UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD '85 DEC 11 A10:52



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| In the Matter of | ) | |
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| CAROLINA POWER & LIGHT COMPANY | ) | |
| and NORTH CAROLINA EASTERN | ) | Docket No. 50-400 OL |
| MUNICIPAL POWER AGENCY | ) | |
| | ) | |
| (Shearon Harris Nuclear Power | ) | |
| Plant) | ) | |

# APPLICANTS' PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW ON EDDLEMAN 57-C-3 (NIGHT-TIME NOTIFICATION)

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Counsel for Applicants

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APPLICANTS' PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW ON EDDLEMAN 57-C-3 (NIGHT-TIME NOTIFICATION)

## I. INTRODUCTION AND BACKGROUND

1. The Licensing Board will be issuing its fourth Partial Initial Decision in this contested proceeding on the application of Carolina Power & Light Company ("CP&L") and North Carolina Eastern Municipal Power Agency (collectively "Applicants") for a license to operate the Shearon Harris Nuclear Power Plant ("Harris").1/ The general history of the case is summarized in the Board's Partial Initial Decision on Environmental Matters, LBP-85-5, 21 N.R.C. 410 (1985).

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1/ Applicants understand that the Board soon will be issuing a separate partial initial decision on, inter alia, EPJ-4(b) and Eddleman 57-C-10, two emergency planning contentions which were heard on June 24 and 25, 1985. See Tr. 9972.

2. Eddleman 57-C-3 was the subject of evidentiary hearings convened in Raleigh, North Carolina on November 4 and 5, 1985. The two remaining emergency planning contentions -- EPX-2 and EPX-8 -- are the subject of ongoing discovery, with the summary disposition process scheduled for completion in mid-February.

3. Appendix A identifies, by witness, the location of the written testimony in the transcript. Appendix B lists the exhibits identified, and indicates the Board's ruling on any offers of exhibits into evidence.

## II. FINDINGS OF FACT

4. As originally admitted, Eddleman 57-C-3 asserted:

> The plan does not have provisions for notification at night, e.g. in the hours between 1 a.m. and 6 a.m. when most people living near the plant would normally be asleep. Nor does the plan assure that they would be timely awakened to take sheltering action, as e.g. on a summer night when many might have windows open or air conditioners on. The plan should provide automatic phone-dialing equipment to transmit an emergency message to all households in the EPZ for Harris, asking people to alert their phoneless neighbors.

The provisions for public notification of an emergency at Harris are the same whether the emergency occurs during the day or at night. The primary means of public notification is a system of 69 Federal Signal Thunderbolt Model 1000 rotating sirens located throughout the EPZ (plus 10 sirens on Harris

Lake). Testimony of David N. Keast, Alvin H. Joyner and Dennis S. Mileti on Eddleman 57-C-3 (Night-time Notification), ff. Tr. 9375 (hereinafter "Keast et al.") at 8; Testimony of Thomas F. Carter Regarding Eddleman Contention 57-C-3, ff. Tr. 9690 (hereinafter "Carter") at 9; Testimony of Van M. Lee Regarding Eddleman Contention 57-C-3, ff. Tr. 9690 (hereinafter "Lee") at 13. In ruling on Applicants' motion for summary disposition, the Board focused on "whether the sirens can wake up virtually all the people sleeping in the EPZ between 1 and 6 a.m., particularly those with windows closed and air conditioners running." The Board further questioned "whether the presently-planned means of back-up mobile notification could and should be augmented to meet the 'about' 15-minute standard in Appendix E, if necessary." Memorandum and Order (Ruling on Eleven Summary Disposition Motions) at 2-4 (February 27, 1985).

A. THE REGULATORY SCHEME

5. The Commission's emergency planning regulations, at 10 C.F.R. § 50.47(b)(5), require, in relevant part, that:

> * * * means to provide early notification * * * to the populace within the plume exposure pathway Emergency Planning Zone have been established.

The regulations further provide:

> The design objective of the prompt public notification system shall be to have the capability to essentially complete the initial notification of the public within the plume exposure pathway EPZ within about 15 minutes.

10 C.F.R. Part 50, Appendix E, § IV.D.3 (emphasis supplied). The language of the regulation itself thus evidences the Commission's intent to afford a degree of flexibility in the implementation of the public alert and notification system requirements.

6. The "design objective" to which Appendix E, § IV.D.3 refers is elucidated in NUREG-0654/FEMA-REP-1, "Criteria For Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness In Support of Nuclear Power Plants" (Rev. 1, Nov. 1980). See Final Rule on Emergency Planning, CLI-80-40, 12 N.R.C. 636, 638 (1980) (Commission endorsement of three-part design objective set forth in NUREG-0654). Specifically, the public alert and notification system is to be designed to provide:

> a) Capability for providing * * * an alert signal * * * to the population on an area wide basis throughout the 10 mile EPZ, within 15 minutes.
>
> b) The initial notification system will assure direct coverage of essentially 100% of the population within 5 miles of the site.
>
> c) Special arrangements will be made to assure 100% coverage within 45 minutes of the population who may not have received the initial notification within the entire plume exposure EPZ.

NUREG-0654, at 3-3. However, these criteria are qualified:

> The design objective for the system shall be to meet the acceptance criteria of section B of this Appendix [quoted immediately above]. This design objective does

> not, however, constitute a guarantee that early notification can be provided for everyone with 100% assurance or that the system when tested under actual field conditions will meet the design objective in all cases.

NUREG-0654, at 3-1 (emphasis supplied). Indeed, in promulgating the regulations on public alert and notification systems, the Commission itself expressly recognized "that not every individual would necessarily be reached by the actual operation of such a system under all conditions of system use."2/ See 45

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2/ This fact has been recognized on numerous occasions by the NRC's adjudicatory boards. The Appeal Board recently held:

> The FEMA criteria do not require that the sirens reach every person in the plume EPZ -- a practical impossibility. (Similarly, and for the very same reason, there is no NRC requirement along that line.)

Duke Power Co. (Catawba Nuclear Station, Units 1 and 2), ALAB-813, 22 N.R.C. 59, 77 (1985) (footnotes omitted). See also Pacific Gas and Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 and 2), LBP-82-70, 16 N.R.C. 756, 774 (1982) ("Joint Intervenors are in error in their assertion that 100 percent notification is required"); Catawba, supra, LBP-84-37, 20 N.R.C. 973, 973 (1984) ("There may be situations where the ambient noise inside a building may exceed the siren volume; however, these do not make the siren system inadequate. The requirements of FEMA-43 and NUREG-0654 were not intended as a guarantee that 100% of the population will actually hear the sirens in an emergency but rather were meant to establish a design objective for the siren system * * * * We find Catawba sirens meet this objective and are in compliance with the acceptance criteria.") In Southern California Edison Co. (San Onofre Nuclear Generating Station, Units 2 and 3), LBP-82-46, 15 N.R.C. 1531, 1534 (1982), the licensing board quoted the disclaimer in NUREG-0654 that 100% notification is not guaranteed under the design objective, and observed:

(Continued next page)

Fed. Reg. 55402, 55407 (August 19, 1980).

7. It is also instructive that an earlier, "for comment" version of NUREG-0654 described the design objective as assuring that 100 percent of the population within 5 miles of the plant and 90 percent of the population from 5 to 10 miles of the plant could be alerted within 15 minutes. However, in the final (November 1980) version of NUREG-0654, the design objective was modified to be "essentially 100%" (emphasis supplied) within 5 miles of the plant, and no specified percentage out to 10 miles.3/ The Commission explained its relaxation of the design objective:

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(Continued)

> It is important to recognize that no warning system can be expected to reach 100 percent of the target population * * * * The best of siren systems presumably will fail to reach some people for a variety of reasons, including, for example, unusually high ambient noise levels in some places, individual hearing defects, being asleep, etc. But we think it reasonable to assume that a carefully engineered siren system will be heard by the great majority of the people in the EPZ and that virtually all those who do not hear the sirens will be warned soon thereafter.

(Emphasis supplied).

3/ Thus, through the three-part design objective, the Commission has clearly recognized a distinction between system performance within 5 miles of the plant and system performance outside the 5-mile radius. Moreover, consistent with the qualified language of Appendix E, § IV.D.3, the Commission has expressly declined to specify any precise percentage which must be alerted within 15 minutes in either area.

> The lack of a specified percentage from 5 to 10 miles is to allow planners the flexibility to design the most cost-effective system to meet this general objective.

The Commission further emphasized that, "[i]n its implementation of this part of the rule, the NRC intends to be guided by FEMA's judgment as to what times and systems are feasible." Final Rule on Emergency Planning, CLI-80-40, 12 N.R.C. 636, 638 (1980).

