UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
DUKE POWER COMPANY, et al.	)	Docket Nos. 50-413
	)	50-414
(Catawba Nuclear Station,	)	
Units 1 and 2)	)	

APPLICANTS' TESTIMONY ON EMERGENCY PLANNING CONTENTION 11

Duke Power Company (Robert F. Edmonds, Jr.
Mark A. Casper, R. Michael Glover)

Thomas E. Potter
Walter M. Kulash
Mecklenburg County (Lewis Wayne Broome)

April 16, 1984

TESTIMONY OF DUKE POWER COMPANY
(ROBERT F. EDMONDS, JR., MARK A. CASPER, AND R. MICHAEL GLOVER)
ON EMERGENCY PLANNING CONTENTION 11

Background Information on Mr. Edmonds

Q. PLEASE STATE YOUR NAME AND PLACE OF EMPLOYMENT.

A. My name is Robert F. Edmonds, Jr. I am employed as Senior Engineer, Duke Power Company, 422 South Church Street, Charlotte, North Carolina 28242.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND AND RELEVANT WORK EXPERIENCE?

A. Please see my current resume, which is attached to this testimony as Attachment A. (RE)

Q. ARE YOU FAMILIAR WITH THE PLUME EXPOSURE PATHWAY EMERGENCY PLANNING ZONE (PLUME EPZ) FOR THE CATAWBA NUCLEAR STATION?

A. Yes. (RE)

Q. ARE YOU FAMILIAR WITH THE POPULATION DATA FOR THE CATAWBA PLUME EPZ AND THE AREA SURROUNDING THE PLUME EPZ?

A. Yes. (RE)

Q. WHAT IN YOUR BACKGROUND QUALIFIES YOU TO DISCUSS POPULATION STUDIES?

A. In my present job, I am responsible for an Environmental Engineering group whose duties include power plant siting. Power plant siting requires population data. (RE)

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. I am testifying on the population data for the Catawba plume EPZ and the surrounding areas in connection with Emergency Planning Contention 11. (RE)

EPC-11 Testimony of Mr. Edmonds

Q. WHAT IS THE 1980 POPULATION WITHIN 10 MILES OF CATAWBA NUCLEAR STATION AND WHAT WAS THE SOURCE?

A. Based on a detailed study using the 1980 census, the population within 10 miles of Catawba was 78,769. (RE)

Q. WHAT IS THE PERMANENT 1980 POPULATION OF 2, 5, AND 10 MILES FROM THE CATAWBA STATION?

A. The 1980 population within 2 miles of Catawba is 537, between 2 and 5 miles is 10,540, and between 5 and 10 miles is 67,692. The cumulative population at 2, 5, and 10 miles is 537, 11,077, and 78,769 respectively. (RE)

Q. WHAT WAS THE 1980 PERMANENT POPULATION OF THE CATAWBA NUCLEAR STATION EPZ, TOTAL AND BY COUNTY?

A. Again based on the 1980 census 93,483 people were residents of the Catawba EPZ. Of this number, 2672 were Gaston county residents, 5724 were Mecklenburg and 85,087 were York County residents. (RE)

Q. WHAT IS THE ESTIMATED POPULATION IN THE EPZ FOR 1985, THE PROJECTED DATE OF COMMERCIAL OPERATION?

A. Based on growth trends, field surveys and building permits issues since the 1980 census, it is estimated that the population of the EPZ in 1985 will be about 104,700. (RE)

Q. HOW MANY OCCUPIED DWELLINGS ARE IN THE EPZ?

A. Based on the 1980 census statistics, there were 31,737 occupied dwellings in the Catawba EPZ. (RE)

Q. WHAT WAS THE 1980 POPULATION WITHIN 50 MILES OF CATAWBA?

A. Based on 1980 census data, the 1980 population within 50 miles of Catawba was 1,405,256, for an average density within 50 miles of Catawba of 179 people per square mile. (RE)

