address are:

(1) The potential for an atmospheric release, similar to that designated as PWRI in the Reactor Safety Study, to occur from a steam explosion or high-pressure melt ejection event.

(2) The range of variation of two parameters which affect plume rise during a "PWRI-type" release, specifically the location of containment breach and the thermal energy release rate for the plume.

(3) The potential for "PWRI-type" releases to contain greater amounts of certain isotopes, such as those of ruthenium, than other categories of releases.

IV. SYNOPSIS OF WASH-1400 SURRY ANALYSIS

Q. Please identify and describe the nature of the NRC report WASH-1400.

A. (Sholly) WASH-1400 (N.C. Rasmussen, et al., Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, U.S. Nuclear Regulatory

Commission, WASH-1400, NUREG-75/014, October 1975) represents a probabilistic risk assessment of two nuclear power plants, namely Surry Unit 1 and Peach Bottom Unit 2. The report consists of a Main Report and eleven Appendices. WASH-1400 represents the first comprehensive application of probabilistic risk assessment methods to the analysis of the risks posed by commercial nuclear power plants. That is, WASH-1400 includes system analyses, source term estimates, and accident consequence estimates. In the parlance of the NRC's PRA Procedures Guide, WASH-1400 is a Level 3 PRA of two plants.^{1/}

Q. Please briefly describe the Surry Unit 1 nuclear power plant and compare its design with that of Seabrook Station, Unit 1.

A. (Sholly) The Surry Unit 1 nuclear power plant is a three-loop, Westinghouse pressurized water reactor with dry, subatmospheric containment. The Surry Unit 1 plant has a design thermal power level of 2441 megawatts, and entered commercial operation in December 1972. Surry Unit 1 is operated by Virginia Power Corporation under operating license DPR-32, issued on May 25, 1972. Seabrook Station Unit 1 is a four-loop, Westinghouse pressurized water reactor with a large,

1/ Jack W. Hickman, et al., PRA PROCEDURES GUIDE: A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants, American Nuclear Society and Institute of Electrical and Electronics Engineers, prepared for the U.S. Nuclear Regulatory Commission, NUREG/CR 2300, January 1983, pages 2-2 to 2-3.

dry containment. Seabrook has a design thermal power level of 3650 megawatts.

Q. Please summarize the results of the WASH-1400 analysis of the Surry Unit 1 plant.

A. (Sholly) The WASH-1400 report calculated a median core melt frequency for Surry Unit 1 of about 5×10^{-5} per reactor-year (or about 1 in 20,000 per reactor-year).^{2/} The NUREG-1150 analysis estimated the core melt frequency for Surry to be 2.6×10^{-5} per reactor year. See, NUREG-1150, draft, page 3-2. The dominant accident sequences for Surry Unit 1 which contributed to this core melt frequency are identified along with their estimated sequence frequencies in Table A, which is attached to this testimony. WASH-1400 also defined nine release categories or source terms which defined the release characteristics and release frequencies for Surry Unit 1. These release categories were designated PWR-1 through PWR-9. Release categories PWR-1 through PWR-7 correspond to

^{2/} The Surry core melt frequency estimate in WASH-1400 has been cited as several different values. For instance, the NUREG-1150 report cites a value of 4.6×10^{-5} per reactor year. See M.L. Ernst, et al., Reactor Risk Reference Document, U.S. Nuclear Regulatory Commission, NUREG-1150, Vol. 1, "Main Report", draft for comment, February 1987, page 3-12 (hereinafter "NUREG-1150 draft"). A technical report supporting NUREG-1150 cites 4.4×10^{-5} per reactor-year. See, Robert C. Bertucio, et al., Analysis of Core Damage Frequency From Internal Events: Surry Unit 1, Sandia National Laboratories, prepared for the U.S. Nuclear Regulatory Commission, NUREG/CR-4550, SAND86-2084, Vol. 3, November 1986 page V-68. In fact, as indicated in Attachment 3 to this testimony, if one adds the point estimate frequencies for the WASH-1400 dominant accident sequences, one obtains a core melt frequency of 1.2×10^{-4} per reactor-year.

core melt accidents. Release Categories PWR-8 and PWR-9 are non-core melt accidents, and are roughly equivalent to the design basis accident with (PWR-8) and without (PWR-9) containment spray operation. The Surry release categories are described and their characteristics and estimated frequencies defined in Table B, which is attached to this testimony. Many of the WASH-1400 release categories (especially PWR-1 through PWR-4) could result in significant ground contamination offsite should accidents leading to such releases occur.

V. USE OF WASH-1400 RESULTS IN NUREG-0396

Q. Please identify and describe NUREG-0396.

A. (Sholly) NUREG-0396 (Task Force on Emergency Planning, Planning Basis for the Development of State and Local Emergency Response Plans in Support of Light Water Nuclear Power Plants, U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency, NUREG-0396, EPA 520/1-78-016, December, 1987), set a revised planning basis for commercial nuclear power plants. In essence, NUREG-0396 concluded that a spectrum of accidents should be used in developing a planning basis.^{3/}

3/ H.E. Collins, B.K. Grimes & F. Galpin, et al., Planning Basis for the Development of State and Local Emergency Response Plans in Support of Light Water Nuclear Power Plants, Task Force on Emergency Planning, U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency, NUREG-0396, EPA 520/1-78-016, December 1978, page 24 (hereinafter "NUREG-0396").

NUREG-0396 recommended the establishment of two generic emergency planning zones (EPZs) for nuclear power plants; a plume exposure pathway EPZ about 10 miles in radius and an ingestion exposure pathway EPZ about 50 miles in radius. These EPZs were designated as "the areas for which planning is recommended to assure that prompt and effective actions can be taken to protect the public in the event of an accident."^{4/} A significant part of the basis for these planning zone distances was derived from accident consequence analyses (specifically dose-distance calculations) using the WASH-1400 release categories and frequencies for Surry Unit 1.

Q. Please describe how the WASH-1400 results for Surry Unit 1 were utilized in NUREG-0396.

A. (Sholly) The Task Force on Emergency Planning, which wrote NUREG-0396, utilized the Surry Unit 1 results from WASH-1400 to perform consequence calculations to "illustrate the likelihood of certain offsite dose levels given a core melt accident."^{5/} While the Task Force members debated various aspects of the WASH-1400 report and considered its results to have limited use for plant-and site-specific factors, it was judged to provide "the best currently available source of information on the relative likelihood of large accidental

4/ Id. at 11.

5/ Id. at 6.

releases of radioactivity given a core melt event."^{6/} WASH-1400 results for Surry were also utilized to provide guidance concerning the timing of radiological releases resulting from core melt accidents, and the radiological characteristics of such releases.^{7/} The planning basis distance, the time dependent characteristics of potential releases and exposures, and the kinds of radioactive materials that can potentially be released to the environment were identified by the Task Force as the three planning basis elements needed to scope the planning effort.^{8/} WASH-1400 results for Surry Unit 1 were used to define all three of the planning basis elements in NUREG-0396.

Q. Please describe the rationale used by the Task Force in establishing the size of the EPZs recommended in NUREG-0396.

A. (Sholly) The Task Force on Emergency Planning considered a number of possible rationales, including risk, probability, cost effectiveness, and the accident consequence spectrum. Following a review of these rationales, "The Task Force chose to base the rationale on a full spectrum of accidents and corresponding consequences tempered by probability considerations."^{9/} The rationale used by the

6/ Id. at 6.

7/ Id. at 18-23.

8/ Id. at 8.

9/ Id. at 15.

Task Force in establishing the EPZ planning distances is more fully described in Appendix 1 to NUREG-0396.

Q. Please describe the spectrum of accidents considered by the Task Force in NUREG-0396.

A. (Sholly) The Task Force on Emergency Planning considered a complete spectrum of accidents, including those discussed in environmental reports prepared by utilities as part of the operating license review (the so-called Class 1 through Class 8 accidents), accidents postulated for the purpose of evaluating plant design (design basis accidents in the Final Safety Analysis Report), and the spectrum of accidents identified in the WASH-1400 report. The Task Force concluded that the Class 1 through Class 8 accident discussions in environmental reports were too limited in scope and detail to be useful in emergency planning, and instead relied on design basis accidents and the WASH-1400 release categories.
10/

Q. Please describe specifically how the Surry Unit 1 results from WASH-1400 were used by the Task Force.

A. (Sholly) Concurrently with the operation of the Task Force, a report was being prepared for the NRC by Sandia Laboratories (now Sandia National Laboratories) which examined offsite emergency response measures for core melt accidents.

10/ Id. at 1-4.

This report, designated SAND78-0454, was published in June 1978.^{11/} The Sandia report grouped the WASH-1400 release categories for Surry Unit 1 into "Melt-Through" and "Atmospheric" release groups (based on the location of containment failure identified for the WASH-1400 release categories).

Surry release categories PWR-1 through PWR-5 consist of accidents in which the containment was concluded to fail directly to the atmosphere as a result of structural failure or containment isolation failure. These release categories were grouped into the "Atmospheric Release" class. Surry release categories PWR-6 and PWR-7 consist of accidents in which the containment base was penetrated by core debris. These release categories were grouped into the "Melt-Through Release" class. The likelihood of the "Atmospheric" and "Melt-Through" classes were estimated by summing the probabilities of the contributing WASH-1400 release categories; "Atmospheric" releases were estimated to have a frequency of 1.4×10^{-5} per reactor-year, and "Melt-Through" releases were estimated to have a frequency of 4.6×10^{-5} per reactor-year.^{12/}

^{11/} David C. Aldrich, Peter E. McGrath & Norman C. Rasmussen, Examination of Offsite Radiological Protective Measures for Nuclear Reactor Accidents Involving Core Melt, Sandia Laboratories, prepared for the U.S. Nuclear Regulatory Commission, SAND78-0454, June 1978 (hereinafter "SAND78-0454"). This report was reissued as NUREG/CR-1131 in October 1979 following the Three Mile Island accident.

^{12/} Id. at 43.

The characteristics of these release classes were then used as input to the WASH-1400 accident consequence code, referred to as CRAC (Calculation of Reactor Accident Consequences). The calculations were carried out using meteorological data from one reactor site and an assumed uniform population density of 100 persons per square mile.^{13/} The CRAC code calculations implemented for the Sandia study used hourly weather data for one year and 91 accident start times (a four day, thirteen-hour shift was assumed to take place for each start time; this results in each hour of the day being represented in 24 samples and a total of 91 samples are taken from one year's data).^{14/} The wind direction is assumed to be held constant during and following the release; other weather changes are modeled as indicated in the data.^{15/} A revised model of public evacuation (ultimately implemented in CRAC2, an improved version of the code) was also used.^{16/}

The most frequently cited curve in NUREG-0396 which was derived from the Surry Unit 1 risk study results is a curve which plots the probability of whole-body dose versus

13/ Id. at 36.

14/ According to a recent Brookhaven National Laboratory report, weather data from a typical year for New York City were used in calculations. See, W.T. Pratt & C. Hofmayer, et al., Technical Evaluation of the EPZ Sensitivity Study for Seabrook, Brookhaven National Laboratory, prepared for the U.S. Nuclear Regulatory Commission, March 1987, page 6-2.

15/ Aldrich, et al., supra note 11, at 37-39..

16/ Id. at 59.

distance. (This curve, Figure 1-11 from NUREG-0396, is attached to this testimony as part of Table C). The curves on this figure were not calculated directly by the CRAC code, however. As explained in a recent Brookhaven National Laboratory (BNL) report, these curves were interpolated. BNL used the newer CRAC2 code to recalculate the dose vs. distance curves. The results of these calculations are shown in Table D, which is attached to this testimony (this calculation is only for the 200 rem whole-body curve).

Q. What results from the Sandia study were used in NUREG-0396?

A. (Sholly) NUREG-0396 contains a series of figures which are drawn from the Sandia report. These figures are Figures 1-11 through 1-18. These figures are reproduced as Table C, attached to this testimony.

VI. USE OF WASH-1400 INSIGHTS IN SETTING EPZ DISTANCES

Q. Please describe the insights from NUREG-0396, Figures 1-11 through 1-18, that were drawn by the Task Force on Emergency Planning.

A. (Sholly) The Task Force derived a number of insights from Figures 1-11 through 1-18. These insights were set forth in terms of the U.S. Environmental Protection Agency (EPA) "Protective Action Guide" (PAG) doses. PAGs are expressed in units of radiation dose (rem) which "represents trigger levels or initiation levels, which warrant pre-selected protective

actions for the public if the projected (future) dose received by an individual in the absence of a protective action exceeds the PAG."^{17/} The EPA PAGs used by the Task Force were those for whole-body exposure and thyroid exposure. These PAGs have a range of 1-5 rem whole-body and 5-25 rem to the thyroid. According to EPA guidance, the lower dose in the PAG range is to be used if "there are no major local constraints in providing protection at that level, especially to sensitive populations." If local constraints make the lower value impractical to use, in no case should the higher value be exceeded in determining the need for protective action.^{18/}

Based on the figures, the Task Force concluded that given a core melt accident, there is about a 70% chance of exceeding the whole-body PAG doses at two miles, a 40% chance of exceeding the whole-body PAG doses at ten miles. Similarly, given a core melt accident, there is a near 100% chance of exceeding the 10-rem thyroid PAG dose at one mile, about an 80% chance at ten miles, and about a 40% chance at 25 miles. Based in significant part of these observations, the Task Force recommended that EPZs of 10 miles be established for the plume exposure pathway and 50 miles^{19/} for the injection exposure

17/ Collins, et al., supra note 3, at 3.

18/ Office of Radiation Programs, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, U.S. Environmental Protection Agency, EPA-520/1-75-001, September 1975, Revised June 1980, page 2.5.

19/ Collins, et al., supra note 3, at 1-41 and 1-43.

pathway.^{20/}

Q. Please describe how NUREG-0396 is related to the NRC's emergency planning regulations.

A. (Sholly) In October 1979, the Commission endorsed a policy of having a "conservative emergency planning policy in addition to the conservatism inherent in the defense-in-depth philosophy," and stated that a 10-mile plume EPZ and a 50-mile injection EPZ should be established around each nuclear power plant.^{21/} Subsequently, these EPZs were codified in the NRC emergency planning rule when the final rule was adopted in 1980.^{22/} Indeed, NUREG-0396 is explicitly referenced in the final rule.^{23/}

NUREG-0654, which provides detailed guidance for the preparation and evaluation of radiological emergency plans for nuclear power plant accidents, also references the NUREG-0396 report. NUREG-0654 states that the 10-mile radius plume EPZ was based primarily on four considerations:^{24/}

^{20/} Id. at 1-37, 1-41, and 1-43.