8. In their review of public alert and notification systems, FEMA and the NRC Staff rely upon the numerical design criteria for fixed siren systems which are set forth in NUREG-0654, and discussed in greater detail in FEMA-43, "Standard Guide For The Evaluation of Alert and Notification Systems For Nuclear Power Plants" (September 1983). The Commission has expressly acknowledged these numerical criteria. See Final Rule on Emergency Planning, CLI-80-40, 12 N.R.C. 636, 639 n.3 (1980). The criteria provide generally that the target level for the design of an adequate siren system should be 10 dB above average daytime ambient background levels. In particular, a siren system satisfies the design objective if, for those geographic areas to be covered by sirens, either (a) the expected siren sound level generally exceeds 70 dBC where the population density exceeds 2,000 persons per square mile4/ and

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4/ The 70 dBC minimum is inapplicable in this case because there is no area within the Harris EPZ where the population density exceeds 2000 persons per square mile. Lee at 9, 26.

60 dBC in other inhabited areas, or (b) the expected siren sound level generally exceeds the average measured daytime ambient sound levels by 10 dB. Carter at 7-8. FEMA also conducts a day-time siren test, followed by a telephone survey of residents.5/ Tr. 9641, 9642 (Keast).

9. FEMA has conducted a thorough review of Applicants' siren system against the NUREG-0654 and FEMA-43 numerical criteria, and has concluded that -- with the addition of six additional sirens being installed by Carolina Power & Light Company6/ -- the system conservatively meets the NRC/FEMA design criteria. Carter at 9-14; Lee at 6-10. Indeed, the Harris siren system (as augmented) is capable of providing, under average conditions, a sound coverage of greater than 80 dBC to almost 60% of the residences in the EPZ. This coverage is 20 dBC greater than that required by FEMA and NRC guidance. This 80 dBC represents 10 times the sound pressure of 60 dBC. Therefore, in the Harris EPZ, almost 60% of the residences are exposed to 10 times the sound pressure considered by FEMA and NRC to be adequate. Carter at 17.

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5/ A 70% positive response in the survey is considered acceptable, based on research indicating that direct notification of that magnitude in a real emergency would result in informal notification of the remainder of the population. Tr. 9940-41 (Carter).

6/ CP&L also plans to install a seventh additional siren, near the southern perimeter of the EPZ (for a total of 79 sirens, including the 10 on Harris Lake). Keast et al. at 8.

10. However, NUREG-0654 and FEMA-43 provide for the use of average summer daytime conditions in analyzing the adequacy of siren system designs. Keast et al. at 11; Lee at 19. Therefore, because siren coverage depends upon meteorological conditions, separate analyses were performed by both the NRC Staff/FEMA and Applicants to address the specific conditions postulated in Contention Eddleman 57-C-3 -- summer nighttime conditions. Keast et al. at 11.

B. THE WITNESSES

11. The evidentiary record on Eddleman 57-C-3 includes the written and oral testimony of the witnesses presented by Applicants and the witnesses presented by the NRC Staff/FEMA. Mr. Eddleman presented no witnesses. However, on November 4, 1985, the opening day of evidentiary hearings on Eddleman 57-C-3, Mr. Eddleman orally requested that the Board issue a subpoena to compel the appearance of Dr. M. Reada Bassiouni of Acoustic Technology, Inc. ("ATI")7/ to testify as a witness

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7/ ATI analyzed the siren system for Harris (as well as the other CP&L nuclear facilities) and prepared the standard documentation submitted to FEMA by CP&L to demonstrate that the system meets the criteria and guidance in NUREG-0654/FEMA-REP-1, "Criteria For Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness In Support of Nuclear Power Plants" (Rev. 1, Nov. 1980) and in FEMA-43, "Standard Guide For The Evaluation of Alert and Notification Systems For Nuclear Power Plants" (September 1983). Tr. 9407-08. The standard documentation analyzes the system for average summer daytime conditions, in contrast to the night-time conditions here at issue.

either for the Board or for Mr. Eddleman. Mr. Eddleman represented that, in a five-minute telephone conversation earlier that morning, Dr. Bassiouni expressed disagreement with some of the prepared testimony filed on this contention. Tr. 9362, 9364-65, 9413.

12. Near the close of the hearing, Dr. Bassiouni presented by telephone a statement of the results of his review, which was limited to the NRC Staff/FEMA testimony. Much of Dr. Bassiouni's statement was essentially a defense of his computer model. But neither Applicants nor the NRC Staff relied upon the Bassiouni model in response to this contention. Accordingly, it is not at issue here. In addition, Dr. Bassiouni disputed the applicability of certain data used in the NRC Staff/FEMA testimony, relying instead upon a 1962 study by the Institute for Phonetics and Communication Research of the University of Bonn, Germany ("the German Study"), which addressed the effectiveness of air raid sirens in alerting a sleeping population -- a study which Dr. Bassiouni characterized as "more applicable to the question of night-time siren alerting." Finally, Dr. Bassiouni challenged consideration of informal notification as a component of an alerting system. Tr. 9867-86.

13. After the November 5 conference call with Dr. Bassiouni, the Board directed Mr. Eddleman to renew his request in writing. Mr. Eddleman did so, and the other parties filed timely responses. Appended to Applicants' response was

an article entitled "Prompt Notification of 100% of People in the EPZ," authored by Dr. Bassiouni and published in Power Engineering (September 1983), at pages 47-49. In addition, counsel for the NRC Staff distributed a written version of Dr. Bassiouni's statement ("the Bassiouni Statement") and a largely untranslated copy of the German Study, which Dr. Bassiouni had provided to the Staff at the request of the Board. Counsel for the NRC Staff then undertook to have the German Study translated, and copies of the translated study were provided to the Board and the parties. In a December 4 conference call, the Board denied Mr. Eddleman's motion, but admitted into evidence the Bassiouni Statement (as if presented under oath), as well as the German Study and the Bassiouni article in Power Engineering. Tr. 10224-25.8/

14. Addressing Eddleman 57-C-3 on behalf of the NRC Staff/FEMA was a distinguished panel of experts: Mr. Thomas F. Carter, Dr. Van M. Lee, Dr. Karl D. Kryter, and Dr. Jiri Nehnevajsa. As Vice President of the Consulting Services Group of International Energy Associates Limited ("IEAL"), Mr. Carter is currently Manager of IEAL's project to support FEMA in the

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8/ For ease of reference, Applicants have taken the liberty of denominating the Bassiouni Statement and the German Study as Eddleman Exhibits 73 and 74, respectively. The Power Engineering article is denominated Applicants' Exhibit 54. In addition, the Bassiouni Statement was read into the record at Tr. 9873-79.

evaluation of alert and notification systems at nuclear power plants. Mr. Carter has a B.S. in Civil Engineering and, in the past, has held a series of management positions with the NRC. In his last position, he was responsible for the formulation of emergency planning policy for all fuel cycle facilities. In addition, he served as Chairman of the NRC's "Three Mile Island" Task Force on Emergency Planning, and -- under subcontract to Argonne National Laboratory -- was the principal author of FEMA-43. Carter at 1-2. Mr. Carter's prepared testimony summarized the NRC and FEMA requirements and guidance for siren systems, IEAL's standard review of the Harris siren system, and the conclusions reached by the NRC/FEMA experts regarding Eddleman 57-C-3. Carter at 6.

15. Dr. Lee, who has a Ph.D. in Noise and Acoustics (with a minor in Applied Mathematics) is President and principal consultant of Analysis & Computing, Inc., specializing in noise assessment and acoustical design, communication and warning system design and evaluation, and computer modeling. Since June 1983, Dr. Lee has been retained by IEAL as an acoustics consultant dealing specifically with the sound level coverage evaluation of nuclear power plant fixed siren systems. Lee at 1-2. Dr. Lee's prepared testimony presented his predictions of the acoustical performance of the Harris siren system. Carter at 5; Lee at 6-10, 22-26.