Q. WHAT IS THE 1980 AND PROJECTED 2020 CUMULATIVE POPULATION AND DENSITY AT 5, 10, 20, and 30 MILES?

A. The 5, 10, 20, and 30 mile cumulative population and density at Catawba are as follows: (RE)

MILES	CUMULATIVE POPULATION 1980[2]	CUMULATIVE POPULATION 2020[3]	POPULATION DENSITY[1] PERSONS/mi^2 1980	POPULATION DENSITY[1] PERSONS/mi^2 2020
0-5	11,077	22,377	141	285
0-10	78,769	94,436	251	301
0-20	526,532	712,164	419	567
0-30	814,686	1,120,996	288	396

1. Trip points per Regulatory Guide 4.7
2. Source 1980 Census
3. Source Catawba Nuclear Station FSAR (RE)

Q. WHAT IS THE TRANSIENT POPULATION WITHIN THE EPZ?

A. Based on recreation studies by Duke and personal contacts by Duke employees and James Carroll, York County Director of Emergency Preparedness (deceased) there was a transient population of approximately 89,699 in 1982, which includes recreation and industry. (RE)

Q. WHAT IS THE MAXIMUM EXPECTED TRANSIENT POPULATION WITHIN 2, 5, and 10 MILES OF THE STATION?

A. The anticipated maximum transient population at 2, 5, and 10 miles is: at 0-2 miles - 6,206; at 2-5 miles - 31,298; and at 5-10 miles - 52,200. (RE)

Q. WHAT IS THE POPULATION OF SOUTHWEST CHARLOTTE, DEFINED AS BEING SOUTH OF US 74 AND WEST OF NC 16?

A. Based on the 1980 census, the population of southwest Charlotte is approximately 124,000. (RE)

Q. WHAT IS THE SPECIAL FACILITIES POPULATION WITHIN THE EPZ?

A. The special facility (Schools, Nursing Homes, Hospitals, Day Care Centers, Penal Institutions) population within the EPZ is 36,231. (RE)

Q. WHAT IS THE REGISTERED POPULATION OF SCHOOLS WITHIN THE EPZ?

A. The enrollment of schools in the EPZ is approximately 25,310. (RE)

Q. HAVE THE AREAS IN THE EPZ OF APPROXIMATELY ONE SQUARE MILE OR GREATER THAT HAVE A POPULATION DENSITY OF GREATER THAN 2000 PER SQUARE MILE BEEN IDENTIFIED, AND IF SO, WHAT WERE THESE AREAS?

A. Such a study has been performed. Parts of the cities of Rock Hill, Fort Mill, and Clover were found to have areas of about one square mile and larger within their town limits with a population density greater than 2000 per square mile. York, South Carolina was checked in detail and was found to have no areas with a density greater than 2000 per square mile. All other areas in the EPZ were eliminated based on a previous study of the 1980 population distribution. (RE)

Q. WHAT IS THE 1980 POPULATION AND DENSITY FROM 5 TO 30 MILES IN THE NORTH THROUGH EAST SECTORS?

A. These numbers are shown in a table titled "Catawba Nuclear Station 1980 Population and Population Density, 5-30 miles, North through East Sectors," attached to Duke's letter to the Board dated August 25, 1983. (RE)

Q. WHAT IS THE PERMANENT, TRANSIENT, AND SPECIAL FACILITY POPULATION OF THE VARIOUS ZONES WITHIN THE EPZ, i.e., A-O, A-1, B-1, ETC.?