^{21/} Federal Register 61123, 23 October 1979.

^{22/} Federal Register 55402, 55406, 55411, 19 August 1980.

^{23/} 10 CFR Part 50, Appendix E, Section 1, fn 2.

^{24/} U.S. Nuclear Regulatory Commission and Federal Emergency Management Agency, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654, FEMA-REP-1, Rev. 1, November 1980, page 12.

- a. projected doses from the traditional design basis accident would not exceed Protective Action Guide levels outside the zone;
- b. projected doses from most core melt accidents would not exceed Protective Action Guide levels outside the zone;
- c. for the worst core melt accidents, immediate life threatening doses would generally not occur outside the zone;
- d. detailed planning within 10 miles would provide a substantial base for expansion of response efforts in the event that this proved necessary.

Quite clearly, two of these four considerations (i.e., considerations "b" and "c", above) are derived from the NUREG-0396 evaluation of doses from core melt accidents (which is based on the Surry analysis in WASH-1400). In addition, NUREG-0654 guidance on the timing and duration of releases and radiological characteristics of the releases is also derived from the NUREG-0396 evaluation of core melt accidents (which is based on the Surry analysis in WASH-1400).

VII. CONCLUSION REGARDING THE TECHNICAL BASES FOR EMERGENCY PLANNING

Q. What is your conclusion concerning the degree to which the NRC's emergency planning requirements are based on the analysis of Surry in WASH-1400?

A. (Sholly) It is evident, based on the above, that the current planning basis in NRC emergency planning regulations for nuclear power plants is substantially based on dose/distances insights derived from the risk assessment of

Surry performed in WASH-1400. Thus, the "spectrum of accidents" which were considered in establishing the EPZ distances in the NRC emergency planning rules explicitly included core melt accidents (up to and including those core melt accidents which were predicted to result in early containment failure and a large radiological release to the environment). A site-specific analysis which examines dose-distance relationships based on similar accidents would therefore provide useful information concerning the effectiveness of offsite emergency planning measures for the Seabrook site.

Q. Have you reviewed the release categories utilized by Dr. Jan Beyea in his calculations as set forth in his testimony in this proceeding?

A. (Sholly) Yes.

Q. Are the release categories utilized by Dr. Beyea consistent with the spectrum of releases utilized by the NRC in setting the technical basis for the emergency planning zones?

A. (Sholly) Yes, Dr. Beyea's release categories are very similar to the PWR-1 through PWR-9 release categories utilized in the NUREG-0396 report, which sets forth the technical basis for the NRC's emergency planning zones.

Q. Does this conclude your testimony?

A. (Sholly) Yes.

VIII. RADIATION RELEASES FROM REPRESENTATIVE ACCIDENTS WITHIN THE PLANNING SPECTRUM

Q. Dr. Beyea, before presenting the results of your calculations, describe in general terms how radioactive material is released to the environment and dispersed.

A. (Beyea) For a large release of radioactive material to occur following an accident, a "release pathway" from the reactor core to the environment is required. (See testimony of Steven Sholly.) One set of these pathways is generated by failure of the reactor's pressure vessel followed by failure of the containment building surrounding the vessel due to overpressurization. Researchers have outlined some, though not all, possible sequences and conditions for these failures.

Other pathways include releases occurring through a containment penetration system. Massive steam generator failure due to aging steam generator tubes might lead to a large release through the secondary cooling system. A so-called check-valve failure could connect the containment directly to the environment.

If a large release of radioactive material to the environment occurs, the material will leave the reactor as a "plume" of gases, aerosols and water droplets. Most of the large releases discussed in our testimony are assumed to occur over a period of thirty to sixty minutes; a few are assumed to take longer.

This escaping plume will rise to a height which is dependent on such variables as 1) the amount of heat released in the accident, 2) the weather condition existing at the time, and 3) whether or not the release takes place at the top or bottom of the structure. As will be shown later, there is no satisfactory formula that predicts the magnitude of plume rise.

The plume will be carried by the prevailing wind. Under the action of wind fluctuations and other weather conditions, the plume will spread in both the horizontal and vertical directions, so that the average concentration of radioactive material in the plume will decrease with time as it travels away from the reactor. (See Figure I). After a short time, the expanding edge of the plume will "touch" ground, and the non-gaseous radioactive aerosols will be dispersed along the ground, on vegetation, buildings, cars, people, etc. The rate at which material is removed from the plume, referred to as the deposition rate or "velocity", will also cause the concentration of material in the plume to decrease with time.

For the most energetic release categories, particularly the steam explosion categories which cause rapid rise of gases into the atmosphere, there is the possibility that escaping water vapor may condense to significant amounts of (radioactive) rain.

The plume may disperse radioactive material along the ground for more than a hundred miles if there is no reversal of wind direction. Much of the area where the plume has passed

will be contaminated for decades and "permanent" evacuation of the original population will be required there. In addition, as much as 10 percent of the material will be resuspended by the action of wind and blown about in succeeding weeks.^{25/} The area of contamination will increase, causing residents who live outside the initial plume path to be exposed to radiation.

Immediately after the release, the plume will be visible, due to the escape of large amounts of cloud-forming water droplets. As the plume travels downwind and as the water droplets evaporate, the plume will most likely disappear from view, making it impossible for anyone without instruments to know where radioactivity is heading.

Q. How does the population receive radiation doses?

A. The population in the area under the plume would receive most radiation doses via three dose pathways.^{26/}

(See Figure II):

- 1) From external radiation received directly from the radioactive plume itself. (In the

^{25/} U.S. Nuclear Regulatory Commission, Reactor Safety Study, (Washington, D.C., WASH-1400 or NUREG-75/014, 1975).

The Reactor Safety Study assumed a 50 percent retention rate for radioactivity deposited on vegetation. [See Appendices E and K] Although most of this loss is probably caused by subsequent rain, experimental data indicates that removal begins immediately after deposition. This initial loss must be due to wind action. Ten percent removal by wind seems a reasonable estimate.

^{26/} See Volume VI of WASH-1400, supra.

most serious accidents, the main part of the plume is projected to pass by very quickly, within one half to one hour, well before any significant evacuations of beach populations could occur.)

- 2) From radiation received following inhalation. The inhalation pathway would be the most important contributor to the thyroid dose. It could also be the major contributor to early health effects for accident sequences in which large quantities of ruthenium are released (PWR-1 type releases), i.e. steam explosion or high-pressure melt ejection.
- 3) From radiation received from material deposited on the ground or other surfaces (cars, skin etc.). It is this "ground dose" which would usually be the most important contributor to early fatalities because it would continue after the plume has passed. Even if evacuation is too slow to prevent inhalation of radiation, evacuation is still needed after the plume passes by to stop the accumulation of "ground dose"; the faster the evacuation, the lower the total "ground dose".

We have concentrated on these three pathways in our testimony, using standard methodology to calculate doses whenever

possible. Because generic models do not consider beach situations, it was necessary to make special calculations for contributions to ground dose not normally considered in accident computer codes, but which are of special concern to unshielded beach populations. For instance, beach users caught in the plume would likely receive significant doses from radioactivity deposited on their skin and hair.

Other important dose pathways exist for persons not under the original plume. These include inhalation and ground dose from resuspended and redeposited radioactivity. (As has been stated earlier, as much as 10 percent of the plume's material may be resuspended within a few weeks.)^{27/} Also of concern is radiation from contaminated vehicles and personal possessions brought to emergency reception centers. Finally, doses are also possible through ingestion of contaminated food or water.

Q. In what units are doses measured?

A. (Beyea) Doses to organs or to the whole body are measured in "rems," an indication of the amount of biologically-damaging energy absorbed by tissue or bone. The units are useful because a dose in rems can be used to project the likelihood that an exposed person will be injured.

^{27/} WASH-1400, supra.

Q. What are the dose levels that enter into your calculations?

A. (Beyea) The health consequences of radiation depend upon the magnitude of the dose received. Radiation doses to the whole body on the order of 100 rems or higher --doses that occur relatively close to the plant--may lead to immediate sickness (e.g., nausea) and "early death." At a dose of 125 rems for example, 50 percent of exposed persons would suffer from nausea.^{28/}

Although not fatal by itself, nausea and vomiting should be considered in emergency planning--especially in estimating evacuation times. It is quite conceivable that outbreaks of nausea could precipitate panic in an evacuating population, thereby interfering with an orderly escape.

"Early death," a technical term in the radiological health field, refers to death within sixty days of exposure to a given dose. The threshold for early deaths is between 100 and 200 rems to the whole body, while the probability of early death increases with increasing dose and changes with "supportive" medical treatment.^{29/} In accordance with standard practice,

^{28/} See Volume VI of WASH-1400.

^{29/} In this proceeding, we do not testify as expert witnesses in the biological effects of radiation. Instead, we have relied on standard references to convert doses to health effects.

"Supportive" treatment is defined in the Reactor Safety Study Appendix VI, as such procedures as reverse isolation, sterilization of all objects in patient's room, use of laminar-air-flow systems, large doses of antibiotics, and transfusions of whole-blood packed cells or platelets.

we have taken 200 rem as a reference dose to indicate the onset of significant probability of early death.

Q. How have you modelled the plume movement and dose pathways?

A. (Beyea) The plume movement and the three major dose pathways^{30/} discussed previously have been modelled by us in several computer programs. The programs have been checked against other consequence codes in use around the world.^{31/} The original programs have been cited in other reports,^{32/}

^{30/} The major sources of radiation that contribute to early death or delayed cancer are inhaled radioiodine, as well as external radiation (whole-body gamma) from the plume and from contaminated ground. In the case of PWR1 releases, there are situations where inhaled isotopes such as ruthenium can cause pulmonary syndrome, leading to early death.

^{31/} International Exercise in Consequence Modelling (Benchmark Study), sponsored by the Organization of Economic Cooperation and Development (O.E.C.D.), Nuclear Energy Agency, 38 Boulevard Suchet, 75016 Paris, France.

^{32/} Jan Beyea, Program BADAC-1, "Short-Term Doses Following a Hypothetical Core Meltdown (with Breach of Containment)" (1978), prepared for the New Jersey Department of Environmental Protection.

Jan Beyea and Frank von Hippel, "Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island," report to the President's Council on Environmental Quality, Center for Environmental Studies, Princeton University, (1979), Appendix E.

A detailed discussion of the basic dose calculations used in these programs can be found in the Appendices of "A Study of the Consequences of Hypothetical Reactor Accidents at Barseback," Jan Beyea (Stockholm: Swedish Energy Commission, 1978).

(footnote continued)

while some modifications have been made for this study.^{33/}
It was not necessary for these proceedings to use our most recent set of programs which directly include time-varying weather such as changing wind speed and changing turbulence. In the Seabrook beach case, doses are so high that these smaller probability events do not dominate the risk.

The dose to the population caught directly in the plume for the release categories under consideration has been calculated by these programs as a function of time after release for a range of weather conditions and for a range of model parameters. Ranges of model parameters were used because the appropriate values of parameters are currently uncertain.

The basic modelling used is similar to the approach taken by radiological protection agencies around the world, including the Nuclear Regulatory Commission and the New Hampshire Department of Public Health.^{34/}

(footnote continued)

Brian Palenik and Jan Beyea, "Some Consequences of Catastrophic Accidents at Indian Point and Their Implications for Emergency Planning," direct testimony on behalf of New York State Attorney General, Union of Concerned Scientists (UCS), New York Public Interest Research Group (NYPIRG), New York City Audubon Society, before NRC Atomic Safety and Licensing Board, July, 1982.

^{33/} For this study, we have used appropriate dose scaling factors, as discussed in detail later, to include dose contributions from material deposited directly on the cars and skin of evacuees.

^{34/} D.V. Pergola, R.B Harvey, Jr., J.G. Parillo, "SB Metpac, A Computer Software Package Which Evaluates the Consequences of an Off-Site Radioactive Release Written for the Seabrook Station Site at Seabrook, New Hampshire" (Yankee Atomic Electric Company, Framingham, Mass., May 1986).

The only specialized aspects of our calculations involve the following:

- 1) Radiation shielding: Radiation shielding factors for cars used in the 1975 Reactor Safety Study have been updated to account for changes in car construction that have been made to improve fuel economy in the intervening years.
- 2) Accounting for dispersion over water. Certain beach sites, like Seabrook, have water between them and the reactor. We have made adjustments for decreased dispersion using standard methodology.^{35/}
- 3) Radioactivity deposited on vehicle surfaces: In some of our calculations, we have accounted for radioactivity that would be deposited on cars caught in the plume. This radioactivity could cause a significant dose to riders and should not be ignored.
- 4) Radioactivity deposited on the skin and clothing of beach-goers: In some of our calculations, we have accounted for radioactivity that would be deposited on beach occupants while standing either on the beach, in parking lots, or outside their cars waiting for traffic to move. Although not generally a major

^{35/} In such a case (Seabrook Beach), we have shifted dispersion parameters by one stability class. See footnote 39.

effect to be considered at other sites, we have found that the dose from skin contamination is significant at Seabrook because of the large beach population that could be caught outdoors.

Because doses from contaminated skin and vehicles have not to our knowledge been considered in past consequence modelling, our calculations have been presented with and without their inclusion. Their impact is to increase, in comparison to other sites, the number of meteorological conditions during which early death would occur.

Q. In what ways have your calculations taken into account the uncertainties in the current state of consequence modelling?

A. (Beyea)

Plume Rise

The treatment of plume rise due to thermal buoyancy illustrates the current uncertainty that exists in dose calculations due to inadequate knowledge of model parameters. Since calculated doses can be very sensitive to whether or not the edge of the plume has "touched" ground, knowledge of the initial rise of the plume can be critical for projecting doses. Yet, lack of understanding, both experimental and theoretical, about plume rise makes prediction of this parameter difficult.

Figure III shows the enormous range in airborne concentration of radioactivity (and therefore inhalation and ground doses) predicted for the same release of radioactivity

by modellers from different countries under one set of weather conditions.^{36/} Most of this range arises because of different predictions of plume rise. These results from the international exercise in consequence modelling demonstrate that dose predictions from a particular computer code may be highly uncertain within about 20 miles from the reactor if based on one set of model parameters. (Output from the computer codes used to develop our testimony were included in this consequence modelling exercise.)