16. The third member of the NRC Staff/FEMA panel was Dr. Kryter, who has a Ph.D. in Psychology (with a minor in Physiology). An eminent expert in the field of psychoacoustics, Dr. Kryter has held an impressive series of teaching and research positions over the course of his career. Most recently, he served for 11 years as the Director of the Sensory Sciences Research Center of the Stanford Research Institute, and since 1976 has served as Staff Scientist with that organization. He also presently serves as President of the Acousis Company. Over the years, he has conducted research on a broad range of problems concerned with basic auditory system functions, with the relations between the acoustical characteristics of sound and physiological, psychological, and social reactions to sound and noise. This work has been conducted under contracts and grants from the military services, the National Institutes of Health, the National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), U.S. Environmental Protection Agency (EPA), National Sonic Boom Office of the President's Office of Science and Technology, and the Port Authority of New York and New Jersey (PANYNJ), as well as industrial organizations and other governmental bodies. He has also conducted research on and developed procedures and models for the assessment of the effects of sound and noise on sleep and annoyance. Recently, he prepared an "Analysis of Laboratory and Field Data on Awakening from Noise" (NASA 1984),

and -- under sponsorship of NASA, EPA, and U.S. Department of Transportation -- authored "The Effects of Noise on Man, 2nd. Edition", Academic Press (1985). Testimony of Karl D. Kryter Regarding Eddleman Contention 57-C-3, ff. Tr. 9690 (hereinafter "Kryter") at 1-3. Dr. Kryter's prepared testimony addressed the arousal of people from sleep in response to the operation of the Harris siren system. Kryter at 3-4; Carter at 5.

17. The final member of the NRC Staff/FEMA panel is Dr. Nehnevajsa. Dr. Nehnevajsa has a Ph.D. in Sociology (with minors in Mathematical Logic and Journalism), and has held a number of teaching positions (both in this country and abroad) during his career. Dr. Nehnevajsa has been affiliated with the University of Pittsburgh for nearly 25 years, and presently serves as Professor of Sociology at that institution. For the past 25 years, he has conducted research on emergency preparedness problems, including consideration of attitudes and behavior related to mass emergencies (both natural and technological hazards). In the last few years, Dr. Nehnevajsa has been engaged in a program to develop a major data bank, including existing findings (as expressed in disaster research literature) as well as original surveys and other studies undertaken over the years by various researchers on attitudes and behavior in anticipation of, preparedness for, and response to emergencies. Testimony of Jiri Nehnevajsa Regarding Eddleman Contention 57-C-3, ff. Tr. 9690 (hereinafter "Nehnevajsa"), at 1-4.

Dr. Nehnevajsa's prepared testimony focused on some of the key issues which arise in the content of behavioral implications of possible night-time emergencies at Harris. Nehnevajsa at 4; Carter at 5.

18. Applicants also presented a panel of impressive experts to address Eddleman 57-C-3: Mr. David N. Keast, Dr. Dennis S. Mileti, and Mr. Alvin H. Joyner. Mr. Keast holds an M.S. in Electrical Engineering, and is presently a Vice President and Senior Project Manager with HMM Associates, Inc., where he specializes in public warning system studies. His 30-year professional career has been almost entirely in the field of acoustics. His specific experience with systems of sirens for emergency public alerting includes the design of siren systems for the Susquehanna, Millstone, Connecticut Yankee, Perry and Seabrook Nuclear Power Plants. In addition, he has prepared reports in response to FEMA-43 for the public alerting systems at Turkey Point, St. Lucie, Crystal River, Hatch, Perry, Seabrook and Pilgrim; and, for Battelle Northwest Laboratories, he supervised the development of an analytical method of estimating the effectiveness of siren systems. Of particular pertinence to the subject of nighttime notification, Mr. Keast has performed research, published papers and provided consulting services on the effects of meteorological conditions on the propagation of sound outdoors, on the sound attenuating properties of building structures, and on ambient background

noise levels. He has also provided consulting services and prepared environmental impact studies on the effects of sounds (noise) on people, and has developed performance criteria for and designed noise control treatments to mitigate noise problems. Keast et al. at 2-3, Attachment 1. Mr. Keast's firm, HMM, was retained by Carolina Power & Light Company to analyze the Harris siren system in response to Eddleman Contention 57-C-3. His prepared testimony thus estimated the percentage of households in the Harris EPZ which would be alerted by the operation of the sirens on a hot summer night, when air conditioning would be in use. Keast et al. at 2, 8.

19. Dr. Mileti is a Professor in the Department of Sociology and Director of the Hazards Assessment Laboratory at Colorado State University, specializing in those areas of study dealing with organizations, hazards, policy and methods.(with a particular emphasis on public response to emergencies). Since 1972, Dr. Mileti has received numerous research grants and contracts from such organizations as Oak Ridge National Laboratories, the National Science Foundation, FEMA and the NRC, dealing with emergency preparedness and response over a broad range of natural and technological hazards. His expertise has been employed by various nuclear utilities, including Pacific Gas & Electric Company, Kansas Gas & Electric Company, Louisiana Power & Light Company. He is the author of more than 150 publications in the field of disaster sociology, including

many on public emergency response. Dr. Mileti is active in a number of professional organizations, and currently serves as a member of the Committee on Natural Disasters in the National Academy of Sciences. Keast et al. at 5-7, Attachment 3. Dr. Mileti's prepared testimony addressed the informal notification processes which would operate in the event of an emergency at Harris. Tr. 9377 (Mileti); Keast et al. at 28-41.

20. The final member of Applicants' panel, Mr. Joyner, is the lead planner for fixed nuclear facilities within the Division of Emergency Management ("DEM") of the North Carolina Department of Crime Control and Public Safety. The basic responsibilities of DEM include fulfilling the State's role in emergency planning for natural and technological disasters, in responding to and recovering from disasters, and in mitigating their effects. Mr. Joyner has been directly involved in the development of the offsite emergency capability for the Harris plant, as well as the Catawba, McGuire, and Brunswick nuclear plants. In addition, he has supported DEM's response to statewide emergencies such as the tornadoes in March 1984, Hurricane Diana in September 1984, the forest fires which occurred across the State in the Spring of this year, and most recently, Hurricane Gloria. Keast et al. at 4-5, Attachment 2. Mr. Joyner's prepared testimony addressed the extensive system of mobile alerting in place throughout the Harris EPZ. Keast et al. at 26-28.

21. This litany of credentials makes it abundantly clear that the experts presented by Applicants and the Staff are eminently qualified, among the foremost authorities in their fields in the country. The knowledge, experience, expertise and judgment evidenced in their analyses -- and, indeed, in their testimony before the Board -- was most impressive.

C. THE ALERT/NOTIFICATION SYSTEM FOR THE HARRIS EPZ

1. Fixed Sirens

22. Different, but fundamentally consistent, methodologies were used by Applicants and the NRC Staff/FEMA in their analyses in response to Eddleman 57-C-3. Tr. 9569-70 (Keast). The first step in both analyses was to calculate the sound coverage around each of the sirens for summer nighttime conditions, to determine the siren sound levels outside of all the houses in the EPZ. Keast et al. at 9; Lee at 22. It was also necessary to account for the attenuation of sound from outside a house to an inside bedroom. Keast et al. at 9; Kryter at 26.

a. Siren Sound Propagation

23. Applicants relied upon the SIREP computer model9/ to

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9/ The SIREP model has also been used for studies of siren coverage around the Seabrook, Pilgrim and Maine Yankee plants. The model accounts for all the major parameters which influence outdoor sound propagation, including spherical divergence, at-

(Continued next page)

calculate the outdoor sound coverage of the 68 sirens which were analyzed.10/ The computer model determined the maximum outdoor sound levels at various distances in each of 16 directions from each siren, given the terrain around each siren and appropriate summer nighttime meteorological conditions. Using the computer calculations, sound-coverage contours (mis-shapen rings) were plotted around each siren in 5 dB steps, from 105 dB to 60 dB, on a map depicting the locations of all residences in the EPZ. Keast et al. at 10-12; Applicants' Ex. 46.

24. Next, the residences within each pair of contours were counted and a sound level attributed to each of these counts. At the lower siren sound levels, many houses were covered by approximately the same sound level from two or more sirens. In such cases, the exposures were logarithmically combined to account for the overlapping siren coverage. In this

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(Continued)

mospheric absorption, attenuation by forests, ground absorption, refraction caused by vertical wind speed and temperature gradients, scattering by buildings in built-up areas and shielding by hills. SIREP predictions have been compared with field measurements of actual siren sounds obtained by other organizations and have been found to be in close agreement. Keast et al. at 10.

10/ Both Applicants and the NRC Staff/FEMA analyzed the performance of a 68 siren system for the particular conditions postulated in Eddleman 57-C-3. The analyses are therefore conservative to the extent that they excluded the 10 sirens around Harris Lake and one new siren to be installed near the southern perimeter of the EPZ. Keast et al. at 8; Lee at 22.

manner, outdoor siren sound levels were assigned to all houses in the EPZ. A total of 19 nominal outdoor siren sound levels, ranging from 67 to 112 dB, were identified. Keast et al. at 12-13.