A. The populations previously identified are distributed into the various zones as follows: (RE)

ZONE	PERMANENT POPULATION	TRANSIENT POPULATION[1]	SPECIAL FACILITY POPULATION[1]
A-0	720	6,206	0
A-1	529	10,187	0
A-2	4,838	4,073	2,862
B-1	2,631	2,588	24
B-2	9,771	46,826	3,094
C-1	6,161	16,827	1,544
C-2	44,964	0	21,031
D-1	1,414	109	0
D-2	9,169	0	4,023
E-1	429	0	0
E-2	4,957	0	2,820
F-1	2,573	1,582	364
F-2	2,655	650	0
F-3	2,672	651	469
Total EPZ	93,483	89,699	36,231

1. Includes individuals that may also be included in Permanent Population column. (RE)

Q. ARE THERE ANY NUCLEAR PLANTS EITHER OPERATING OR UNDER CONSTRUCTION WHICH HAVE PERMANENT POPULATION CONCENTRATIONS SIMILAR TO OR GREATER THAN CATAWBA FROM 10 TO 20 MILES FROM THE PLANT?

A. Yes. (RE)

Q. WHAT ARE SOME OF THEM?

A. A sampling of these plants with Catawba as a comparison is as follows: (RE)

Station	Largest Population Sector 1980 Population in 10-20 Mile Ring	Sector
Catawba	140,455	NE
Quad Cities	216,916	SW
Turkey Point (1978)	184,900	NNW
Salem (1967)	187,000	N
Enrico Fermi	95,716	NNE
Surry	160,000	SE
Indian Point	176,083	SSW
Peach Bottom	115,720	N
Ginna	401,191	WSW
Shoreham	145,025	WSW
Davis Besse	419,223	WNW
Fort Calhoun	160,998	S
Sequoyah	115,955	SW
Three Mile Island	98,600	NW
Byron	143,554	NE
Limerick	124,311	ESE
Waterford	236,347	NNW

EPC-11 Testimony of Mr. Glover

Q. CONTENTION 11 ASSERTS THAT ALL OR PART OF SOUTHWEST CHARLOTTE SHOULD BE INCLUDED IN THE 10-MILE EPZ FOR CATAWBA, BECAUSE OF POPULATION IN SOUTHWEST CHARLOTTE, THE LOCAL METEOROLOGICAL CONDITIONS, AND THE ANTICIPATED FLOW OF EVACUEES THROUGH EVACUATION ROUTES IN CHARLOTTE. IN YOUR OPINION, MR. GLOVER, SHOULD THIS AREA BE INCLUDED IN THE CATAWBA EPZ? WHY OR WHY NOT?

A. In my opinion Charlotte should not be a part of the Catawba plume EPZ. My reasons are twofold. Statements in NUREG-0396 and NUREG-0654 seem to address the very issue here in this case. Also, an emergency plan already exists for Charlotte and has been used to evacuate residents for actual emergencies. (RMG)

NUREG-0396 -- In NUREG-0396, Appendix 1, p. 52, the NRC and EPA Task Force that evaluated the necessary distance for the plume exposure pathway made a summary statement as to the importance or the necessity of planning outside of 10 miles. It says, "Therefore, although protective actions may be required for individuals located in areas further than 10 miles from the reactor, for an atmospheric release the actual measures used and how rapidly or efficiently they are implemented will not strongly influence the number of projected early health effects." (RMG)

Also, in NUREG-0654 on p. 12, the considerations of the NRC/EPA Task Force that established the plume exposure pathway EPZ at "about 10 miles" are shown. Item "d" of that list states "detailed planning within 10 miles would provide a substantial base for expansion of response efforts in the event that this provided necessary." Regulators have in essence

approved "ad hoc" planning outside the 10 mile area based on the capabilities available and in place for the area inside 10 miles. Further, the regulators seem to anticipate that if resources are established within 10 miles that a "tie" of some sort exists to those outside the zone if the need arises to facilitate this "ad hoc" planning. When I read that statement and had reviewed the City of Charlotte All Hazards Plan, I realized that the City of Charlotte's "All Hazards Plan" addresses the need for a "tie" to resources and a way of facilitating "ad hoc" planning.(RMG)