If a range of weather conditions is examined, the range of doses predicted by different computer codes shows much less of a spread. It is for this reason that we considered a range of weather conditions in this study rather than relying exclusively on predictions using one set of model parameters. The dose ranges used in our testimony fall well within the full range given in Figure III.

At Seabrook, plume rise is a critical issue only for the PWRI-type releases. The other releases are not characterized by sufficient thermal bouyancy to make it an issue.

^{36/} Figure III has been taken from S. Vogt, CNSI Benchmark Study of Consequence Models, International Comparison of Models Established for the Calculation of Consequences of Accidents in Reactor Risk Studies, Comparison of Results Concerning Problem 1. SINDOC(81) 43.

Deposition Velocity

A range of deposition velocities has not been examined in this testimony. (Deposition velocity governs the rate at which radioactive material deposits on surfaces). Like plume rise, this parameter is also uncertain, but does not have a critical impact on any of our calculations. For simplicity we have used a mid-range value of 1 cm/sec.^{37/}

Sea Breezes

Because of the complexity involved in modelling sea breezes, we have treated them qualitatively. To obtain an understanding of the sea breeze phenomenon, it is useful to begin with a simple case, where the inland wind speed is very low. A circulating cell structure would result from daytime heating of the land, extending many miles over both land and water.^{38/}

In this example, the wind would blow toward the reactor away from the beach, yet radioactivity would still reach the beach for either low-rising or high-rising plumes, as radioactivity became entrained in the cell and circulated within it. However, in this scenario, because it would take several hours for the radioactivity to reach the beach, it is

37/ A complete discussion of this parameter can be found in the Barseback Study, supra.

38/ C.S. Keen, "Sea Breezes in the Complex Terrain of the Cape Peninsula," in Third Conference Meteorology of the Coastal Zone (American Meteorological Society, Boston, Mass., January 1984, pp. 129-134).

not possible to say, without detailed study, whether or not the radioactivity would arrive before the beach goers had left.^{39/}

In many other sea-breeze cases, the inland wind would be too strong to ignore. The resulting structures can be very complex, either causing plumes to rise above the beach and reduce doses or to slow plumes down, producing higher doses. If the inland wind is very strong, it will eliminate the cell structure entirely or drive it offshore.

In general, turbulence at the beach should increase under sea breeze conditions, leading to the possibility that above-ground plumes will be brought quickly to the ground (fumigated) once the region of excess turbulence has been reached.

The possibility must be considered that a moisture-laden plume could produce its own rain, following rapid mixture with cold, turbulent sea air that would be filled with salt particles capable of nucleating water droplets. Rain would be

^{39/} W.A. Lyons, "Lectures on Air Pollution and Environmental Impact Analysis," American Meteorological Society, Boston, Mass., 1975. See also, S.J. Mass and P.R. Harrison, "Dispersion Over Water: A Case Study of a Non-Buoyant Plume in the Santa Barbara Channel, California," in Joint Conference on Applications of Air Pollution Meteorology, Nov. 29-Dec. 2, 1977 (American Meteorological Society, Boston, Mass., pp. 12-15). See also, S. Barr, W.E. Clements, "Diffusion Modeling: Principles of Application," in Atmospheric Science and Power Production, (Report DOE/TIC-27601, Department of Energy, Washington, D.C., 1984, p. 613).

extremely serious for the beach goers, because unusually large amounts of radioactivity would be carried to ground level along with the drops.

In considering the various meteorological combinations that could occur, it is possible to find some conditions that increase doses at the beach and some conditions that decrease doses--sometime during the course of the same day.

In light of this variation, we have assumed that our calculations without sea breeze effects represent a mid-range case.

Q. What are the characteristics of the release types you have considered and why have you chosen to use them?

A. (Beyea) Because the number of possible accident sequences is very large, it would be prohibitive to perform consequence calculations for every possibility. Instead, following standard practice, we have picked surrogate release categories that are intended to span the range of possibilities. As mentioned in the summary, releases have been chosen that generally fall into the release categories used in NUREG-0396, but which take into account site-specific differences. The basic reference documents utilized relating to site-specific accident sequences at the Seabrook Plant are 1) the Licensee's Seabrook Probabilistic Safety Assessment (PSA),^{40/} and the review of the PSA carried out by analysts

^{40/} Pickard, Lowe and Garrick, Seabrook Station Probabilistic Safety Assessment, 6 volumes, December, 1983.

at Brookhaven National Laboratories for the NRC.^{41/}

In our study, we have generally accepted the Brookhaven recommendations, although for completeness we have considered some PSA categories without modification. In such cases, we have included them as part of our generic release categories.

In the release categories used for our testimony, we have picked one specific sequence to define the release magnitude for each category. However, it is important to bear in mind that the probability of the category is not the probability of the specific accident analyzed. The true probability is the sum of the probabilities of all accident sequences, known or unknown, that have similar release magnitudes.

1. Category 1 (PWRI-type): Early Containment Failure with Core Oxidation. This category is represented by an "S1" sequence as defined in the Seabrook (PSA). Also included in this category is a high-pressure melt ejection sequence.

One of the questions raised by the Brookhaven review of the PSA concerns the assumed rate at which heat would be released during an accident--a variable which governs plume rise. The PSA assumes uniformly high values. In particular, for the S1 case, the PSA assumes such a high release of thermal energy that the plume passes high overhead, causing relatively low doses to the beach population, according to

^{41/} M. Khatib-Rahbar, A.K. Agrawal, H. Ludewig, W.T. Pratt, "A Review of the Seabrook Station Probabilistic Safety Assessment: Containment Failure Modes and Radiological Source Term," Brookhaven National Laboratory, Upton, Long Island, prepared for U.S. NRC, draft, September, 1985.

U.S. Nuclear Regulatory Commission, Reactor Safety Study, (Washington, D.C., WASH-1400 or NUREG-75/014, 1975).

conventional consequence models. As indicated by Gordon Thompson (at p. 76 *infra*) it will not be possible to resolve this discrepancy since a large range of heat rates is possible, depending on the dynamics of the accident. Because the Brookhaven assumption on heat rates represents a mid-range value in the spectrum found by Thompson, we have used it in our calculations of doses from SI releases, recognizing that the actual doses could be significantly higher or lower.

2. Category 2 (PWR2-type): Severe Containment Bypass. We include in this category an "S6V-total" sequence as defined by analysts at Brookhaven. In this release category, a direct pathway to the atmosphere is opened as a result of containment bypass. 43% of radioiodine, 43% of radiocesium, and 40% of radiotellurium in the core are projected to escape.

In addition to the "interfacing systems accidents" used to define this accident in the PSA, we include in this category thermally-induced steam generator tube failures.

We also specifically analyze the PWR2 release overpressurization scenario utilized in the Reactor Safety Study and NUREG-0396. Note that this release category is generally similar to the preceding rapid bypass category represented by S6V-total.

3. Category 3 (PWR3-type) Slow Containment Bypass. The Seabrook PSA modelled a containment bypass release as a "puff" release in which radioactivity is assumed to escape at different times, for periods of varying duration. We refer to this release category in the Tables with the notation used in the PSA to label the first and most dangerous puff (S6V-1).

Brookhaven, in its review of the PSA assumed radioactivity would be assumed to escape over a period of one hour. For our testimony, we have made consequence calculations using both sets of assumptions. S6V-total in Category 2 represents the Brookhaven approach; S6V-1 in Category 3 represents that taken in the PSA.

4. Category 4: (PWR4-PWR9 -types) The less severe accidents utilized in NUREG-0396 are grouped in this category. Although such accidents can cause doses in excess of protective action guidelines and can increase delayed cancer risks in exposed populations, they are not generally projected to lead to early health effects.

A summary of the characteristics of the first three release categories is given in Table 1.

Q. What special characteristics around Seabrook affect the consequences of a release there?

A. (Beyea) Our investigation of the consequences of releases of radioactivity at Seabrook concentrates on the summer months. The potential consequences, especially with respect to early death from a serious accident at the Seabrook plant, increase greatly during these months due to a large summer population in the area. These summer residents, day visitors, etc. increase the exposed population, and by increasing the evacuation time necessary to clear the area, they increase the potential time exposure. Furthermore, the consequences to a beach area population may be greater than the consequences to an inland population under similar conditions due to a lack of shielding normally provided by buildings. The addition of increased consequences due to material deposited directly on the skin of a beach population must also be considered for the Seabrook plant. Taken together, these factors make summer release scenarios at Seabrook worthy of

special consideration, and we have included them in our investigation of the potential consequences of accidents at Seabrook.

Figure IV shows the location of the Seabrook beaches.

It should be noted that for the most severe accident categories considered, as will be discussed below, doses are so far above threshold for overcast conditions, that early deaths are possible at any time of the year. Nevertheless, the number of people who would die would increase greatly during the summer. Furthermore, intermediate accidents--those that would usually not cause early deaths--would be expected to cause early deaths at the beaches. In other words, during the summer, there is a much wider spectrum of accidents that can cause early fatalities.

Q. What are the assumptions behind the evacuation times you have used?

A. (Beyea) At some point during the operation of a reactor, the nuclear facility operator (NFO) may notify the appropriate state and local officials of an "unusual event," an occurrence that may lead to an eventual release of radioactivity. Depending on the seriousness of the event or of following events, a higher emergency level may be reached. The NFO may eventually recommend, in consultation with officials and technical support staff, that an evacuation is necessary of all or part of the surrounding population. The appropriate

local officials, who may or may not have received prior warning, are then notified, and the emergency warning system will presumably be activated as soon as possible.

Time elapses between an initial indication to the operator and the moment state and local officials begin notification of the population. CONSAD (a consulting firm to FEMA) estimated this time to take 19-78 minutes during the day and 50 minutes at night. ^{42/} Their review of historical data shows these kinds of estimates can range from one to many hours for a range of natural disasters and false alerts. Our work here assumes 45 minutes. In addition, some time will be needed to actually notify the population that an evacuation is needed. We take 15 minutes for this time, so that evacuation is assumed to begin one hour (45 plus 15 minutes) after the decision is made to evacuate.

We also assume that the NFO receives an indication of a pending release before the release. This warning time is taken as 18 minutes for a steam explosion, one hour for a rapid containment bypass (S6V-total), one hour for a PWR-2 release, and 1.7 hours for a slow containment bypass (S6V-1). These are the assumptions made by the analysts (Brookhaven, Seabrook PSA, Reactor Safety Study) who devised the release categories

^{42/} CONSAD Research Corporation, "An Assessment of Evacuation Time Around the Indian Point Nuclear Power Station," June 20, 1980; revised June 23, 1980, p. 2.7-2.9.

studied. When the one hour delay involved in starting the actual evacuation is accounted for, the results are as follows.

Steam explosion: evacuation starts 42 minutes after radioactivity begins escaping.

PWR-2 and rapid containment bypass (S6V-total): evacuation starts at the same time as radioactivity begins to escape.

Slow containment bypass (S6V-1): Evacuation starts 42 minutes before radioactivity begins to escape.

The evacuation time estimates themselves are based on assumptions about conditions during the evacuation, the state of readiness of an evacuation system, etc. These assumptions vary, leading to differences in evacuation times. The evacuation times for five earlier studies of a Seabrook area evacuation are listed in Table 2. Some of the evacuation times in the table for a two mile radius (and five mile radius) appear to be for a selective evacuation from within that radius. We have used five hours as a representative estimate for beach site evacuation.

Current emergency plans at Seabrook call for notification of beach populations at an earlier stage in an accident than for the general population. However, for PWR1-PWR3 categories, there is doubt as to how much time would actually be gained by this procedural modification. Although we have not taken credit for extra warning time to the beach population, our results can be easily modified to do so. It is only necessary to relabel the evacuation time assigned to our tables. In

other words, if beach populations are assumed to begin evacuating 15-minutes earlier than normal, the equivalent evacuation time in our calculations would be 5 hours minus 15 minutes, not 5 hours.

According to testimony by Thomas Adler in this proceeding, actual evacuation times from the contaminated area would be much, much longer. Some of the persons exposed in an accident will therefore likely receive larger doses than presented in our tables. Our tables, therefore, lead to conservative estimates of the numbers of persons exposed to possible early death.

Q. Is the population around Seabrook subjected to possible "early death" for releases during the summer?

A. (Beyea) We have investigated the conditions under which the nearest beach population, at 2 miles and 4 miles, might be exposed to doses at a threshold level for early death (200 rem) for the release categories discussed previously. According to standard references (see Moeller, et al.)^{43/} At 200 rem, a few percent of exposed persons would die within a two month period, a few percent of women under 40 would be

43/ J.S. Evans, D.W. Moeller, D.W. Cooper, "Health Effects Model for Nuclear Power Plant Accident Consequences Analyses," (U.S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-4214, 1985) The "LD50" for nausea is given as 1.4 Gy in Table 1.3, page II-29. 1.4 Gy equals about 125 rem.

Biological Effects of Ionizing Radiation, National Academy of Sciences, Washington, D.C., 1980.

permanently sterilized, and a few percent more would develop cataracts. Table 3 illustrates some of our findings for 2 miles. Weather stability class, wind speed, and the time it would take for the beach population to receive a 200 rem dose under those conditions are listed.

We have found these estimates for two sets of assumptions. The first set assumes that all the population is inside cars when the release occurs so that skin and clothes do not get contaminated. Doses are also reduced because of the partial shielding provided by the car from the radioactivity on the ground. The fractional decrease in dose from shielding, here referred to as a "dose scaling factor", is calculated to be .53-.78 for this set of assumptions. The time it takes for a person in a car waiting within the plume to receive a 200 rem dose is then listed in the table. We assume that vehicles remain stalled in traffic within contaminated ground and then move rapidly out of the area once the roads are cleared at the end of five hours. We also assume that a person once evacuated receives no additional dose once outside the plume path.

On the basis of our consideration of a Seabrook-type evacuation, we have decided to also use a second set of assumptions. Some of the population will not have reached their vehicles before plume passage. (Maguire, for example, assumes up to an hour for the beach population to "mobilize"

to specific problems at the request of governmental and non-governmental bodies around the world. I have written major reports on the safety of specific nuclear facilities for the President's Council on Environmental Quality (TMI reactor), for the New York State Attorney General's Office (Indian Point), for the Swedish Energy Commission (Barsebeck reactor), and the state of Lower Saxony (Gorbleben Waste Disposal Site). I have also examined safety aspects of specific sites for the California Energy and Resources Commission, the Massachusetts Attorney General's Office and the New York City Council.