25. In determining the siren sound levels indoors (in the bedroom), Applicants' analysis considered the differing attenuation characteristics of different houses (attributable almost entirely to windows). On the basis of acoustic studies and demographic data, the houses in the EPZ were divided into eight sub-groups,11/ assuming an even distribution of each sub-group,

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11/ The eight sub-groups included: (1) Homes with no air-conditioning, with bedroom windows open and a window fan in operation (35.6% of the houses in the EPZ); (2) Homes with window air conditioners in the bedroom, with windows closed and storm windows open or absent (16% of the houses in the EPZ); (3) Homes with window air conditioners elsewhere in the house, with windows closed and storm windows open or absent (3.6% of the houses in the EPZ); (4) Homes with window air conditioners elsewhere in the house, with windows and storm windows closed (10.6% of the houses in the EPZ); (5) Homes with central air conditioning cycled "on", with windows closed and storm windows open or absent (2.6% of the houses in the EPZ); (6) Homes with central air conditioning cycled "on", with windows and storm windows closed (8% of the houses in the EPZ); (7) Homes with central air conditioning cycled "off", with windows closed and storm windows open (5.9% of the houses in the EPZ); and (8) Homes with central air conditioning cycled "off", with windows and storm windows closed (17.7% of the houses in the EPZ).

Applicants' analysis assumed that all houses without air conditioning would have a window fan in use; the analysis is thus conservative to the extent that it overstates the background noise for houses without window fans. Similarly, for that percentage of the housing stock with a window unit installed in a room other than the bedroom, Applicants' analysis assumed the installation of those units in rooms immediately

(Continued next page)

according to its percentage of the housing stock, within each of the sound contour levels. Keast et al. at 13, Attachment 6. Each of the 19 groups of houses covered by different outdoor siren sound levels was analyzed separately, by dividing it into the eight sub-groups with different siren sound levels in the bedroom, and with different amounts of siren sound relative to the background noise in the bedroom. Thus, Applicants' exhaustive analysis determined the siren sound levels in the bedroom for a total of 152 separate cases (19 times 8). Keast et al. at 13-15.

26. Similarly, the NRC Staff/FEMA analysis applied the OSPM computer model12/ individually to each of the 68 sirens to calculate the outdoor siren sound coverage under summer nighttime meteorological conditions. The output of each of the

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(Continued)

adjacent to the bedroom, with the intervening door open. This also introduces an element of conservatism to the extent that it overstates the background noise in the bedroom of such houses. Keast et al. at 13-14, Attachment 6.

12/ The Outdoor Sound Propagation Model ("OSPM") is used by Dr. Lee to evaluate the FEMA-43 reports submitted by all licensees, and has been verified extensively by comparison to actual field data. Tr. 9830 (Lee); see also Tr. 9729-30 (Lee). The OSPM accounts for factors influencing outdoor sound propagation, such as spherical divergence, atmospheric absorption, ground impedance, vertical wind speed and temperature gradients, natural and man-made obstructions, foliage attenuation, and turbulence. Thus, OSPM is based on established principles of sound propagation in the atmosphere and over the ground. In addition, its application has demonstrated reasonable success in quantifiable statistical terms. Lee at 8, 12-18.

68 computer runs (consisting of estimated siren sound pressure levels in dBC at each of 112 polar grid points) was then fed individually into a surface interpolation and mapping program to generate a finer mesh over the entire EPZ. Next, each of 46,225 grid mesh points was analyzed and, for each point, the maximum of multiple siren sound level contributions was selected. (The NRC Staff/FEMA analysis is thus conservative to the extent that it understates the effect of overlapping coverage of multiple sirens). Final contours were drawn through this mesh at intervals of 5 dB. The resulting contour map was scaled and overlaid on a map depicting the locations of all residences in the EPZ. Then, the number of houses located within incremental 10 dB contours (ranging from 110 dB to 60 dB) was counted. Outdoor siren sound levels were thus assigned to all houses in the EPZ. Lee at 22-23. Finally, the NRC Staff/FEMA analysis considered the attenuation of siren sound from outdoors to an inside bedroom. Like Applicants' analysis, the NRC Staff/FEMA analysis (which was based on acoustic studies) focused on the position of windows (i.e., open or closed). Kryter at 26-27.

b. Probability of Alerting

27. Given the determined siren sound levels in the bedroom, the analyses of Applicants and the NRC Staff/FEMA next considered the probability that a sleeper would be awakened by

such levels. There are five factors which determine whether a sound will arouse a sleeper. First, the level of the awakening sound at the sleeper's head position must be high enough to be audible. Once this threshold is exceeded, the chance of awakening increases as the sound level increases. Secondly, the duration of the sound is important. The longer a sound of a given level persists the more likely it is that it will awaken people. Third, the age of the sleeper has some bearing. The tendency of people to be awakened by a sound generally increases with their age. Fourth, the meaning of the sound, or the motivation of the sleeper to be awakened by the sound, is a factor. Even when sleeping, individuals still hear and discriminate among the sounds in their environment. Depending upon motivation, they are more likely to be awakened by certain "recognizable" sounds than by others. It is a common experience that some sounds sufficient to awaken people are quite modest: a footstep in the hall or a restless child in another room. Finally, physiologists have determined that normal sleep has several different stages which occur at various times during th sleep period. People are more likely to be awakened during some of these sleep stages than during others. Keast et al. at 17-18; Kryter at 6-9.

28. Applicants' sleep awakening analysis was based primarily upon a report by Jerome S. Lukas of the Stanford Research Institute, "Measures of Noise Levels: Their Relative

Accuracy in Predicting Objective and Subjective Responses to Noise During Sleep," EPA-600/1-77-010 (EPA, Feb. 1977) (Applicants' Ex. 48) -- a comprehensive analysis of about 20 different research studies on the effects of sound on sleep. Applicants' analysis applied two of the major findings of the Lukas report: First, the use of Effective Perceived Noise Level ("EPNdB") as the appropriate measure of sound exposure (in terms of sound level, spectral content, and duration) to relate sound to sleep disturbance and awakening13/; and second, the relationship between sound (measured in EPNdB) and the percentage of people awakened. Keast et al. at 18-20.

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13/ Effective Perceived Noise Level is a measure which combines the various physical properties of a sound into a number that correlates highly with people's judgment of the noisiness of the sound. EPNdB is expressed in decibels. Included in the EPNdB measure computed for a sound are factors for the spectral content (akin to pitch) of the sound, the magnitude or level of the sound, the duration of the sound, the rapidity with which it occurs and the presence of any strong tonal characteristics in the sound. Keast et al. at 18-20.

Thus, for example, in computing EPNdB values, a doubling of sound duration has the same effect as a doubling of sound level -- a 3 dB increase in both cases. In this way, the EPNdB concept reflects the fact that the probability of awakening can be enhanced either by increasing the duration of the sound or by increasing the level of the sound. (This is the justification for logarithmically adding the outdoor siren sound levels for those houses that fall within the coverage areas of two or more sirens). Similarly, in computing EPNdB values, Applicants' analysis considered the effective sound duration for rotating sirens, reflecting both the directivity of the sirens and the siren rotation rate. Keast et al. at 20-22.

29. Using Lukas' method, and assuming a total siren operating time of 10 minutes,14/ the EPNdB values were calculated for each of the 152 categories of houses identified by Applicants' analysis. Keast et al. at 20; Tr. 9500-02 (Keast). Applicants then determined the percentage of people who would be awakened at those EPNdB values. The Lukas report gives the percentage of people who would be awakened at any EPNdB value. That percentage, divided by 100, is the probability of awakening any one person exposed to that EPNdB. It is only necessary to awaken one person in a household in order to assure that the whole household will be alerted. U.S. Census data indicate that 18.5% of the households in the Harris EPZ have one person; 29.5% have 2 persons; 19.6% have 3 persons; and the remaining 32.4% have 4 or more persons. Applicants therefore calculated the probability of awakening one person for 18.5% of the houses; the probability of awakening one out of two persons for 29.5% of the houses; the probability of awakening one out of three persons for 19.6% of the houses; and the probability of awakening one out of four persons for 32.4% of the houses. Summed over all 152 housing categories, this data demonstrated that at least one person would be awakened in 69% of the

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14/ Because Applicants' EPNdB calculations were performed assuming a total siren operating time of 10 minutes, Applicants' computations are conservative in light of the 12 minute operating time planned by the State of North Carolina. Keast et al. at 24-25.

households in the EPZ. Based upon information from Arbitron Rating Service on the population already awake between 1 a.m. and 6 a.m., 3% was added, to conclude that a total of 72% of the households would be directly alerted by the Harris siren system under the conditions postulated in Eddleman 57-C-3. Keast et al. at 9, 22-23.