In the case of the Catawba area and specifically Charlotte, local planners have taken the planning process one step further than envisioned in the minds of those who wrote NUREG-0654 and 0396, and rather than waiting to react on an "ad hoc" basis, they have developed the City of Charlotte All-Hazards Plan to deal with an event affecting this area. The "tie" contemplated to the resources that would be used in Charlotte to protect residents is the All-Hazards Plan. In addition to the "tie," the plan provides, the Charlotte/Mecklenburg Emergency Management Office is a "tie" to resources outside the EPZ, in that it serves as a coordinating agency for both city and county resources. Therefore, if necessary, without

extension of the existing plume exposure EPZ in the direction of Charlotte, protective action can be implemented for residents outside the EPZ. The existence of the "All Hazards Plan" and the Charlotte/Mecklenberg Management Office (a joint City-County agency) gives me confidence that the EPZ is properly configured in relation to local emergency response needs and capabilities and that item "d" of p. 12, NUREG-0654 has been adequately addressed in the Charlotte area.(RMG)

<u>Background Information on Mr. Casper</u>

Q. PLEASE STATE YOUR NAME AND PLACE OF EMPLOYMENT.

A. My name is Mark A. Casper. My business address is Duke Power Company, 422 South Church Street, Charlotte, North Carolina 28242. (MC)

Q. WHAT IS YOUR CURRENT POSITION WITH DUKE POWER COMPANY?

A. I am a meteorologist for the Design Engineering Department of Duke Power Company. In this position I conduct various meteorological analyses associated with Duke Power Company's fossil and nuclear generation facilities. My professional qualifications are attached to this testimony as Attachment A. (MC)

<u>EPC-11 Testimony of Mr. Casper</u>

Q. WHAT IS THE PURPOSE OF THIS TESTIMONY?

A. This testimony puts into perspective the meteorological conditions in the area of Catawba Nuclear Station so that the meteorology question in Palmetto Alliance and CESG's Emergency Planning Contention 11 can be rationally resolved. (MC)

Q. WHAT ARE THE WIND DIRECTION FREQUENCIES FROM CATAWBA TO THE CHARLOTTE AREA?

A. Using meteorological data gathered at Catawba at the 10 meter level from the most representative time period (December 17, 1975 through December 16, 1977) the wind direction frequencies from the west-southwest, southwest, and south-southwest sectors are 5.2, 13.5, and 13.9 percent respectively (three 22.5 degree sectors). If one were to consider joint frequencies with only stable atmospheric conditions (Pasquill Stability Classes E, F, and G) these wind direction frequencies become 2.4, 5.5, and 6.3 percent respectively. The total three sector (67.5 degree) frequencies become 32.6 percent for all stability classes and 14.2 percent for stable cases. (MC)

Q. WOULD YOU CALL THE SOUTH-SOUTHWEST DIRECTION THE PREVAILING WIND DIRECTION?

A. In the strict definition of prevailing wind direction, yes. However, a meteorologist will not only look at the section with the highest percentage

of winds, he/she would also consider the other sectors with high frequencies of winds. For instance, the Piedmont area is generally known to have bimodal prevailing winds, that is prevailing wind directions from both the southwest and northeast sectors. During the fall months especially, the predominant wind direction in the Piedmont region is from the northeast. (MC)

Q. IS THE PREVAILING WIND PHENOMENON UNIQUE TO THE CATAWBA AREA?

A. No. All sites have a prevailing wind direction. If one were to look at annual surface wind roses in the Climatic Atlas of the United States, most of the stations have prevailing winds with greater frequencies than the Piedmont area. The prevailing wind direction is attributed to various factors. These factors include the channelling of wind by surrounding terrain and the effects of land-sea interface. In absence of these effects, the wind direction in the mid-latitudes is due to migratory high and low pressure systems or synoptic scale meteorological phenomena. (MC)

Q. I AM LOOKING AT MR. EDMONDS' PART OF THE TESTIMONY LISTING THE LARGEST POPULATION SECTOR IN A 10-20 MILE RING BY STATION (P. 6). DO ANY OF THESE LARGEST POPULATION SECTORS COINCIDE WITH THE PREVAILING WIND DIRECTION?