While at Princeton, I wrote a computer program useful for reactor emergency planning for the New Jersey Department of Environmental Protection. This program, appropriately modified, has been used for some of the calculations presented in this testimony.

After joining the National Audubon Society, I continued to work as an independent consultant on nuclear safety issues. I participated in a study, directed by the Union of Concerned Scientists at the request of the Governor of Pennsylvania, concerning the proposed venting of krypton gas at Three Mile Island. The U.S.C. study, for which I made the radiation dose calculations, was the major reason the Governor gave for approving the venting.

I participated in the international exercise on consequence modelling (Benchmark Study) coordinated by the Organization for Economic Cooperation & Development (O.E.C.D.). Scientists and

doses below 200 rem for an S6V-Total release. On the other hand, the first of the evacuees to leave during an S6V-1 release would escape a 200-rem dose.

If the time to reach a 200-rem dose shown in the tables is compared with a 5-hour evacuation time, one arrives at a "yes/no" indication of whether or not the population at 2 miles is exposed to risk of early death. This is noted in the last set of columns in each table.

Some of the entries are marked with a question mark. A question mark indicates that even though doses do not reach the 200-rem early death threshold, the 100-rem threshold for nausea has been reached early in the evacuation. In such cases, a 5-hour evacuation time calculated from traffic models may be optimistic. Because we were unable to determine a quantitative estimate of the likely delay in evacuation that would result from cases of nausea, we have not been able to do more than indicate uncertainty.

Note that no entries are shown in the Tables for a PWR-2 release. The results turned out to be so similar to, or worse than, the SV6-total release that it was not necessary to include separate entries.

Several caveats about the tables should be kept in mind, especially when exposure of the population is indicated. First of all, risk of early death is much higher for persons very close to the plant where doses reach high levels very rapidly.

Second, we have not looked at slower wind speeds for the various stability classes nor have we examined changing weather conditions. Both of these situations can lead to higher doses. Thus, Tables 3 and 4 do not include the worst possible weather conditions but only the most probable.

A third caveat is that, while D conditions generally represent overcast days, we have not looked at actual precipitation conditions that sometimes catch populations on the beach. The time for a dose to reach 200 rem is greatly decreased in this case (for the same wind speed) due to the increased deposition of radioactive material. Evacuation time is also increased.

On the other hand, overcast conditions in the morning would deter people from coming to the beach. The lower populations would mean reduced clear time estimates. Recall, however, that there is a multi-hour underestimate of clear times in our work for most of the beaches (see Adler). In any case, doses tend to be so high under D-conditions for the S6-V total release that reduced clear times are insufficient to provide protection. The same is true for the S1 release for low thermal release rates and low plumes rise.

Finally, it should be emphasized that the population's exposure may be increased if the shown evacuation times are, for whatever reason, longer than assumed here.

In any case, the results of Tables 3 and 4 can be combined with weather frequency data (Table 15) to show that for the S6V-total release which represents the severe-containment-bypass categories, if the 2-mile beach population is downwind, it will be exposed to risk of early death under meteorological conditions that would be expected to occur about 70-75% of the time.

In contrast, the results in Tables 3 and 4 for the slow-containment-bypass release, S6V-1, indicate that the population at 2 miles is generally not exposed to early death for this release.

Surprisingly, the S1-steam-explosion release, which represents the largest release of all, in some circumstances might cause fewer problems for the beach population at 2 miles than the PWR-3 type release. The reason for this is that the projected plume rise may be so great, as occurred at Chernobyl, that the plume passes high over the nearby populations. We estimate a 50-percent chance that this will be the case for A, B and C stability conditions and a 75-percent chance during D conditions. Our rationale is that the height to which any radioactive plume rises is uncertain, as was discussed earlier.

Should the true plume rise be a factor of two less than the mid-range value predicted by standard plume rise formulas, which is within the range of uncertainty (see Fig. 5), early

deaths from external gamma exposures become frequent for A, B, and C stability classes. It should also be borne in mind that the PWR-1 releases are projected to include copious amounts of isotopes that can give high lung doses. Thus, 1-day lung dose can contribute to early death when whole body dose is below 200 rem.

When these factors are all included, the combined uncertainty is so broad that it is a toss up (50%) as to whether or not early deaths would occur following an S1 release for A, B, and C stability classes. As for D-stability class, two independent events must conspire to produce early deaths: both the heat rate must be low and a low plume rise formula must be correct. As a result, we estimate that there is a 25% chance that doses will exceed 200 rem to the whole body or the equivalent 1-day lung dose under D-stability class for this release.

It should also be recognized that a real accident may be less severe than the S1-case assumes. Paradoxically, because of lower plume rise, a small breach of containment following a steam explosion could be more severe than a large breach as far as nearby populations are concerned.

Finally, it should be borne in mind that turbulent interaction with the sea breeze and/or condensation of radioactive rain could bring radioactivity down to ground level. An enormous amount of radioactivity would be passing

overhead; even a relatively weak meteorological process, one normally not considered in reactor accident dispersion modelling, could couple the upper air with air at ground level, causing high doses.

Note that we have not shown results for release classes PWR4 through PWR9. Although these releases can cause doses in excess of protective action guides, they rarely lead to doses in excess of 200 rem. Doses for those categories are dominated by noble gases, so that ground deposition can be ignored. As a result, the dose ends after plume passage. Without effective sheltering, the only emergency measure that has any impact on doses for these release classes is pre-plume evacuation.

IX. RADIATION DOSES FROM REPRESENTATIVE ACCIDENTS WITHIN THE PLANNING SPECTRUM

Q. How were your dose scaling factors obtained?

A. (Beyea) The basic dose scaling factor, with car and skin deposition ignored, was calculated to have a range of 0.53-0.78, assuming that an evacuee is inside a car in the plume deposition area. This range represents an updating of the 0.4-7 shielding factor range used in the Reactor Safety Study (WASH-1400). Cars are lighter today (and will be more so in the future) compared to the 1975-vehicles analyzed in the Reactor Safety Study. Assuming that vehicles involved

in an evacuation will be 30% lighter than 1975 vehicles,^{45/} the appropriate shielding factor range turns out to be 0.53-0.78^{46/}

The relative contribution of various doses, including car and skin deposition doses, can be obtained as follows.

Dose per unit time (Relative to dose from a flat, contaminated plane):^{47/}

- | | |
|--|-------------------------|
| A) to person standing on contaminated beach, parking lot, road, etc. | 1.0 X Sg ^{48/} |
| B) Dose inside car from contaminated ground | 1.0 X Sc ^{49/} |

^{45/} Due especially to the decrease in the amount of steel used in U.S.-built cars, the material weight of U.S. cars dropped 15% between 1975 and 1981 and is projected to drop another 15% by 1985. (Table 4.3, p. 122, Transportation Energy Data Book, edition 6, G. Kulp, M.C. Holcomb, ORNL-5883 (special), Noyes Data Corporation.)

^{46/} Shielding varies exponentially with mass per unit area. Thus $(.4)^{.7} = 0.53$; $(.7)^{.7} = 0.78$.

^{47/} In the absence of detailed calculations, we assume that absorption effects in air can be handled by neglecting all absorption at distances less than 100 meters and by treating absorption beyond 100 meters as total. Thus, we replace the exact problem of a contaminated plane of infinite extent by a finite circular surface of radius 100 meters. Since the integral over the disk turns out to be logarithmic with radial distance, the total dose is insensitive to the cutoff distance chosen. These calculations are conservative since they ignore ground scattering effects which increase relative doses from deposition close to the receptor.

Deposition is assumed to proceed uniformly on any external surface regardless of the surface's orientation. Thus, a square centimeter of ground is assumed to receive the same contamination as a square centimeter of skin.

^{48/} Shielding factor, Sg = 0.47-0.85. See footnotes 26 and 60.

^{49/} Shielding factor, Sc = 0.53-0.78. See footnotes 26 and 60.

C) Dose inside car from radioactivity deposited on outside of vehicle	.22 X Sc 50/
D) Dose inside car from radioactivity deposited on inside of vehicle with open windows	.04 -.251/
E) Dose from skin contaminated while outside vehicle	.3552/
F) Dose from skin contaminated while inside vehicles with open windows	.1753/

50/ Based on numerical integration over an idealized automobile, deposition is assumed to take place on the underside of the vehicle as well as on the top surface.

51/ This case would occur 1) if windows had been left open, or 2) if evacuees reached their vehicles and opened windows before plume passage were complete.

The low number corresponds to low wind speeds; the high number corresponds to high wind speeds.

52/ An estimate of the relative contribution of skin contamination to the total dose can be obtained by replacing the complex shape of the human body with a set of bounding geometric surfaces:

- 1) sphere: the dose rate at the center of a sphere contaminated with N curies of radioactivity per square centimeter is 43% of the dose rate 1 meter above a circle of 100 meter radius that has also been contaminated with N curies per unit area.

Although a cylindrical model would be more accurate, the results will not differ by a large amount, as shown below.

- 2) right circular cylinder: numerical integration in the case of a cylinder with radius 1/10th of the length indicates that the average centerline dose is approximately 17% greater than the sphere center dose discussed previously. For a cylinder with radius 1/5th of the length, the average centerline dose is slightly less than the sphere case.

The results of these rough calculations suggest that direct contamination of people must make a significant contribution to the total dose. We take the numerical relationship to be 35%, that is, the skin contribution is assumed to be 35% of the dose from contaminated ground.

53/ We take this dose to be half of the value for a person standing in the open, assuming that half of a person's surface area is pressed against a seat and, therefore, not subject to deposition.

The total dose can be obtained by multiplying each of the above dose components by the amount of time spent under each set of conditions. Unfortunately, there are a number of time parameters that must, in principle, be specified to calculate a dose precisely. Rather than make a complex model, we have chosen to simplify the calculations by ignoring a number of effects that should tend to cancel:

- 1) We ignore the finite duration of the plume, that is, we assume radioactivity is deposited instantaneously. This is equivalent to adding 30 minutes to the evacuation clear time for S6V releases, 15 minutes for the S1 release.
- 2) We ignore doses from skin and car received after evacuees reach reception centers. This neglected dose should compensate for the above simplification.
- 3) In cases when skin contamination is assumed to take place, we assume that at least some evacuees remain outside vehicles during the entire time that the plume passes. This appears to be a reasonable assumption, given the fact that traffic will be stalled and it will be uncomfortable inside vehicles that do not have air conditioning.
- 4) In cases when car deposition is included, we assume that a significant number of evacuees who leave their vehicles to cool off (while waiting for traffic to move) will stand next to, or lean on, a contaminated vehicle.

The net result is that we numerically calculate doses to beachgoers in one of two ways:

When skin deposition is neglected, we assume that the last group of evacuees remains inside or close to cars, stalled in traffic, while exposed to contaminated ground. Doses do not begin to accumulate until the wind carries the plume to the vehicle. Doses continue to accumulate until the clear time is reached, at which point evacuees are assumed to leave contaminated ground instantaneously and exit their vehicles.

When skin deposition is not neglected, evacuees are assumed to receive the above dose plus the dose from skin contamination that is accumulated up until the clear time.

These assumptions lead to an effective dose shielding factor range of 1.0-1.3, when skin contamination is included, and a range of 0.65-0.95 when it is not.

In our judgment, the net effect of these simplifications is to underestimate the high end of the dose spectrum.

Tables 10, 17, and 18 (to be presented later) were calculated for winter populations, which are initially indoors. In these cases we have assumed cloud and inhalation sheltering factors of around 0.75. We have also assumed, for simplicity, a building shielding factor range that is identical to the automobile case (0.53-0.78).

Q. How many people are located near the plant?

A. (Beyea) The size of the beach area population around Seabrook is uncertain. One estimate of this population has been made by Public Service of New Hampshire and is found in Figure 6. Although its accuracy is uncertain, this estimate

does indicate that a substantial number of people are located within two miles of the plant. Estimates by other witnesses in this proceeding are much higher.

The number of persons who would be located within a plume obviously varies not only with wind direction but also with stability class and distance from the plant. At two miles the plume could be viewed as being between a 29-wedge (A stability class) and a 13-wedge (D stability class)^{54/} compared to the 22.5 population wedges in the table.

Q. How large are doses likely to be and how do they compare with doses that would be received at other sites?

A. (Beyea) In order to gain a better appreciation of the higher risk faced by the beach population (higher than that faced by residents at comparable distances at other sites for comparable releases), we present a series of Tables that show radiation doses likely to be received under various scenarios. Table 8 shows the highest-risk case, which applies to the Seabrook beach population that is separated from the reactor by a lagoon. (Because plumes disperse less over water, the plume is more concentrated by the time it reaches the population than had it traveled over land.)

The doses shown apply to a person assumed to leave the contaminated area after 5 hours. The doses are truly enormous for the S6V-Total release. (Note that a 500-rem dose has a

^{54/} Wedges are assumed to have plume widths of 3 times the horizontal dispersion coefficient.

mortality rate greater than 70%.) As discussed below, doses exceed the threshold for meteorological conditions that hold 93% of the time.

The doses for an S6V-1 release are smaller than for S6V-Total, but still exceed threshold for meteorological conditions that hold about 33% of the time. Doses shown for the high-rising S1 release have been calculated using a standard plume rise formula, so they almost always remain below threshold. (However, as mentioned earlier, the occurrence of a low-rising plume is expected frequently. For this reason, we continue to list probability values under the yes/no columns in Table 8 that indicate whether or not there is a risk of early death.)

Not all of the 2-mile beach population is separated from the reactor by water. Table 9 shows the results for populations separated by land. The doses are still extraordinarily high for the S6V-Total release, but are significantly less serious for an S6V-1 release. It is of interest to compare these results with doses that would be accumulated at the median reactor site around the United States. The results are shown in Table 10. We have taken 1.5 hours for the evacuation clear time within 2 miles, based on an NRC estimate of the median time.^{55/}

^{55/} T. Urbanik II, "An Analysis of Evacuation Time Estimates Around 52 Nuclear Power Plants," Nuclear Regulatory Commission, Washington, NUREG/CR-1856 (1981), Vol. I, Table 10, p. 21.

Table 10 shows that doses, even for S6V-Total, get very high only for two meteorological conditions (D-stability, wind speeds 2 and 4 meters/second). Doses for the other releases never rise above early-death threshold. In general, doses at these other sites are less than one-fifth the doses for the highest-risk Seabrook beach case.