30. The NRC Staff/FEMA sleep awakening analysis was based primarily upon a study by Horonjeff and others.15/ Specifically, based on the Horonjeff study, Single Event Level ("SEL") in dBA was selected as the appropriate measure for the combined effect of sound level and duration.16/ Further, the NRC Staff/FEMA analysis relied upon curves representing the arousability from sleep of various age groups, derived from the Horonjeff study. Kryter at 18, 20-23.

31. With the dBA levels of the sirens outdoors converted into indoor SELs (Kryter at 26, 28), the NRC Staff/FEMA analysis then determined the number of people who would be alerted at those SEL values. The arousal probabilities for one-person

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15/ See Horonjeff, R.D.; Bennett, R.L.; and Teffeteller, S.R.; Sleep Interference, EA-1240, Vol. 2, Project 852, Electric Power Research Institute, Palo Alto, CA 94304 (1979); and Horonjeff, R.D.; Fidell, S.; Teffeteller S.R.; and Green, D.M.: Behavioral Awakening as Functions of Duration and Detectability of Noise Intrusions in the Home. J. Sound & Vib., Vol. 84, No. 3, 1982, pp. 327-36. Kryter at 9, 33.

16/ The SEL measure used in the NRC Staff/FEMA analysis is thus conceptually comparable to the EPNdB measure employed in Applicants' analysis.

households (based on the Horonjeff curves) were applied to households varying in size, with a variable number of adult household members, assuming a siren signal sounded 3 times, for 3 minutes each time.17/ The NRC Staff/FEMA presented results for three basic attenuation categories (all houses with windows open, half with windows open, and all with windows closed), broken out to differentiate between the first, second and third siren activations, and distinguishing between the time period 12-2 a.m. and the time period 2-6 a.m. The NRC Staff/FEMA results do not separate the percentage awakened by the sirens from the percentage where someone was already awake at the time of the signal; rather, they combine the two percentages. In addition, the NRC Staff/FEMA results are expressed both as a percent of people aroused or awake, as well as a percent of households aroused or awake. Nehnevajsa at 14-16.

32. Given the differing assumptions and methodologies employed by Applicants and the NRC Staff/FEMA, and considering the differing ways in which the two parties have expressed their results, it is difficult to compare the results of the two analyses directly. Nevertheless, Applicants' estimate of 72% of households alerted is at least generally comparable to

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17/ Thus, like Applicants' computations, the NRC Staff/FEMA calculations are also conservative, given the effective 12 minute siren operating time planned by the State of North Carolina. Keast et al. at 24.

the NRC Staff/FEMA estimate of 70.5% of households alerted at 2-6 a.m. (72.3% at 12-2 a.m.), after 9 minutes of siren activation, assuming half the houses with windows open.18/ Tr. 9569 (Keast); Nehnevajsa at 15. The results of the different but complementary analytical approaches taken by the NRC Staff/FEMA and by Applicants thus generally confirm one another.

33. Dr. Bassiouni appears to challenge the awakening curves on which the NRC Staff/FEMA analysis relies. Instead, Dr. Bassiouni would rely upon a 1962 German Study of "the effectiveness of air raid sirens for alerting a sleeping population." According to Dr. Bassiouni, that study "concluded that a 60 dB signal was necessary for 60% alerting."19/ Eddleman Ex. 73 at 5; Eddleman Ex. 74 at 3, 18, 35.20/ However,

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18/ In a June 1985 survey in the aftermath of a tornado, some 83.6% of respondents indicated that they typically sleep with their bedroom windows open. Based on that information, the NRC Staff/FEMA assumption that half the houses have windows open may be conservative. Nehnevajsa at 15.

19/ As noted elsewhere, when the Board requested (through Staff counsel) a copy of the German Study, Dr. Bassiouni provided a copy in German, with only the captions on the tables and graphs translated. There is no indication that Dr. Bassiouni or anyone on the ATI staff reads German. If that is true, it would appear that the Bassiouni Statement was based solely on the tables and graphs of this apparently unpublished paper, with no consideration of the explanatory (untranslated) text of the study.

20/ All references are to the pagination of the translated version of the German Study.

comparison of these figures to those used by Applicants and the NRC Staff/FEMA reveals that the conclusions of the German Study are actually less conservative than the figures used by Applicants and the NRC Staff/FEMA. In other words, use of the German figures would show a greater percentage of the population awakened than would use of the data relied upon by Applicants and the NRC Staff/FEMA.

34. For example, to compare the results of the German Study to the NRC Staff/FEMA analysis, one must convert sound level into SEL. Assuming that the 60 dB reference in the German Study is to C-weighting (as opposed to A-weighting),21/ approximately 3 decibels must be subtracted to convert dBC to dBA: 60 dBC minus 3 equals 57 dBA. Lee at 23-25. Next, the 45-second siren duration used in the German tests22/ must be converted to seconds, and plugged into the formula in the Kryter Testimony. Thus, the SEL for the 45-second siren

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21/ It is unclear whether the German Study used A-weighting or C-weighting. For the sake of this analysis, it is assumed that the German Study used C-weighting, since C-weighting is commonly used to rate sirens (Lee at 5), and since A-weighting was not widely used in 1962. In any event, the comparison of Applicants' analysis to the German Study would not be affected in any way if the German Study actually used A-weighting; and, while the difference would be narrowed, the NRC Staff/FEMA analysis would still be conservative relative to the German Study.

22/ The German tests used a 1-minute test period, in which test subjects were exposed to 45 seconds of sound, with an additional 15 seconds to record their responses to the signal. Eddleman Ex. 74 at 16, 18.

sounding in the German tests can be calculated by adding 16.5 dB to the peak dBA level. Kryter at 19. Adding 16.5 dB to 57 dBA yields an SEL of 73.5. Figure 7A of the Kryter Testimony (Kryter at 25) indicates that an SEL of 73.5 can be expected to awaken about 37% of those between 18 and 34 years of age, about 41% of those between 35 and 54 years old, and about 50% of those 55 years of age and older -- compared to the 60% indicated by the German Study.

35. Similarly, to compare the results of the German Study to Applicants' analysis, one must convert sound level into EPNdB. First, a tone correction of 10 dB and an onset correction of 3 dB must be added to 60 dB. Then, the 45-second siren duration used in the German Study must be converted to half-seconds, and plugged into the formula in the Kryter Testimony. Thus, the EPNdB for the 45-second siren sounding in the German tests can be calculated by adding 60 dB plus 10 dB plus 3 dB plus 19.5 dB, to yield 92.5 EPNdB. Tr. 9502 (Keast); Kryter at 19. This measure, 92.5 EPNdB, can be expected to awaken about 34% of the population -- again, in contrast to the 60% stated by the German Study. Applicants' Ex. 48 at 21. In short, contrary to the implication of the Bassiouni Statement, the German Study is in fact less conservative than the analyses performed by Applicants and the NRC Staff/FEMA.

36. The results of the quantitative analyses performed by Applicants and the NRC Staff/FEMA are also validated by

anecdotal evidence -- instances where sirens have operated at night, either intentionally or inadvertently, and awakened large numbers of people as a result. Most recently, when Hurricane Elana was approaching the west coast of Florida, the siren system in the EPZ around the Crystal River Nuclear Plant was activated at 1:00 in the morning, and was very effective. In addition, there have occasionally been inadvertent operations of a few sirens at night near the Indian Point and Pilgrim Nuclear Plants, and indeed at Harris in April. In every case, there were large numbers of irate phone calls to local police departments and other public officials. Keast et al. at 25-26.

2. Mobile Alerting

37. In addition to the fixed siren system, emergency response officials would provide additional public notification of an emergency through an extensive system of mobile alerting throughout the entire EPZ. Thus, in all four counties within the EPZ, vehicles with flashing lights, sirens and/or public address systems would be dispatched to provide additional public warning by driving predesignated routes within the EPZ. Keast et al. at 26.

38. Based on past experience, the State of North Carolina is confident that the flashing lights, sirens and/or PA systems of mobile alerting vehicles passing throughout the EPZ would

alert most households who might not have heard the fixed sirens. A specific illustration of the use of mobile alerting is the November 1977 evacuation of between 400 and 500 people in Clyde, North Carolina, due to a flash flood. Beginning at about 2:00 a.m., using two police cars and a fire truck, emergency officials completed public notification within approximately 30 minutes. Keast et al. at 27.