Q. Are the beach populations beyond two miles exposed to risk of early death during a summer day?

A. (Beyea) Yes, certainly for an S6V-Total release. Tables 11 and 12 show the calculated results for beach populations at 4 miles and an evacuation time of 5 hours. Note that the beach population is not protected for a low-rising S4 release either.

Additional insight into how far from the reactor threshold doses are likely to occur for an S6V-Total release can be gained from examining Table 13. It shows early death radii for D-stability class and a five-hour evacuation time. This means that an individual remaining in the plume at a radius given in the last column of the table for five hours under the given weather conditions will receive at least a 200-rem dose. These are the individuals who have not been able to evacuate earlier due to traffic congestion, etc. It should be noted, however, that individuals at this radius who have evacuated earlier may still receive a 200-rem dose due to the continuing dose contribution from material deposited on their skin and car. Similarly, individuals beyond the early death radius for a

given set of conditions are not necessarily protected from a 200-rem dose, because we have not accounted for the doses they might receive outside the plume from skin and car deposition material.

As noted previously, if evacuation times for the beaches beyond 2 miles are longer than 5 hours, as is documented by Adler, the consequences of these releases for a given set of conditions will be more serious. The early death radii will be larger and many more people will be exposed.

Q. How would a summer evening scenario affect your results?

A. (Beyea) There is evidence that there would still be a substantial population on or near the beaches on summer evenings. Although evacuation times might be reduced due to a smaller evacuating population, it is not clear that this reduction would be enough to ensure that no early deaths occurred in the population--especially since night-time plumes are more concentrated and therefore are more dangerous. In order to investigate the consequences of a summer evening scenario, we have obtained an estimate from our model of the doses at 2 miles which would be received for typical evening weather scenarios assuming a clear time of 1.5 hours. We have assumed, in contrast to the summer scenario, that the population is wearing more clothes and could remove them after exposure to reduce the skin deposition dose. While it is very uncertain how much this would reduce the skin deposition dose,

we have also assumed for simplicity that removing clothes would eliminate it, including the contribution from contaminated hair. We have still assumed a dose component from material deposited on cars. (The dose scaling factor range for this scenario becomes .65-.95)

The results of our model are shown in Table 13a. The time to reach 200 rem is usually one hour or less for the S6V-total release, which means that any reduction of evacuation times during the evening is not going to protect the population for this release category.

Q. How frequently do the various weather conditions occur?

A. (Beyea) The frequencies of the Pasquill stability classes, as reported in the SB 1&2, ER-OLS,^{56/} are given in Table 14. The frequencies of the A,B, and C stability classes increase during the summer months, with C the most frequent of the three. D and E are the dominant stability classes. Although not indicated in the Table (which is based on 24 hour data), C and D stability classes would probably dominate during daytime hours because the E, F, and G stability classes tend to occur primarily in the evening or early morning hours.

The consequences during C, D, and E classes are all serious in terms of early death. Consequences would also be serious

^{56/} Public Service of New Hampshire, "Seabrook Station - Units 1 & 2, Environmental Report, Operating License Stage," Figure 2.1-19.

for F and G conditions though we have not considered them. Our results are not based on an infrequently occurring weather scenario.

The distribution of wind speeds within the stability classes is given in Table 15.^{57/} Note that these distributions are not disaggregated by season, and the summer distribution might be different.

Although the frequency data in Tables 14 and 15 are not precisely applicable to early tables, it is possible to use the information to make a rough assessment of the probability that the population would not be protected from early death should a severe release occur with the wind blowing toward a beach. For instance, it was indicated in Table 9 that for an S6V-total release, the 2-mile beach population on a summer day was not protected from early death under C and D conditions. These meteorological conditions are likely to occur 75% of the time during summer days.^{58/} The probability is even higher for the highest-risk Seabrook beach population -- around 93%.

Q. What about the S6V-1 release?

^{57/} New Hampshire Emergency Response Plan, Rev. 2., Vol. 6, p. 10-52.

^{58/} This assumes that C and D stability classes occur with a 75% probability on a summer day (E, F, and G do not occur during the day and about one half of the D percentages in Table 14 occur at night.)

A. In this case, a similar analysis suggests that doses exceeding threshold would occur about one-third of the time for the highest-risk population at Seabrook beach, if it were downwind.^{59/}

Q. How many people would be contaminated during a summer release?

A. (Beyea) It must be recognized that, based on Tables 6, 9, and 11, thousands of people might be exposed to life-threatening doses should a release occur on a summer day.

In order to put some bounds on the health consequences to a beach area population, we have done a simple calculation of the number of people who might be contaminated due to a release at Seabrook. An unknown fraction of this number would receive doses at or above 200 rem. The others might suffer a range of consequences, from nausea within a few hours to cancer many years in the future.

The lower bound to this limit is zero; that is, with enough warning time, it is possible that no one will be contaminated. The maximum number of persons contaminated within ten miles

^{59/} The S6V-1 column in Table 8 indicates that the early death threshold would occur for 1) D stability class and wind speeds of 2 and 4 m/sec, and 2) C stability class and wind speeds around 2 m/sec.

According to Table 15, the D wind speeds would occur 60% of the time, while the C wind speeds would occur 18% of the time. The net result, based on the data for summer months in Table 14, is a 28% chance of early death threshold under D conditions and a 5% chance under C conditions.

during an accident on a summer weekday is listed in Table 16, for a low estimate of weekday population taken from New Hampshire Seabrook Plan. (See testimony of other experts in this proceeding for an explanation of why the actual population may be considerably higher.) The table shows a range of between 10,000 and 23,000 people who may be exposed.

The table assumes no one within ten miles will have had sufficient time to evacuate before passage of the plume. The purpose of the table is basically to show the size of the population that may be of immediate concern--those persons within ten miles who will know they may have been exposed, later will presumably learn that they have been exposed, and who will wonder what the potential consequences will be.

The maximum number is so large that it is questionable whether medical facilities will be adequate to treat those seeking treatment.

Q. Is the population exposed to "early death" during other times of the year?

A. (Beyea) Yes. We prepared Tables 17 and 18 in a manner similar to those for a summer day beach scenario and found that the population is not always protected from "early death" (200 rem) at two and four miles for the rapid bypass sequence, S6-V total, although the population is protected for other sequences considered.

For those tables we examined evacuees who would take about three hours to evacuate as shown in Table 19. During plume

passage, residents were assumed to be inside buildings with cloud and inhalation shielding factors of 0.75. We assumed a ground-dose scaling factor of 0.65-0.95, implying that the evacuees were in cars within the plume, and that the cars had radioactive material deposited on them. No skin deposition dose was assumed.

Although Table 17 shows several "unprotected" cases for the rapid bypass sequences at two miles, it should be noted that the actual doses above threshold would be considerably higher in the summer time. Doses to the highest-risk beach population would be about four times as high as those projected for an off-season accident. (At four miles the corresponding ratio would be two to one.) As a result of these higher doses, the total number of injuries would be greater in the summer even if the exposed populations were the same.

Furthermore, because the population during the off-season scenarios is smaller than for summer scenarios, fewer people would receive radiation doses during off-season scenarios. Therefore, there would be less of a chance that medical facilities would be overwhelmed, and more of a chance that most of those exposed to doses about 200 rem would receive the "supportive" medical treatment that would be needed to raise the early death threshold above 200 rem. This would be particularly important for the 4-mile case shown in Table 18.

Q. What difficulties are associated with reducing the health consequences of a large release at Seabrook?

A. (Beyea) Limited options exist for reducing the severity of accidents at Seabrook.

None of the extraordinary emergency measures that we, or other nuclear analysts have been able to devise are likely to eliminate or effectively reduce the serious radiation doses that would result from a range of releases at Seabrook.

(A) Possibility of reducing skin and car deposition dose.

Our work here has shown that skin and car deposition doses could make important contributions to the total dose to an individual, but no consideration has been given to reducing these doses in emergency planning. We have considered whether or not extraordinary emergency measures could be taken to protect against them. For instance, evacuees could be instructed to leave the evacuation vehicle as soon as possible, to shower (skin and hair) as soon as possible, and perhaps to remove hair with scissors. Automated car spraying devices could be installed near important beach exit points in an attempt to remove some of the material from cars as soon as possible, thus reducing doses to the occupants. The effectiveness of various methods for removing radioactive aerosols from skin, hair, and cars must be investigated, however, before credit can be taken for them. The logistics of washing every car in the beach area would be formidable and would likely add to

evacuation times. (Removal of aerosols is complicated by the fact that radioactive aerosols attach themselves too strongly to clean surfaces to be removed easily. On the other hand, the fraction depositing on dirty or oily surfaces could be removed at the same time as dirt and oil were removed.)

All these measures, if they worked, could be helpful in reducing the number of delayed cancers that would show up in later years. However, their implementation would not change the significance of our tables with respect to early health effects. This is because post-evacuation doses are not even considered in our calculations and because not all cars could be decontaminated. Also, populations are not protected, even when car deposition doses are excluded.

B) Possibility of relying on shelters.

In principle, one way to reduce the chances of early death occurring in the beach population would be to provide shielding by means of sheltering, especially from ground dose, while people wait for roads to clear. However, shelters would only be useful if they are suitably massive, which seems doubtful in this case.^{60/} Serious questions exist as to whether they

^{60/} Z.G. Burson and A.E. Profio, "Structure Shielding from Cloud and Fallout Gamma Ray Sources for Assessing the Consequences of Reactor Accidents," EG & G, Inc., Los Vegas, Nev., EGG-1183-1670.

would actually be used by a majority of the population. As is indicated by the testimony of other experts in this proceeding, sheltering is not a realistic option for the beach populations.

The possibility of having beach occupants shield themselves by immersing themselves in ocean water has been rejected by us because of the low temperature of the water. On the other hand, it would be physically possible for exposed persons to partially shield themselves from ground dose by covering themselves with sand prior to evacuation. However, the notion that people will wait away from their cars buried in the sand or immersed in the water while traffic congestion clears seems grotesquely unrealistic.

C) Possibility of evacuating on foot or by bike.

The beach population might be instructed to walk out of the area. If the release has occurred, has blown towards the beaches, and has been confined to a relatively narrow area, this might be the best strategy to reduce doses from a theoretical nuclear physics perspective. In this way, no one would wait within the plume area accumulating doses from the radioactive material on the ground or on cars. Our calculations show that a person walking out in certain circumstances would have received, about five hours after the release, between a 30 to 40% lower dose than a person who has

remained in a car within the plume while trying to evacuate.^{61/} However, this type of forced march strategy flounders when faced with normal human behavior.

Providing bicycles for beachgoers might be a strategy since it would offer the hope of relatively rapid escape. Nevertheless, it is not clear what percentage of beachgoers would utilize the bikes and what the traffic impact would be. In fact, access to bikes might increase the disorderliness of the evacuation. For example, consider those beachgoers who opted for driving (with or without official permission), only to return for bicycles after being stuck in traffic for an hour or so. Their abandoned automobiles could well block traffic for those remaining. Certainly no credit could be given in emergency planning for reliance on bicycles without a full-scale test of the process. Yet, a convincing test would be impossible. How could a test reliably simulate the stress and fear that would be generated in a real accident?

^{61/} We calculated the dose to an individual on the beach who waits for about one and a half hours after the release (dose scaling factor of 1.35), who then leaves the plume, but accumulates doses from skin deposition (dose scaling factor .35). We also calculated the dose to an individual in a car within the plume, accumulating doses from the plume on skin and car deposition material (dose scaling factor of 1.0-1.3). By comparing the doses for about five hours after the release, we found a 30-40 percent lower dose for those individuals walking out.

D) Possibility of pre-distributing potassium iodide.

The value of pre-distributing potassium iodide near nuclear power plants has been discussed by us previously. However, pre-distribution will not work for a transient beach population, unless the authorities are willing to hand out tablets every day to everyone who visits the beaches. Also, potassium iodide would be of limited usefulness for the high-dose scenarios that would develop at Seabrook beaches.

Q. What about the probability of the releases discussed in your testimony?

A. (Beyea) PWR1-PWR9 releases are established by NUREG-0396 as the spectrum of releases that must be considered in emergency planning for nuclear power plants. The NRC took the probability and credibility of these accidents classes into account in developing NUREG-0396. Every emergency plan, therefore, must address the entire range of these releases, and should also examine the site-specific equivalent of these generic releases.

Q. What is your overall assessment of the doses that might be delivered at Seabrook?

A. (Beyea) The summer Seabrook situation is the worst case I have ever examined in connection with emergency planning or hypothetical reactor accidents. The doses that would be received following a range of releases at the Seabrook site, even with the proposed emergency plans in effect, are higher

than doses that would be received at most other sites in the complete absence of emergency planning.

Q. Dr. Beyea, does that complete your testimony?

A. (Beyea) Yes, it does.

X. PWR-1 RELEASES AT SEABROOK

Q. Dr. Thompson, what is the basis for your statements in your testimony?

A. (Thompson) As mentioned earlier, I have co-authored a review (Sholly and Thompson, 1986) of various "source term" issues. This review was current through mid-1985. I used that review and the documents cited within it as a basis for my statements. In addition, I have studied a variety of more recent documents, which collectively form the remaining basis for my statements. These more recent documents include the draft NRC report NUREG-1150 (NRC, 1987a) and the documents generated as a result of a January 1987 technical meeting sponsored by the NRC (Kouts, 1987; NRC 1987b). (See attached references.)

Q. Please describe the potential for a "PWR1-type" release.

A. (Thompson) The Reactor Safety Study (NRC, 1975) described the PWR1 release category as being "characterized by a core meltdown followed by a steam explosion on contact of molten fuel with the residual water in the reactor

vessel." More recent work has identified the potential for a similar release through a different mechanism--high-pressure melt ejection. In this case, molten core material is expelled from the reactor vessel under pressure of steam and gases within the vessel.

Q. Where might the containment breach occur during an accident sequence leading to a "PWR 1-type" release?

A. (Thompson) For either steam explosion or high-pressure melt ejection sequences, the location of the breach cannot be predicted. The breach might occur anywhere from the base of the containment wall to the containment dome. In addition, a co-existing bypass pathway could lead to some release through buildings adjacent to the main containment building.

Q. Please describe the range of thermal energy release rates which could be experienced during a "PWR 1-type" release.

A. (Thompson) This range is illustrated by Figure 7, which is drawn from the Seabrook Station Probabilistic Safety Assessment (PLG, 1983). For present purposes, release category S1 is relevant. The table shows that the estimated energy release rate for this release category could vary from 21,000 million BTU per hour to 60 million BTU per hour, according to the size of the containment leak area. Present knowledge of containment failure modes is

such that the energy release rate cannot be predicted within this range, and perhaps within a wider range.

Q. Please describe the potential for "PWR 1-type" releases to be relatively enriched in certain radioactive isotopes?

A. (Thompson) In Appendix VI of the Reactor Safety Study (NRC, 1975), release category PWR1 is shown as having a relatively large release fraction for the ruthenium group of radioactive isotopes--40% for this release category as opposed to 2% for release category PWR 2. Such an enhanced release is predicted to occur because of the physical and chemical behavior of a steam explosion event. More recent studies have shown that a high-pressure melt ejection event could also lead to enhanced release of certain isotopes including those of ruthenium, molybdenum and tellurium.

Q. Mr. Thompson, does this complete your testimony?

A. (Thompson) Yes, it does.

REFERENCES TO TESTIMONY OF GORDON THOMPSON

(Kouts, 1987)

H. Kouts, Review of Research on Uncertainties in Estimates of Source Terms from Severe Accidents in Nuclear Power Plants, Brookhaven National Laboratory, NUREG/CR-4883, April 1987.

(NRC, 1975)

U.S. Nuclear Regulatory Commission, Reactor Safety Study, WASH-1400, October 1975.

(NRC, 1987a)

U.S. Nuclear Regulatory Commission, Reactor Risk Reference Document, NUREG-1150 (3 vols.), Draft, February 1987.

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U.S. Nuclear Regulatory Commission, Uncertainty Papers on Severe Accident Source Terms, NUREG-1265, May 1987.

(PLG, 1983)

B. John Garrick (Study Director) et al., Seabrook Station Probabilistic Safety Assessment, Pickard, Lowe and Garrick Inc., prepared for Public Service Company of New Hampshire and Yankee Atomic Electric Company, 6 volumes, December 1983.

(Sholly and Thompson, 1986)

Steven Sholly and Gordon Thompson, The Source Term Debate: A Report by the Union of Concerned Scientists, Union of Concerned Scientists, January 1986.

RELATED CORRESPONDENCE

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before Administrative Judges:
Ivan W. Smith, Chairperson
Gustave A. Linenberger, Jr.
Dr. Jerry Harbour



In the Matter of)

PUBLIC SERVICE COMPANY OF)
NEW HAMPSHIRE, ET AL.)
(Seabrook Station, Units 1 and 2))

) Docket Nos.
) 50-443-444-OL
) (Off-site EP)
) April 25, 1988
)

ATTACHMENTS

TO

COMMONWEALTH OF MASSACHUSETTS TESTIMONY OF
STEVEN C. SHOLLY ON THE TECHNICAL BASIS FOR THE NRC
EMERGENCY PLANNING RULES, DR. JAN BEYEA ON POTENTIAL
RADIATION DOSAGE CONSEQUENCES OF THE ACCIDENTS THAT FORM
THE BASIS FOR THE NRC EMERGENCY PLANNING RULES, AND
DR. GORDON THOMPSON ON POTENTIAL RADIATION RELEASE SEQUENCES

Department of the Attorney General
Commonwealth of Massachusetts
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ATTACHMENTS

Attachment 1	Professional Qualifications of Steven C. Sholly
Attachment 2	Professional Qualifications of Jan Beyea
Attachment 3	Professional Qualifications of Gordon Thompson
Attachment 4	Town of Hampton Revised Contention VIII SAPL Contention 16 NECNP Contention RERP-8

ATTACHMENT 1

RESUME OF STEVEN C. SHOLLY

STEVEN C. SHOLLY
MHB Technical Associates
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San Jose, California 95125
(408) 266-2716

EXPERIENCE:

September 1985 - PRESENT

Associate - MHB Technical Associates, San Jose, California

Associate in energy consulting firm that specializes in technical and economic assessments of energy production facilities, especially nuclear, for local, state, and federal governments and private organizations. MHB is extensively involved in regulatory proceedings and the preparation of studies and reports. Conduct research, write reports, participate in discovery process in regulatory proceedings, develop testimony and other documents for regulatory proceedings, and respond to client inquiries. Participated as a panelist at the NRC-sponsored Containment Performance Design Objective Workshop, Harpers Ferry, West Virginia (NUREG/CP-0084) (1986), and as a panelist at the Severe Accident Policy Implementation External Events Workshop, Annapolis, Maryland (presentation on seismic risk assessment) (1987). Clients have included: State of California, State of New York, State of Illinois, State of Massachusetts, and Suffolk County (New York).

February 1981 - September 1985

Technical Research Associate and Risk Analyst - Union of Concerned Scientists, Washington, D.C.

Research associate and risk analyst for public interest group based in Cambridge, Massachusetts, that specializes in examining the impact of advanced technologies on society, principally in the areas of arms control and energy. Technical work focused on nuclear power plant safety, with emphasis on probabilistic risk assessment, radiological emergency planning and preparedness, and generic safety issues. Conducted research, prepared reports and studies, participated in administrative proceedings before the U.S. Nuclear Regulatory Commission, developed testimony, analyzed NRC rule-making proposals and draft reports and prepared comments thereon, and responded to inquiries from sponsors, the general public, and the media. Participated as a member of the Panel on ACRS Effectiveness (1985), the Panel on Regulatory Uses of Probabilistic Risk Assessment (Peer Review of NUREG-1050: 1984), Invited Observer to NRC Peer Review meetings on the source term reassessment (BMI-2104: 1983-1984), member of the Independent Advisory Committee on Nuclear Risk for the Nuclear Risk Task Force of the National Association of Insurance Commissioners (1984).

January 1980 - January 1981

Project Director and Research Coordinator - Three Mile Island Public Interest Resource Center
Harrisburg, Pennsylvania

Provided administrative direction and coordinated research projects for a public interest group based in Harrisburg, Pennsylvania, centered around issues related to the Three Mile Island Nuclear Power Plant. Prepared fundraising proposals, tracked progress of U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and General Public Utilities activities concerning cleanup of Three Mile Island Unit 2 and preparation for restart of Three Mile Island Unit 1, and monitored developments related to emergency planning, the financial health of General Public Utilities, and NRC rulemaking actions related to Three Mile Island.

July 1978 - January 1980

Chief Biological Process Operator - Wastewater Treatment Plant, Derry Township Municipal
Authority, Hershey, Pennsylvania

Chief Biological Process Operator at a 2.5 million gallon per day tertiary, activated sludge, wastewater treatment plant. Responsible for biological process monitoring and control, including analysis of physical, chemical, and biological test results, process fluid and mass flow management, micro-biological analysis of activated sludge, and maintenance of detailed process logs for input into state and federal reports on treatment process and effluent quality. Received certification from the Commonwealth of Pennsylvania as a wastewater treatment plant operator. Member of Water Pollution Control Association of Pennsylvania, Central Section, 1980.

July 1977 - July 1978

Wastewater Treatment Plant Operator - Borough of Lemoyne, Lemoyne, Pennsylvania

Wastewater treatment plant operator at 2.0 million gallon per day secondary, activated sludge, wastewater treatment plant. Performed tasks as assigned by supervisors, including simple physical and chemical tests on wastewater streams, maintenance and operation of plant equipment, and maintenance of the collection system.

September 1976 - June 1977

Science Teacher - West Shore School District, Camp Hill, Pennsylvania

Taught Earth and Space Science at ninth grade level. Developed and implemented new course materials on plate tectonics, environmental geology, and space science. Served as Assistant Coach of the district gymnastics team.

September 1975 - June 1976

Science Teacher - Carlisle Area School District, Carlisle, Pennsylvania

Taught Earth and Space Science and Environmental Science at ninth grade level. Developed and implemented new course materials on plate tectonics, environmental geology, noise pollution, water pollution, and energy. Served as Advisor to the Science Projects Club.

EDUCATION:

B.S., Education, majors in Earth and Space Science and General Science, minor in Environmental Education, Shippensburg State College, Shippensburg, Pennsylvania, 1975.

Graduate coursework in Land Use Planning, Shippensburg State College, Shippensburg, Pennsylvania, 1977-1978.

PUBLICATIONS:

1. "Determining Mercalli Intensities from Newspaper Reports," Journal of Geological Education, Vol. 25, 1977.
2. A Critique of: An Independent Assessment of Evacuation Times for Three Mile Island Nuclear Power Plant, Three Mile Island Public Interest Resource Center, Harnsburg, Pennsylvania, January 1981.
3. A Brief Review and Critique of the Rockland County Radiological Emergency Preparedness Plan, Union of Concerned Scientists, prepared for Rockland County Emergency Planning Personnel and the Chairman of the County Legislature, Washington, D.C., August 17, 1981.
4. The Necessity for a Prompt Public Alerting Capability in the Plume Exposure Pathway EPZ at Nuclear Power Plant Sites, Union of Concerned Scientists, Critical Mass Energy Project, Nuclear Information and Resource Service, Environmental Action, and New York Public Interest Research Group, Washington, D.C., August 27 *.
5. "Union of Concerned Scientists, Inc., Comments on Notice of Proposed Rulemaking, Amendment to 10 CFR 50, Appendix E, Section IV.D.3," Union of Concerned Scientists, Washington, D.C., October 21, 1981. *
6. "The Evolution of Emergency Planning Rules," in The Indian Point Book: A Briefing on the Safety Investigation of the Indian Point Nuclear Power Plants, Anne Witte, editor, Union of Concerned Scientists (Washington, D.C.) and New York Public Interest Research Group (New York, NY), 1982.
7. "Union of Concerned Scientists Comments, Proposed Rule, 10 CFR Part 50, Emergency Planning and Preparedness: Exercises, Clarification of Regulations, 46 F.R. 61134," Union of Concerned Scientists, Washington, D.C., January 15, 1982. *
8. Testimony of Robert D. Pollard and Steven C. Sholly before the Subcommittee on Energy and the Environment, Committee on Interior and Insular Affairs, U.S. House of Representatives, Middletown, Pennsylvania, March 29, 1982, available from the Union of Concerned Scientists.
9. "Union of Concerned Scientists Detailed Comments on Petition for Rulemaking by Citizen's Task Force, Emergency Planning, 10 CFR Parts 50 and 70, Docket No. PRM-50-31, 47 F.R. 12639," Union of Concerned Scientists, Washington, D.C., May 24, 1982.
10. Supplements to the Testimony of Eilyn R. Weiss, Esq., General Counsel, Union of Concerned Scientists, before the Subcommittee on Energy Conservation and Power, Committee on Energy and Commerce, U.S. House of Representatives, Union of Concerned Scientists, Washington, D.C., August 16, 1982.

11. Testimony of Steven C. Sholly, Union of Concerned Scientists, Washington, D.C., on behalf of the New York Public Interest Research Group, Inc., before the Special Committee on Nuclear Power Safety of the Assembly of the State of New York, hearings on Legislative Oversight of the Emergency Radiologic Preparedness Act, Chapter 708, Laws of 1981, September 2, 1982.
12. "Comments on 'Draft Supplement to Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant'," Docket No. 50-537, Union of Concerned Scientists, Washington, D.C., September 13, 1982. *
13. "Union of Concerned Scientists Comments on 'Report to the County Commissioners', by the Advisory Committee on Radiological Emergency Plan for Columbia County, Pennsylvania," Union of Concerned Scientists, Washington, D.C., September 15, 1982.
14. "Radiological Emergency Planning for Nuclear Reactor Accidents," presented to Kernenergie Omtmanteid Congress, Rotterdam, The Netherlands, Union of Concerned Scientists, Washington, D.C., October 8, 1982.
15. "Nuclear Reactor Accident Consequences: Implications for Radiological Emergency Planning," presented to the Citizen's Advisory Committee to Review Rockland County's Own Nuclear Evacuation and Preparedness Plan and General Disaster Preparedness Plan, Union of Concerned Scientists, Washington, D.C., November 19, 1982.
16. Testimony of Steven C. Sholly before the Subcommittee on Oversight and Investigations, Committee on Interior and Insular Affairs, U.S. House of Representatives, Washington, D.C., Union of Concerned Scientists, December 13, 1982.
17. Testimony of Gordon R. Thompson and Steven C. Sholly on Commission Question Two, Contentions 2.1(a) and 2.1(d), Union of Concerned Scientists and New York Public Interest Research Group, before the U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board, in the Matter of Consolidated Edison Company of New York (Indian Point Unit 2) and the Power Authority of the State of New York (Indian Point Unit 3), Docket Nos. 50-247-SP and 50-286-SP, December 28, 1982. *
18. Testimony of Steven C. Sholly on the Consequences of Accidents at Indian Point (Commission Question One and Board Question 1.1), Union of Concerned Scientists and New York Public Interest Research Group, before the U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board, in the Matter of Consolidated Edison Company of New York (Indian Point Unit 2) and the Power Authority of the State of New York (Indian Point Unit 3), Docket Nos. 50-247-SP and 50-286-SP, February 7, 1983, as corrected February 16, 1983. *
19. Testimony of Steven C. Sholly on Commission Question Five, Union of Concerned Scientists and New York Public Interest Research Group, before the U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board, in the Matter of Consolidated Edison Company of New York (Indian Point Unit 2) and the Power Authority of the State of New York (Indian Point Unit 3), Docket Nos. 50-247-SP and 50-286-SP, March 22, 1983. *
20. "Nuclear Reactor Accidents and Accident Consequences: Planning for the Worst," Union of Concerned Scientists, Washington, D.C., presented at Critical Mass 83, March 26, 1983.