39. There simply are not sufficient resources available to complete mobile alerting within 15 minutes.23/ Keast et al. at 27. But, although the mobile alerting process cannot be completed within 15 minutes,24/ it would be well underway within that period. The times for completion of route alerting would range from approximately 20 to 45 minutes, depending on the subzone. (These times include the time needed for

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23/ Moreover, there are obvious practical constraints on the ability to restructure mobile alerting routes to target rural areas for coverage within 15 minutes. Emergency vehicles are routinely stationed in populated areas, and it may take all of 15 minutes for the vehicles to travel to the rural areas to be alerted. Tr. 9583 (Joyner).

24/ Where (as here) it is not relied upon as a part of the primary notification system, mobile alerting is not subject to the time limits that the Commission regulations and guidance impose on the primary notification system (here, the fixed sirens). See, e.g., Philadelphia Electric Co. (Limerick Generating Station, Units 1 and 2), Docket Nos. 50-352-OL, 50-353-OL, "Memorandum and Order Ruling On Limerick Ecology Action's Petition For Reconsideration of Rulings On Admissibility of Offsite Emergency Planning Contentions" (May 21, 1984), slip op. at 6 ("route alerting" not subject to regulatory time limits where fixed siren system is primary notification system).

emergency personnel to reach their duty posts to begin the notification process). Keast et al. at 26-27. Indeed, because many of the routes commence in populated areas (where the mobile alerting vehicles are routinely stationed and therefore readily available), thirty to forty percent of the households in the EPZ could be covered via route alerting within 15 minutes. Tr. 9583 (Joyner).

40. Following the initial fixed siren and mobile alerting warnings, mobile alerting personnel would run back through their routes to confirm public notification, stopping to give personal notification at houses which are still dark. In addition, law enforcement and other official vehicles would be in the area to ensure complete evacuation or other protective action, and to provide security. They will be instructed to check premises where no protective action activity is evident. Keast et al. at 41; Tr. 9596-97 (Joyner).

3. Informal Notification

41. In addition to the two means of formal notification discussed above (the fixed siren system and mobile alerting), the general public would be alerted to an emergency through a wide variety of informal means. Disaster research literature is replete with data pertaining to the fact that many people, if alerted to a danger, will seek to contact others.25/ Thus,

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25/ Public response to emergency information and warnings of impending disasters has been a topic of investigation by social

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informal notification is a very typical public response to emergency information and warnings. It is a phenomenon that is well documented by social science research, and it would undoubtedly occur in response to formal notification of an emergency within the Harris EPZ. Nehnevajsa at 16-17, 19; Keast et al. at 28.

42. Historically, many people in emergencies have received their first warning from other members of the general public. There are two reasons why this is the case. First, the initial response of most people to a warning of an impending emergency is to engage in a process of "confirming" the warning information. Confirmation of warning information occurs in a variety of ways; for example, people may turn to different radio or TV stations to hear the warning several times, check with friends and neighbors to ask if they heard the same message, and talk the situation over with others. One consequence of the behaviors in which people engage as they seek confirmation of warning information is that they actually

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scientists for almost three decades. Many studies have been performed on the subject in a variety of emergencies stemming from geological, climatological, and technological phenomena, and have been documented in a vast body of emergency literature. This research record provides evidence about a wide range of emergency warning/public response phenomena, including public notification and communication between members of the public in an area at risk. Keast et al. at 28-29.

become part of the notification/warning dissemination effort, albeit informally, through social networking. In other words, in the event of an emergency at the Harris plant, the seeking of confirmation would lead people to contact others who might or might not as yet have learned of the emergency. Nehnevajsa at 7, 17; Keast et al. at 29-30.

43. There is a second reason why many people in emergencies have received their first warning from other members of the public. People generally respond to emergency warnings in groups. Accordingly, because emergency response is largely group behavior, emergencies transform the order of a community into one in which people act towards one another in ways which are more altruistic and caring than the patterns of interpersonal interaction which form routine, day-to-day community life. Some exemplary consequences of this are that, in an emergency, neighbors, friends and family -- and even total strangers -- check on one another and offer assistance if it is needed. One obvious result of this tendency of people in emergencies to form groups and to offer aid and assistance to one another is that it causes people to be in communication with other members of the public who might not as yet have learned of the emergency. Thus, for example, people who have been awakened in the night and received notification of an emergency at Harris generally can be expected to spread the warning to neighbors, friends, and family -- including

neighbors whose houses are still dark, where no one appears to be stirring. In effect, any contact with households not alerted by the sirens will amount to alert notification, whatever the reason may have been for initiating the contact. Nehnevajsa at 7, 17; Keast et al. at 31.

44. It is possible to estimate the extent and speed of such informal notification processes, based both on past projections of informal notification in hypothetical emergencies, as well as research efforts on actual emergencies. These research efforts on actual emergencies have collected data on the proportion of a particular population at risk that (a) learned of the emergency through informal notification and/or (b) was formally alerted and then engaged in the informal notification of others. This research documents the occurrence of informal notification in emergencies, and provides an empirical basis for estimating its rate of occurrence, given estimates of the proportion of a population notified formally (for example, through sirens). Keast et al. at 32; Nehnevajsa at 19.

45. Both Applicants and the NRC Staff/FEMA developed projections for informal notification in the event of an emergency at the Harris plant. Indeed, Applicants actually prepared two separate sets of estimates. One was based on the "natural" rate of informal notification. These estimates reflect what would be likely to occur given the natural tendency of people to engage in this sort of activity in an emergency. The second

set of estimates was termed the "facilitated" rate of informal notification. These estimates reflect what would likely occur if emergency planning for Harris were to capitalize on this natural tendency in people, to maximize its occurrence in an actual emergency. Keast et al. at 33. Thus, Dr. Mileti suggested that the number of people who would spontaneously engage in the informal notification of others in an emergency could be increased by simply incorporating into the emergency broadcast system (EBS) messages some simple words to the effect that "if your neighbors' house is dark, wake them." Keast et al. at 38. Because the State of North Carolina has committed to include the suggested instruction in the initial EBS messages for broadcast in the event of a nighttime emergency at Harris, the discussion of Applicants' projections below is confined to the "facilitated" rate of informal notification. Keast et al. at 41.

46. Applicants' projection of the "facilitated" rate of informal notification is based on their determination that approximately 72% of the households in the EPZ would be alerted within 15 minutes by the fixed siren system in the event of an emergency on a hot summer night. That 72% was multiplied by 80% (the estimated rate for those formally alerted who would engage in informal notification),26/ to produce an estimate of

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26/ The 80% multiplier was based on historical experience with public emergency response. For example, in the 1981

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57% of the households engaged in initiating informal notification. This 57% of the population would successfully alert a non-alerted household 28% of the time (72% of the time an already-alerted household would be contacted). Thus, 57% of the 28% success rate indicates that an additional 16% more of the population would be alerted via "faciliated" informal notification. Applicants therefore reached an overall 15 minute notification estimate of 88% (adding the 72% of the population alerted by the fixed sirens to the 16% alerted via informal notification). By the same process, Applicants' analysis demonstrated an overall 30 minute notification estimate of 95% (the 72% of the population alerted by the fixed sirens plus an

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Mt. St. Helens emergency, 30% of the total population had direct notification of an emergency, and they alerted an additional 38% of the total population within 15 minutes. These data suggest that a 126% multiplier operated in that emergency for informal notification in the first 15 minutes. And, in the 1972 Rapid City, South Dakota flood, which occurred at night when many people were asleep, 75% of the population receiving a first warning or alert responded by engaging in additional communication; over half of these (some 40%) engaged in activities that would translate into informal notification. Keast et al. at 35-36. These data on "natural" informal notification rates support even higher rates where informal notification is "facilitated." This is consistent with social science research which establishes that the key determinant of public response to warnings is the emergency information that the public receives. It is therefore reasonable to expect that emergency public information that reminds people that they may be needed to awaken their neighbors would engage most of the alerted population in checking to see if their neighbors were awake. Keast et al. at 40-41.

approximate 23% alerted via informal notification). Keast et al. at 39-40.

47. Applicants' estimates of "facilitated" informal notification are considered to be quite conservative. First, while numbers vary from emergency to emergency, Applicants' multiplier is a very conservative estimate of the number of people formally alerted who would engage in the informal notification of others. See notes 26, 28; Keast et al. at 35, 39-40. Second, Applicants' computation assumed that households initiating informal notification would do so only once, with one other household. This would be the case for some, but would not be the case for all those initiating informal notification, as demonstrated in the Mt. Saint Helens emergency (where 30% of the population alerted another 38% of the population). Third, Applicants' computation assumed that persons notified informally would not themselves engage in initiating informal notification of others. Finally, the estimate did not take into account the proportion of the population that would be "alerted" or awakened by all the activity associated with, for example, an evacuation.27/ Keast et al. at 36, 39-40.