21. Testimony of Steven C. Sholly on Emergency Planning and Preparedness at Commercial Nuclear Power Plants, Union of Concerned Scientists, Washington, D.C., before the Subcommittee on Nuclear Regulation, Committee on Environment and Public Works, U.S. Senate, April 15, 1983. (with "Union of Concerned Scientists' Response to Questions for the Record from Senator Alan K. Simpson," Steven C. Sholly and Michael E. Faden).
22. "PRA: What Can it Really Tell Us About Public Risk from Nuclear Accidents?," Union of Concerned Scientists, Washington, D.C., presentation to the 14th Annual Meeting, Seacoast Anti-Pollution League, May 4, 1983.
23. "Probabilistic Risk Assessment: The Impact of Uncertainties on Radiological Emergency Planning and Preparedness Considerations," Union of Concerned Scientists, Washington, D.C., June 28, 1983.
24. "Response to GAO Questions on NRC's Use of PRA," Union of Concerned Scientists, Washington, D.C., October 6, 1983, attachment to letter dated October 6, 1983, from Steven C. Sholly to John E. Bagnulo (GAO, Washington, D.C.).
25. The Impact of "External Events" on Radiological Emergency Response Planning Considerations, Union of Concerned Scientists, Washington, D.C., December 22, 1983, attachment to letter dated December 22, 1983, from Steven C. Sholly to NRC Commissioner James K. Asselstine.
26. Sizewell 'B' Public Inquiry, Proof of Evidence on: Safety and Waste Management Implications of the Sizewell PWR, Gordon Thompson, with supporting evidence by Steven Sholly, on behalf of the Town and Country Planning Association, February 1984, including Annex G, "A review of Probabilistic Risk Analysis and its Application to the Sizewell PWR," Steven Sholly and Gordon Thompson, (August 11, 1983), and Annex O, "Emergency Planning in the UK and the US: A Comparison," Steven Sholly and Gordon Thompson (October 24, 1983).
27. Testimony of Steven C. Sholly on Emergency Planning Contention Number Eleven, Union of Concerned Scientists, Washington, D.C., on behalf of the Palmetto Alliance and the Carolina Environmental Study Group, before the U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board, in the Matter of Duke Power Company, et. al. (Catawba Nuclear Station, Units 1 and 2), Docket Nos. 50-413 and 50-414, April 16, 1984. *
28. "Risk Indicators Relevant to Assessing Nuclear Accident Liability Premiums," in Preliminary Report to the Independent Advisory Committee to the NAIC Nuclear Risk Task Force, December 11, 1984, Steven C. Sholly, Union of Concerned Scientists, Washington, D.C.
29. "Union of Concerned Scientists' and Nuclear Information and Resource Service's Joint Comments on NRC's Proposal to Bar from Licensing Proceedings the Consideration of Earthquake Effects on Emergency Planning," Union of Concerned Scientists and Nuclear Information and Resource Service, Washington, D.C., Diane Curran and Eilyn R. Weiss (with input from Steven C. Sholly), February 28, 1985. *
30. "Severe Accident Source Terms: A Presentation to the Commissioners on the Status of a Review of the NRC's Source Term Reassessment Study by the Union of Concerned Scientists," Union of Concerned Scientists, Washington, D.C., April 3, 1985. *

31. "Severe Accident Source Terms for Light Water Nuclear Power Plants: A Presentation to the Illinois Department of Nuclear Safety on the Status of a Review of the NRC's Source Term Reassessment Study (STRS) by the Union of Concerned Scientists." Union of Concerned Scientists, Washington, D.C., May 13, 1985.
32. The Source Term Debate: A Review of the Current Basis for Predicting Severe Accident Source Terms with Special Emphasis on the NRC Source Term Reassessment Program (NUREG-0956). Union of Concerned Scientists, Cambridge, Massachusetts. Steven C. Sholly and Gordon Thompson, January 1986. (Available from the Union of Concerned Scientists)
33. Direct Testimony of Dale G. Bridenbaugh, Gregory C. Minor, Lynn K. Price, and Steven C. Sholly on behalf of State of Connecticut Department of Public Utility Control, Prosecutorial Division and Division of Consumer Counsel, regarding the prudence of expenditures on Millstone Unit III, February 18, 1986.
34. Implications of the Chernobyl-4 Accident for Nuclear Emergency Planning for the State of New York, prepared for the State of New York Consumer Protection Board, by M-3 Technical Associates, June 1986. *
35. Review of Vermont Yankee Containment Safety Study and Analysis of Containment Venting Issues for the Vermont Yankee Nuclear Power Plant, prepared for New England Coalition on Nuclear Pollution, Inc., December 16, 1986.
36. Affidavit of Steven C. Sholly before the Atomic Safety and Licensing Board, in the matter of Public Service Company of New Hampshire, et al., regarding Seabrook Station Units 1 and 2 Off-site Emergency Planning Issues, Docket Nos. 50-443-OL & 50-444-OL, January 23, 1987. *
37. Direct Testimony of Richard B. Hubbard and Steven C. Sholly on behalf of California Public Utilities Commission, regarding Diablo Canyon Rate Case, PG&E's Failure to Establish Its Committed Design QA Program, Application Nos. 84-06-014 and 85-08-025, Exhibit No. 1C-335, March, 1987.
38. Testimony of Gregory C. Minor, Steven C. Sholly et. al. on behalf of Suffolk County, regarding ULCO's Reception Centers (Planning Basis), before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station Unit 1, Docket No. 50-322-OL-3, April 13, 1987. *
39. Rebuttal Testimony of Gregory C. Minor and Steven C. Sholly on behalf of Suffolk County regarding ULCO's Reception Centers (Addressing Testimony of Lewis G. Hulman), Docket No. 50-322-OL-3, May 27, 1987. *
40. Review of Selected Aspects of NUREG-1150, "Reactor Risk Reference Document", prepared for the Illinois Department of Nuclear Safety, forthcoming.

* Available from the U.S. Nuclear Regulatory Commission, Public Document Room, Lobby, 1717 H Street, N.W., Washington, D.C.

ATTACHMENT 2

Resume for Jan Beyea
July 1986

EDUCATION:

Ph.D., Columbia University, 1968 (Physics).
B.A., Amherst College, 1962.

EMPLOYMENT HISTORY:

1980 to date, Senior Staff Scientist and, as of 1985,
Director of the Environmental Policy Analysis Department,
National Audubon Society, 950 Third Avenue, NY, NY 10022.

1976 to 1980, Research Staff, Center for Energy and Environmental Studies
Princeton University.

1970 to 1976, Assistant Professor of Physics, Holy Cross College.

1968 to 1970, Research Associate, Columbia University Physics Department.

CONSULTING WORK:

Consultant on nuclear energy to the Office of Technology Assessment, the
New Jersey Department of Environmental Protection; the Offices of the Attorney
General in New York State and the Commonwealth of Massachusetts; the State of
lower Saxony in West Germany; the Swedish Energy Commission; the Three Mile
Island Public Health Fund; and various citizens' groups in the United States.

PUBLICATIONS CONCERNING ENERGY CONSERVATION, ENERGY POLICY, AND ENERGY RISKS:

Articles:

"Oil and Gas Resources on Federal Lands: Wilderness and Wildlife
Refuges," Stege and Beyea, Annual Review of Energy (to be published, October
1986). [An earlier version appeared as National Audubon Society Report, EPAD
No. 28, June 1985.]

"U.S. Appliance Efficiency Standards," Pollin and Beyea, Energy Policy,
13, p. 425 (1985).

"Computer Modeling for Energy Policy Analysis," Medsker, Beyea, and
Lyons, Proceedings of the 15th Annual Modeling and Simulation Conference,
Pittsburgh, PA, 15, part 3, p. 1111 (1984).

"Containment of a Reactor Meltdown," (with Frank von Hippel), Bulletin of
the Atomic Scientists, 38, p. 52 (August/September 1982).

"Second Thoughts (about Nuclear Safety)," in Nuclear Power: Both Sides,
W. W. Norton and Co. (New York, 1982).

"Indoor Air Pollution," Bull. At. Scientists, 37, p. 63 (Feb. 1981)

Articles (Con't)

"Emergency Planning for Reactor Accidents," Bulletin of the Atomic Scientists, 36, p. 40 (December 1980). (An earlier version of the article appeared in German as Chapter 3 in Im Ernstfall hilflos?, E. R. Koch, Fritz Vahrenholt, editors, Keipenheuer & Witsch, Cologne, 1980.)

"Dispute at Indian Point," Bull. At. Scientists, 36, p. 63, (May 1980).

"Locating and Eliminating Obscure but Major Energy Losses in Residential Housing," Harrje, Dutt, and Beyea, ASHRAE Transactions, 85, Part II (1979). (Winner of ASHRAE outstanding paper award.)

"Attic Heat Loss and Conservation Policy," Dutt, Beyea, and Sinden. ASME Technology and Society Division Paper 78-TS-5, Houston, Texas, 1978.

"Critical Significance of Attics and Basements in the Energy Balance of Twin Rivers Townhouses," Beyea et al., Energy and Buildings, Vol. I (1977), Page 261. Also Chapter 3 of Saving Energy in the Home, Ballinger, 1978.

"The Two-Resistance Model for Attic Heat Flow: Implications for Conservation Policy," Woteki, Dutt, Beyea, Energy--The Intl. Journal, 3, 657(1978)

Published Debates:

Proceedings of the Workshop on Three Mile Island Dosimetry, Three Mile Island Public Health Fund, 1622 Locust Street, Phila., Pa., Dec. 1985

"Land Use Issues and the Media," Ctr. for Communication, NYC, Oct. 1984.

Nuclear Reactors: How Safe Are They?, panel discussion sponsored by the Academy Forum of the National Academy of Sciences, Wash., D.C., May 5, 1980.

The Crisis of Nuclear Energy, Subject No. 367 on William Buckley's Firing Line, P.B.S. Television. Transcript printed by Southern Education Communications Assoc., 928 Woodrow Street, P. O. Box 5966, Columbia, S.C., 1979.

Reports:

The Audubon Energy Plan, Beyea et al., 2nd Ed., July 1984 (1st Ed., 1981) [See also, Intro. to Special Issue on Legal Issues Arising From The Audubon Energy Plan 1984, Columbia Journal of Environmental Law, 11, p.251, (1986)]

A Review of Dose Assessments at Three Mile Island and Recommendations for Future Research, Report to the Three Mile Island Public Health Fund, August 1984. [See also, "Author Challenges Review," Health Physics Newsletter, March, 1985, and "TMI--Six Years Later," Nuclear Medicine, 26, p. 1345 (1985).]

Reports (Con't)

"Implications for Mortality of Weakening the Clean Air Act," (with G. Steve Jordan), National Audubon Society, EPAD Report No. 18, May 1982.

"Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island," Report to the President's Council on Environmental Quality, December 1980.

"Decontamination of Krypton 85 from Three Mile Island Nuclear Plant," (with Kendall, et al.), Report of the Union of Concerned Scientists to the Governor of Pennsylvania, May 15, 1980.

"Some Comments on Consequences of Hypothetical Reactor Accidents at the Philippines Nuclear Power Plant" (with Gordon Thompson), National Audubon Society, EPAD Report No. 3, April 1980.

"Nuclear Reactor Accidents: The Value of Improved Containment," (with Frank von Hippel), Center for Energy and Environmental Studies Report PU/CEES 94, Princeton University, January 1980.

"The Effects of Releases to the Atmosphere of Radioactivity from Hypothetical Large-Scale Accidents at the Proposed Gorleben Waste Treatment Facility," report to the Government of Lower Saxony, Federal Republic of Germany, as part of the "Gorleben International Review," February 1979.

"Reactor Safety Research at the Large Consequence End of the Risk Spectrum," presented to the Experts' Meeting on Reactor Safety Research in the Federal Republic of Germany, Bonn, September 1, 1978.

A Study of Some of the Consequences of Hypothetical Reactor Accidents at Barseback, report to the Swedish Energy Comm., Stockholm, DS I 1978:5, 1978.

Testimony:

"Responses to the Chernobyl Accident," before the Senate Committee on Energy and Natural Resources, U. S. Senate, June 19, 1986.

"Dealing with Uncertainties in Projections of Electricity Consumption," before the Comm. on Energy and Natural Resources, U. S. Senate, July 25, 1985.

"Some Consequences of Catastrophic Accidents at Indian Point and Their Implications for Emergency Planning," testimony and cross-examination before the Nuclear Regulatory Commission's Atomic Safety and Licensing Board, on behalf of the New York State Attorney General and others, July 1982.

Testimony (Con't)

"In the Matter of Application of Orange and Rockland Counties, Inc. for Conversion to Coal of Lovett Units 4 and 5," testimony and cross-examination on the health impacts of eliminating scrubbers as a requirement for conversion to coal; Department of Environmental Resources, State of N.Y., Nov. 5, 1981.

"Future Prospects for Commercial Nuclear Power in the United States," before the Subcommittee on Oversight and Investigations, Committee on Interior and Insular Affairs, U. S. House of Representatives, October 23, 1981.

"Comments on Energy Forecasting," material submitted for the record at Hearings before the Subcommittee on Investigations and Oversight of the House Committee on Science and Technology; Committee Print No. 14, June 1-2, 1981.

"Stockpiling of Potassium Iodide for the General Public as a Condition for Restart of TMI Unit No. 1," testimony and cross-examination before the Atomic Safety and Licensing Board on behalf of the Anti-Nuclear Group Representing York, April 1981.

"Advice and Recommendations Concerning Changes in Reactor Design and Safety Analysis which should be Required in Light of the Accident at Three Mile Island," statement to the Nuclear Regulatory Commission concerning the proposed rulemaking hearing on degraded cores, December 29, 1980.

"Alternatives to the Indian Point Nuclear Reactors," statement before the Environmental Protection Committee of the New York City Council, December 14, 1979. Also before the Committee, "The Impact on New York City of Reactor Accidents at Indian Point, June 11, 1979. Also "Consequences of a Catastrophic Reactor Accident," statement to the New York City Board of Health, August 12, 1976 (with Frank von Hippel).

"Emergency Planning for a Catastrophic Reactor Accident," testimony before the California Energy Resources and Development Commission, Emergency Response and Evacuation Plans Hearings, November 4, 1978, Page 171.

"Comments on the Proposed FTC Trade Regulation Rule on Labeling and Advertising of Thermal Insulation," Beyea and Dutt, before the FTC, 1978.

"Consequences of Catastrophic Accidents at Jamesport," testimony before the N.Y. State Board on Electric Generation Siting and the Environment in the Matter of Long Island Lighting Co. (Jamesport Nuclear Power Station), May 1977.

"Short-Term Effects of Catastrophic Accidents on Communities Surrounding the Sundesert Nuclear Installation," testimony before the California Energy Resources and Development Commission, December 3, 1976.

ATTACHMENT 3

1

**Resume
for
Gordon Thompson**

January 1987

Professional Expertise

Consulting scientist on energy, environment, and international security issues.

Education

- * PhD in Applied Mathematics, Oxford University, 1973.
- * BE in Mechanical Engineering, University of New South Wales, Sydney, Australia, 1967.
- * BS in Mathematics and Physics, University of New South Wales, 1966.