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27/ The high level of activity which would be associated with an emergency at Harris would have a strong "ripple effect," generally alerting members of the public to seek additional information about the events taking place, even if they had not been directly warned by either the fixed sirens, the mobile alerting system, or another member of the public. In other

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48. Like Applicants, the NRC Staff/FEMA also predicated their projections of informal notification (or "social networking") on the estimated proportion of the EPZ population which would be alerted within 15 minutes by the fixed siren system, under the conditions postulated in the contention. However, the NRC Staff/FEMA used slightly different assumptions, and presented their results for each of their assumed three 3-minute siren activations. Nehnevajsa at 16-21.

49. As a basis for their calculations, the NRC Staff/FEMA modeled a "realistic though conservative situation." First, they focused on the time period 2 a.m. to 6 a.m., the "worst case" with respect to the proportion of people asleep. Nehnevajsa at 17, 23, 27. Given their determination that 35.5% of households will remain asleep and unalerted at the end of the first hypothetical siren sounding, and assuming that only half the awake and aroused households attempt to contact another household,28/ the NRC Staff/FEMA determined that the

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words, the activities of other residents who have already received notification (turning on the lights in their homes, perhaps preparing to evacuate, or even the stream of traffic driving out of the EPZ) could awaken (if necessary) and alert most members of the public who may not yet have been warned, and cause them to seek additional information about what is going on (for example, by turning on the TV or radio, or by talking to neighbors). Keast et al. at 31-32.

28/ The NRC Staff/FEMA assumption is a very conservative one. In a June 1985 survey in the aftermath of a tornado, 87.5% of

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probability of an alerted household actually making contact with an unalerted household is about 11.6%. The NRC Staff/FEMA discounted this figure slightly (to 10.8%), to account for the possibility that some people simply might not be awakened by a ringing phone, or might unplug their phone at night. Thus, the NRC Staff/FEMA determined that -- at the end of the first sounding of the siren -- an estimated 75.3% of the households would have been alerted to the emergency. Nehnevajsa at 18-19.

50. For the calculations based on subsequent hypothetical siren soundings, the NRC Staff/FEMA analysis accounted for the fact that there were fewer people to be aroused after each sounding. Using the same methodology as for the calculations based on the first siren sounding, and given the arousal probabilities upon the second siren sounding, the NRC Staff/FEMA concluded that an additional 2.5% of households would be informally notified -- for a total of 77.8% of EPZ households alerted after the second sounding of the sirens. Nehnevajsa at 19-20.

51. For the calculations based on the third siren sounding, the NRC Staff/FEMA analysis factored in the probability

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the respondents indicated that people in their area would contact others to warn them of impending danger; the same number of respondents indicated that someone would try to contact them in such an emergency. Nehnevajsa at 16-17, 18. See also note 26.

that some people might make more than one contact, assuming that one-third would do so (rather than one-half, as postulated for the initial sounding). The NRC Staff/FEMA thus assumed that the "average" contact probability would have declined from .5 to .33 (though an increased probability could be theoretically rather well justified). Again, the NRC Staff/FEMA used the same methodology as for the previous two siren soundings. The NRC Staff/FEMA analysis thus concluded that, after three soundings of the sirens, 87.8% of the persons in the EPZ (83.6% of households) would have been alerted to the emergency, under the conditions postulated in the contention. Nehnevajsa at 20-21, 23. These figures must be considered particularly conservative since they reflect "natural" rates of informal notification; that is, the NRC Staff/FEMA analysis did not reflect the effect of the State of North Carolina's revised EBS message. Presumably the NRC Staff/FEMA projection would have been even higher had the revised EBS message been considered in their analysis. See generally note 26.

52. Dr. Bassiouni acknowledges the occurrence of informal notification, but maintains that it should not be considered "an integral part of the warning system"29/ -- a view which

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29/ Dr. Bassiouni asserts that informal notification can only be relied upon in the presence of an appropriate public information program. Eddleman Ex. 73 at 6. This is at odds with historical experience in emergencies, which amply demonstrates

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directly contradicts the professional judgment of Dr. Mileti and Dr. Nehnevajsa. Eddleman Ex. 73 at 6; Keast et al. at 42; Nehnevajsa at 8. However, Dr. Bassiouni has no apparent expertise in disaster sociology. Tr. 9865. We therefore accord little weight to his opinions on the subject of informal notification.

53. In any event, to the extent that Dr. Bassiouni can be considered to have the requisite expertise in disaster sociology, his position in the Bassiouni Statement is strongly undermined by prior published statements. In his Power Engineering article, Dr. Bassiouni attests to the efficacy and predictability of informal notification, explaining:

> It is difficult to guarantee 100% notification by purely physical means under any circumstances. This is true even when specially designed alert systems are installed within the 10-mile EPZ. For 100% alerting, it is essential to take into consideration some complex physical and sociological factors and capitalize on them.

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the spontaneous occurrence of informal notification processes. Keast et al. at 29-31; Nehnevajsa at 7, 17. In any event, the emergency public information for Harris -- specifically, the EBS messages for night-time use -- are expressly designed to facilitate informal notification. Keast et al. at 41. Dr. Bassiouni also suggests that use of the telephone system for informal notification could "hinder other emergency procedures." Eddleman Ex. 73 at 6. However, emergency response organizations within the Harris EPZ would not be dependent upon the use of the commercial phone system during the public notification phase of an emergency. Tr. 9601-02 (Joyner). Thus, Dr. Bassiouni's views lack any basis in fact.

Applicants' Ex. 54 at 1. According to Dr. Bassiouni:

> A computer analysis of alerting in an EPZ was run to illustrate the effectiveness of multiple notification and cascading concepts associated with word-of-mouth communications. The analysis used a data set for a hypothetical EPZ. It showed the mechanical COA ["chance-of-alert"] from sirens alone was 71% for this model.
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> * * * *
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> * * * The significant finding about the cascade effect is that if even a small percentage of alerted people attempts to alert others, the final COA is very high.
>
> For example, if only 20% of those persons alerted by sirens each notifies four new people, the resulting COA is close to 99%.

Applicants' Ex. 54 at 2-3. Dr. Bassiouni concludes:

> Obviously the word-of-mouth notification concept is too important to ignore. Siren systems for alerting the public should be designed or modified to capitalize on this natural phenomenon by which the final incremental alerting can be achieved.

Applicants' Ex. 54 at 3. This conclusion stands in stark contrast to the assertion in the Bassiouni Statement that "ATI does not believe that [informal alerting] should be heavily relied upon to validate the effectiveness of nighttime notification." Eddleman Ex. 73 at 6.

54. Moreover, the existence and efficacy of informal notification processes are recognized in Commission case law. See, e.g., Duke Power Co. (Catawba Nuclear Station, Units 1 and 2), LBP-84-37, 20 N.R.C. 933, 973 (1984); Southern California

Edison Co. (San Onofre Nuclear Generating Station, Units 2 and 3), LBP-82-46, 15 N.R.C. 1531, 1534-35 (1982). Accordingly, we discount Dr. Bassiouni's views and conclude -- on the basis of historical experience in actual emergencies, as well as the professional judgment of Dr. Mileti and Dr. Nehnevajsa and Commission precedent -- that informal notification can be relied upon in emergency planning as a component of public notification in the event of an actual emergency. Keast et al. at 42; Nehnevajsa at 8.

D. CONCLUSION

55. The public alert and notification system for the Harris EPZ is comprised of three elements -- an extensive system of fixed sirens located throughout the EPZ (designed to existing, FEMA design objectives and criteria), a comprehensive mobile alerting plan, and the empirically well-established informal notification processes which occur naturally in emergencies. In response to Eddleman 57-C-3, both Applicants and the NRC Staff/FEMA analyzed the public alert and notification system under the night-time conditions specified in that contention. Using different -- but fundamentally consistent -- methodologies, the two reached similar conclusions: Applicants determined that the fixed siren system and informal notification processes would alert approximately 88% of EPZ households within 15 minutes, while the NRC Staff/FEMA analysis (which did

not reflect the revised EBS message) predicted that 87.8% of the population would be alerted within 15 minutes. (The mobile alerting system, which was not considered in the quantitative analysis of either party, also can be expected to alert some additional incremental proportion of the population in the same time period.)

56. In reaching its conclusion on the adequacy of the Harris alert and notification system, the Board acknowledges the significant role of the Commission in the development of the design objectives and criteria which FEMA and the NRC Staff have used since 1980 to evaluate this system (and others across the country) against the Commission's regulations. The Board is mindful, too, of the deference which the Commission accords to FEMA's views on this subject. Finally, the Board is cognizant of the Commission's express intent to afford a degree of flexibility in the implementation of its public alert and notification system requirements. Recognizing that the conditions specified in the contention constitute the "worst case" scenario for public alerting (Tr. 9646 (Keast)), the Board concludes that the Harris alert and notification system meets the Commission's regulations, providing "the capability to <u>essentially</u> complete the initial notification of the public within the plume exposure pathway Emergency Planning Zone within <u>about</u> 15 minutes" (emphasis supplied).