Current Appointments

- * Executive Director, Institute for Resource & Security Studies (IRSS), Cambridge, MA.
- * Coordinator, Proliferation Reform Project (an IRSS project).
- * Treasurer, Center for Atomic Radiation Studies, Acton, MA.
- * Member, Board of Directors, Political Ecology Research Group, Oxford, UK.
- * Member, Advisory Board, Gruppe Okologie, Hannover, FRG.

Consulting Experience (selected)

- * Natural Resources Defense Council, Washington, DC, 1986-1987 : preparation of testimony on hazards of the Savannah River Plant.
- * Lakes Environmental Association, Bridgton, ME, 1986 : analysis of federal regulations for disposal of radioactive waste.
- * Greenpeace, Hamburg, FRG, 1986 : participation in an international study on the hazards of nuclear power plants.
- * Three Mile Island Public Health Fund, Philadelphia, PA, 1983-present : studies related to the Three Mile Island nuclear plant.
- * Attorney General, Commonwealth of Massachusetts, Boston, MA, 1984-present : analyses of the safety of the Seabrook nuclear plant.
- * Union of Concerned Scientists, Cambridge, MA, 1980-1985 : studies on energy demand and supply, nuclear arms control, and the safety of nuclear installations.

- * Conservation Law Foundation of New England, Boston, MA, 1985 : preparation of testimony on cogeneration potential at the Maine facilities of Great Northern Paper Company.
- * Town & Country Planning Association, London, UK, 1982-1984 : coordination and conduct of a study on safety and radioactive waste implications of the proposed Sizewell nuclear plant.
- * US Environmental Protection Agency, Washington, DC, 1980-1981 : assessment of the cleanup of Three Mile Island Unit 2 nuclear plant.
- * Center for Energy & Environmental Studies, Princeton University, Princeton, NJ, 1979-1980 : studies on the potentials of various renewable energy sources.
- * Government of Lower Saxony, Hannover, FRG, 1978-1979 : coordination and conduct of studies on safety aspects of the proposed Gorleben nuclear fuel center.

Other Experience (selected)

- * Co-leadership (with Paul Walker) of a study group on nuclear weapons proliferation, Institute of Politics, Harvard University, 1981.
- * Foundation (with others) of an ecological political movement in Oxford, UK, which contested the 1979 Parliamentary election.
- * Conduct of cross-examination and presentation of evidence, on behalf of the Political Ecology Research Group, at the 1977 Public Inquiry into proposed expansion of the reprocessing plant at Windscale, UK.
- * Conduct of research on plasma theory (while a PhD candidate), as an associate staff member, Culham Laboratory, UK Atomic Energy Authority, 1969-1973.
- * Service as a design engineer on coal plants, New South Wales Electricity Commission, Sydney, Australia, 1968.

Publications (selected)

- * The Nuclear Freeze Revisited (written with Andrew Haines), November 1986, Nuclear Freeze and Arms Control Research Project, Bristol, UK.
- * Nuclear-Weapon-Free Zones : A Survey of Treaties and Proposals (edited with David Pitt), Croom Helm Ltd, Beckenham, UK, forthcoming.
- * International Nuclear Reactor Hazard Study (written with fifteen other authors), September 1986, Greenpeace, Hamburg, FRG (2 volumes).
- * "What happened at Reactor Four" (the Chernobyl reactor accident), Bulletin of the Atomic Scientists, August/September 1986, pp 26-31.

- * The Source Term Debate : A Report by the Union of Concerned Scientists (written with Steven Sholly), January 1986, Union of Concerned Scientists, Cambridge, MA.
- * "Checks on the Spread" (a review of three books on nuclear proliferation), Nature, 14 November 1985, pp 127-128.
- * Editing of Perspectives on Proliferation, Volume I, August 1985, published by the Proliferation Reform Project, Institute for Resource and Security Studies, Cambridge, MA.
- * "A Turning Point for the NPT ?", ADIU Report, Nov/Dec 1984, pp 1-4, University of Sussex, Brighton, UK.
- * "Energy Economics", in J Dennis (ed), The Nuclear Almanac, Addison-Wesley, Reading, MA, 1984.
- * "The Genesis of Nuclear Power", in J Tirman (ed), The Militarization of High Technology, Ballinger, Cambridge, MA, 1984.
- * A Second Chance : New Hampshire's Electricity Future as a Model for the Nation (written with Linzee Weld), Union of Concerned Scientists, Cambridge, MA, 1983.
- * Safety and Waste Management Implications of the Sizewell PWR (prepared with the help of 6 consultants), a report to the Town & Country Planning Association, London, UK, 1983.
- * Utility-Scale Electrical Storage in the USA : The Prospects of Pumped Hydro, Compressed Air, and Batteries, Princeton University report PU/CEES #120, 1981.
- * The Prospects for Wind and Wave Power in North America, Princeton University report PU/CEES # 117, 1981.
- * Hydroelectric Power in the USA : Evolving to Meet New Needs, Princeton University report PU/CEES # 115, 1981.
- * Editing and part authorship of "Potential Accidents & Their Effects", Chapter III of Report of the Gorleben International Review, published in German by the Government of Lower Saxony, FRG, 1979 -- Chapter III available in English from the Political Ecology Research Group, Oxford, UK.
- * A Study of the Consequences to the Public of a Severe Accident at a Commercial FBR located at Kalkar, West Germany, Political Ecology Research Group report RR-1, 1978.

Expert Testimony (selected)

- * County Council, Richland County, SC, 1987 : Implications of Severe Reactor Accidents at the Savannah River Plant.
- * International Physicians for the Prevention of Nuclear War, 6th Annual Congress, Köln, FRG, 1986 : Relationships between nuclear power and the

- threat of nuclear war.
- * Maine Land Use Regulation Commission, 1985 : Cogeneration potential at facilities of Great Northern Paper Company.
 - * Interfaith Hearings on Nuclear Issues, Toronto, Ontario, 1984 : Options for Canada's nuclear trade and Canada's involvement in nuclear arms control.
 - * Sizewell Public Inquiry, UK, 1984 : Safety and radioactive waste implications of the proposed Sizewell nuclear plant.
 - * New Hampshire Public Utilities Commission, 1983 : Electricity demand and supply options for New Hampshire.
 - * Atomic Safety & Licensing Board, Dockets 50-247-SP & 50-286-SP, US Nuclear Regulatory Commission, 1983 : Use of filtered venting at the Indian Point nuclear plants.
 - * US National Advisory Committee on Oceans and Atmosphere, 1982 : Implications of ocean disposal of radioactive waste.
 - * Environmental & Energy Study Conference, US Congress, 1982 : Implications of radioactive waste management.

Miscellaneous

- * Australian citizen.
- * Married, one child.
- * Resident of USA, 1979 to present; of UK, 1969-1979.
- * Extensive experience of public speaking before professional and lay audiences.
- * Author of numerous newspaper, newsletter, and magazine articles and book reviews.
- * Has received many interviews from print and electronic media.

ATTACHMENT # 4

TOH Revised Contention VIII to Revision 2:

Revision 2 fails to provide adequate emergency equipment, facilities, or personnel to support an emergency response and fails to demonstrate that adequate protective responses can be implemented in the event of a radiological emergency. 10 CFR §50.47(1)(8)(10).

Appendix, Board's Order & Memorandum, May 18, 1987

Admitted Bases:

In preparing the Hampton RERP, the State relies upon a "shelter-in-place" concept as a "valuable protective action" (in) that it can be implemented quickly, usually in a matter of minutes. RERP, pgs. II-25, 26. The Hampton RERP acknowledges, however, that "sheltering may not be considered as a protective action on Hampton Beach during the summer." RERP, pg. II-25. The plan thereby fails to provide reasonable assurance that adequate and immediate protection measures will be available to the thousands of beachgoers in the event of emergency. Under its RERP, therefore, the Town is required to rely upon evacuation as the sole means of avoiding radiological exposure to large segments of the population. Since a "major portion" of radioactive material may be released within one hour of the initiating event, NUREG, pg. 17, and present estimates indicate evacuation could take up to seven and one-half hours, RERP, II-32, RERP measures for evacuation are a wholly inadequate protective response to meet an emergency.

Contentions of Town of Hampton to Radiological Emergency Response Plan for the Town of Hampton, New Hampshire, November, 1985 (Contention VIII), at p. 12, admitted per Board's Memoranda and Orders of April 29, 1986, at 8, and May 18, 1987, at 27.

While acknowledging that "Hampton has a very high seasonal population," Revised Hampton RERP II-24, the State has revised the Hampton RERP to purportedly provide for "Protective Actions For Seasonal Beach Population." Revised Hampton RERP Appendix G. These "precautionary measures" merely provide that beaches may be closed and traffic control initiated for all but the lowest level of emergency classification in the event an emergency develops at Seabrook. By relying upon evacuation as the sole means to "protect" the beach population, the State thereby implicitly

acknowledges that no adequate sheltering or other protective responses short of evacuation would be appropriate or adequate in the event of radiological emergency. Indeed, the Revised Hampton RERP expressly acknowledges that, although "sheltering is a valuable protective action. . . sheltering may not be considered as a protective action on Hampton Beach during the summer." Revised Hampton RERP, Page II-26.

As set forth in the bases to Town of Hampton Contentions IV (Inadequate Transportation), Contention V (Inadequate Road System), and Contention VI (Lack of Adequate Personnel), however, evacuation of the tens of thousands of people from Hampton Beach is simply not feasible. Since a "major release" of radioactive material may occur within one hour of notification of onset of an accident, NUREG-0654 pages 13, 14, the thousands of beachgoers, many without benefit of the protection of even normal clothing, will likely be subject to significant radiological exposure and injury. 13, 14.

The Revised Hampton RERP and the Compensatory Plan prepared by the State, therefore, fail to make provision for any substantive changes over the original Hampton RERP to protect the beach population, confirm the Town's position that sheltering or alternative protective actions are unavailable to the Hampton Beach population, and fails to demonstrate that evacuation will provide adequate protection in the event of radiological emergency.

Contentions of the Town of Hampton to Revised Radiological Emergency Response Plan and to Compensatory Plan for the Town of Hampton, New Hampshire, April 14, 1986 (Revised Contention VIII), at pp. 8-10, as admitted by Board's Memoranda and Order of May 22, 1986, at 5, and May 18, 1987, at 27.

SAPL Contention 16:

The New Hampshire State and local plans do not make adequate provisions for the sheltering of various segments of the populace in the EPZ and therefore the plans fail to meet the requirements of 10 CFR § 50.47(a)(1), § 50.47(b)(10) and NUREG-0654 II.J.10.a. and m.

Appendix, Board's Memorandum and Order, May 18, 1987

Admitted Bases:

10 CFR § 50.47(b)(10) requires that a range of protective actions be developed for the plume exposure pathway EPZ. NUREG-0654 requires that there be maps of shelter areas and the inclusion of the bases for the choice of recommended protective actions from the plume exposure pathway during emergency conditions. NUREG-0654 II.J.10.m. specifies that the expected level of protection to be afforded in residential and other units must be evaluated. The New Hampshire State and local plans fail to meet these requirements because there are no provisions for sheltering the population in the beach areas and no provisions for the sheltering of the population in the many camping areas in the EPZ. In a quickly developing accident with anticipated fast release of short duration, sheltering could be the only realistic protective action that could be implemented. Evacuation of all transients is supposed to be carried out, according to the plans, if an evacuation is ordered. There is, however, no realistic description as to how this can be done. Given the current status of these plans and the lack of availability of sheltering capability for large segments of the population, a reasonable level of assurance that adequate protective measures will be available for transients in beach or camping areas has simply not been attained.

Seacoast Anti-Pollution League's Second Supplemental Petition for Leave To Intervene, dated February 21, 1986 (Contention 16), at pp. 19-20, admitted per Board Memorandum and Order of April 29, 1986, at 93.

Though an evaluation of the sheltering adequacy of some of the buildings housing special facilities appears at Table 2.6-3 of Vol. 1 of the NHRERP Rev. 2, there is no information given with regard to schools and day care centers.

Seacoast Anti-Pollution League's Contentions on Revision 2 of the New Hampshire Radiological Emergency Response Plan, November 26, 1986 (amended Contention 16), at pp. 24-25, admitted per Board Memorandum and Order of May 18, 1987, at 38.

NECNP Contention RERP-8:

Neither the New Hampshire RERP nor the local plans provide a "reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency," as required by 10 CFR § 50.47(a)(1), in that the plans do not provide reasonable assurance that sheltering is an "adequate protective measure" for Seabrook. Nor do the plans provide adequate criteria for the choice between protective measures, as required by § 50.47(b)(10) and NUREG-0654, § II.J.10.m.

Appendix, Board's Memorandum and Order, May 18, 1987

Admitted Bases:

The New Hampshire RERP relies on two principal protective actions for the public: sheltering and evacuation. The plan, however, contains only the most general criteria for determining when shelter should be used as opposed to evacuation. It provides no evaluation of the sheltering capacity of the Seabrook EPZ; or any analysis of how sheltering is expected to contribute to dose reduction in the event of an emergency. The following examples illustrate the plan's lack of analysis of the adequacy of sheltering, in spite of Seabrook area characteristics which raise considerable questions about the effectiveness of sheltering there.

a. The RERP includes virtually no assessment of the capacity to protect the public with sheltering facilities, whether during peak use periods or at other times. Only the adequacy of special facilities is described to any degree. Thus, there is no basis for a finding of reasonable assurance that sheltering constitutes an adequate protective measure for all people who may need it.

NECNP Contentions on Revision 2 of the New Hampshire State and Local Radiological Emergency Response Plans, November 26, 1986 (Contention RERP-8), at 7, as admitted per Board Memorandum and Order of May 18, 1987, at 53.

b. The RERP suggests that in order to achieve the greatest protection, "shelter should be sought in the lowest level of the building (e.g., in basements), away from windows." RERP at 2.6-6. No assessment is made of the number of structures in the Seabrook EPZ that have basements. In fact, it may reasonably be assumed that an unusually high proportion of Seabrook area houses, many of which are summer homes, do not have the tight construction that is necessary for effective sheltering.

NECNP Contentions on the New Hampshire State and Local Radiological Emergency Plans, February 24, 1986 (Contention RERP-8), at pp. 11-13, as admitted per Board Memorandum and Order of April 29, 1986, at 59.