## III. CONCLUSIONS OF LAW

57. This is a contested proceeding on an application for an operating license for a utilization facility. The Board has not determined that a serious safety, environmental, or common defense and security matter exists. See 10 C.F.R. § 2.760a. Other findings required to be made prior to the issuance of an operating license, except for any remaining matters in controversy, are to be made by the Director of Nuclear Reactor Regulation. See id. and 10 C.F.R. § 50.57.

58. In reaching this decision, the Board has considered all the evidence submitted by the parties and the entire record of this proceeding, consisting of the Commission's Notice of Hearing, the pleadings filed by the parties, the transcripts of the hearing and the exhibits received into evidence. All issues and proposed findings presented by the parties, and not addressed in the Board's decision, are deemed to be without merit or unnecessary to the decision. The Board's findings of fact are supported by reliable, probative and substantial evidence in the record.

59. If the Board, in its partial initial decisions, decides all matters in controversy in favor of authorizing operation of the facility, it should conclude that, as to the matters resolved in those decisions, the Director of Nuclear Reactor Regulation would be authorized, upon making the requisite findings with respect to matters not resolved in those

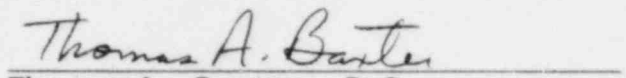
decisions, to issue to CP&L a license to operate the Shearon Harris Nuclear Power Plant. Such authorization by the Board would not be deemed granted, however, until the Board resolves the outstanding emergency preparedness matters in controversy or issues a further order to the contrary.

## IV. ORDER

60. WHEREFORE, THE BOARD ORDERS, in accordance with 10 C.F.R. §§ 2.760(a) and 2.762, that its Partial Initial Decision on this matter shall constitute the final action of the Commission thirty (30) days after the date of its issuance, unless an appeal is taken in accordance with section 2.762 or the Commission directs that the record be certified to it for final decision. Any Notice of Appeal from the decision must be filed within ten (10) days after service of the decision. A brief in support of the appeal must be filed within thirty (30) days (forty (40) days in the case of the NRC Staff) after filing the Notice of Appeal. Any party which is not an appellant may file a brief in support of or in opposition to the appeal within thirty (30) days (forty (40) days in the case of the NRC Staff)

after the period has expired for the filing and service of the briefs of all appellants.

Respectfully submitted,



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Dated: December 9, 1985

# APPENDIX A

## WRITTEN TESTIMONY RECEIVED INTO EVIDENCE

APPENDIX B

EXHIBITS

| Exhibit Number | Description | Identified At Transcript Page | Admitted At Transcript Page |
|---|---|---|---|
| App. Ex. 46 | Map of Harris EPZ, showing siren locations, nighttime siren coverage contours and house locations. Prepared by HMM Associates (September 1985) | 9369 | 9372 |
| App. Ex. 47 | Map, Revised 60 dBC Coverage Within the EPZ of the Shearon Harris Nuclear Power Plant. Prepared by Acoustic Technology, Inc. (October 1, 1985) | 9427-28 | 9433-34 |
| App. Ex. 48 | EPA-600/1-77-010, "Measures of Noise Level: Their Relative Accuracy in Predicting Objective and Subjective Responses to Noise During Sleep," by Jerome S. Lukas (February 1977) | 9614-15 | 9614-15 |
| App. Ex. 49 | Excerpts from State and County Emergency Plans, relating to mobile alerting (citations at Tr. 9633-34) | 9966-67 | 9966-67 |
| App. Ex. 54 | "Prompt Notification of 100% of People in the EPZ," by M. Reada Bassiouni, reprinted from Power Engineering (September 1983), pages 47-49 | 10213-14 | 10225 |

| Exhibit Number | Description | Identified At Transcript Page | Admitted At Transcript Page |
|---|---|---|---|
| WE Ex. 68 | First page of data sheet, captioned "Measurement of Acoustic Properties of Homes In the Shearon Harris EPZ," for House #1 | Per stipulation memorialized in "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85 | |
| WE Ex. 69 | Two tables, "July Monthly Average Meteorological Parameters" at RDU, for 1 a.m. and 4 a.m. (1973-1984) | Per stipulation memorialized in "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85 | |
| WE Ex. 69-B | Table, "CP&L Harris Onsite Meteorological Data For the Period 1973 through 6/30/85, 1 AM through ___ AM, Months of June, July and August (8 pages) | Per stipulation memorialized in "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85 | |
| WE Ex. 70 | Kryter, K., The Effects of Noise on Man (Academic Press, New York, 1970), pages 471-83 | Per stipulation memorialized in "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85 | |
| WE Ex. 71 | Driscoll, D.A., J.P. Dulin, Jr., and D.N. Keast, "Attenuation of Northern Dwellings To A Linear Source of Noise" (presented at 95th Congress of The Acoustical Society of America, Providence, R.I., May 1978) | Per stipulation memorialized in "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85 | |

| Exhibit Number | Description | Identified At Transcript Page | Admitted At Transcript Page |
|---|---|---|---|
| WE Ex. 72 | Data sheets, captioned "Measurement of Acoustic Properties of Homes In The Shearon Harris EPZ," for Houses #2 - #13 | Marked for Identification Only (per "Wells Eddleman's Letter re: Exhibit Numbers on Contention 57-C-3," dated 11/26/85) | |
| | Four data sheets, captioned "Noise Measurement of Window Air Conditioner in Bedroom" | | |
| | Anon, "Noise in Urban and Surburban Areas," Report FT/TS-26 (Federal Housing Administration, Department of Housing and Urban Development, March 1968) | | |
| | Anon, "House Noise Reduction Measurements For Use in Studies of Aircraft Flyover Noise," SAE Aerospace Information Report AIR 1081, (Society of Automotive Engineers, New York, October 1971) | | |
| | Three tables, captioned "Housing Units Within Shearon Harris EPZ With Storm Windows," "Distribution of Housing Units By Age and By Window Area Requirements, Shearon Harris EPZ," and "Exterior Material of Yearround Housing Units, 1982, Shearon Harris EPZ" | | |
| | Carter, T.M., S. Kendall, and J.P. Clark, "Household Response to Warnings," International Journal of Mass Emergencies and Disasters, 1, 1:95-104 (1983) | | |
| | Mileti, D., T.E. Drabek, and J.E. Haas, Human Systems in Extreme Environments (Boulder: Institute of Behavioral Science, University of Colorado, 1975), pages 44-45 | | |
| | Lindell, M.K. et al., Planning Concepts and Decision Criteria For Sheltering and Evacuation In A Nuclear Power Plant Emergency, AIF/NESP-031 (Washington, D.C. 1985), pages 5-15 through 5-17 | | |

| Exhibit Number | Description | Identified At Transcript Page | Admitted At Transcript Page |
|---|---|---|---|
| WE Ex. 73 | "ATI Review of Pre-filed Testimony, Eddleman Contention 57-C-3, Shearon Harris Nuclear Power Plant Licensing Hearings" | 10211-12 | 10225 |
| WE Ex. 74 | "Abschlussbericht: Untersuchungen uber die Wirkung von Wecksignalen auf Schafer verschiedener Schlaftiefen und Dispositionen," translated: "Final Report: Studies of the Effects of Waking Signals on Sleepers With Different Depths of Sleep and Dispositions" (Institute for Phonetics and Communications Research University of Bonn, 1962) | 10212 | 10214-15, 10225 |

December 9, 1985



UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | |
| CAROLINA POWER & LIGHT COMPANY and NORTH CAROLINA EASTERN MUNICIPAL POWER AGENCY | ) | Docket No. 50-400 OL |
| | ) | |
| (Shearon Harris Nuclear Power Plant) | ) | |

CERTIFICATE OF SERVICE

I hereby certify that copies of "Applicants' Proposed Findings of Fact and Conclusions of Law on Eddleman 57-C-3 (Night-time Notification)" were served this 9th day of December, 1985, by hand delivery to those identified by an asterisk, by Federal Express to those identified with two asterisks, and by deposit in the U.S. mail, first class, postage prepaid, to all others listed on the attached Service List.

Thomas A. Baxter

Thomas A. Baxter, P.C.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| (Shearon Harris Nuclear Power Plant) | ) | |
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