A. Yes. The Indian Point plants' largest population sector (10-20 miles) is also the sector into which the prevailing wind direction blows, 13.5% of the time, based on January 1971 to December 1971 data. Also the Surry plant's largest population sector (10-20 miles) is also 8.7% of the time, based on November 1967 to December 1969 data. Enrico Fermi and Peach Bottom have similar situations with wind direction freq encies of 8.8% and 8.5%, respectively, into the largest population sector (10-20 miles). Although not "prevailing wind directions," these frequencies represent sectors with greater frequencies than that given by a uniform wind distribution. (MC)

Q. ARE WIND DIRECTION SHIFTS A PART OF THE METEOROLOGY OF THE AREA?

A. Yes. The wind direction will shift over time. Generally the shift is gradual. During very low wind speed conditions, there is a meandering of the wind direction, usually over a wide range, but never a complete wind reversal (180 degree) unless there is

some kind of orographic or sea-breeze effect. The other case of sudden wind direction change is the passage of a frontal system, but in terms of a direction reversal of a plume, the direction change is moot. The plume is traveling with its initial air mass. Fronts in the ideal sense may be considered as separating walls in the moving air streams through which the air particles cannot move but which must move along at the same speed as the normal component of the air particles. For example, if one imagines a continuous plume before frontal passage, it is traveling in one direction with the air mass. As the front passes, the plume exiting its source would follow the wind direction of the new air mass, however, the previously emitted plume would still be going in the same general direction of the old air mass. (MC)

Q. DOES A PREVAILING WIND DIRECTION HAVE AN IMPACT ON THE RESULTS OF A DESIGN BASIS ACCIDENT (DBA) ANALYSIS?

A. The wind direction frequencies are figured into the DBA analysis. (MC)

Q. HOW DOES THE PREVAILING WIND AFFECT THE RESULTS OF A SEVERE ACCIDENT ANALYSIS?

A. In the case of the Staff's severe accident analysis (CRAC Code), the consequences are the same in terms of deaths, cancer, economic loss, etc., but the probability of the event happening varies with wind direction frequencies. For example, if the probability of a consequence is one in a million under a uniform wind direction distribution, under a prevailing wind direction that occurs twice as frequently as uniform wind direction, the consequence probability is two in a million. Conversely, if the wind direction frequency is half the uniform frequency, the probability of the consequence is one-half in a million. (MC)

Q. WHAT IS THE URBAN HEAT ISLAND EFECT?

A. The urban heat island effect is the characteristic warmth of an urban area due to the man-made local weather modifications on the natural radiation balance, obstacles to the wind, water vapor balance, and the generation of heat in the urban area. (MC)

There are several dispersion characteristics in an urban area. Urban areas tend to have much lower inversion frequencies than the surrounding rural areas. This would mean that there are less instances of stable conditions in an urban area, therefore, dispersion is greater. Second, the surface roughness (mechanical dispersion) increases dramatically as a

plume travels from rural to urban areas, thereby increasing dispersion even further. Third, there tends to be a circulation cell where a plume entering the urban area would rise away from ground level. (MC)

Q. WOULD YOU ANTICIPATE THAT CHARLOTTE WOULD GIVE RISE TO AN URBAN HEAT ISLAND EFFECT?

A. Yes. (MC)

Q. WOULD YOU SAY THAT THE PIEDMONT REGION HAS AN USUAL AMOUNT OF RAINFALL?

A. No, it is average for the southeastern United States, even below average. Coastal and mountain regions tend to have greater precipitation amounts. Therefore since the Piedmont region is neither coastal nor mountain, the rainfall amounts tend to be minimum for the southeastern United States. (MC)

TESTIMONY OF THOMAS E. POTTER
ON EMERGENCY PLANNING CONTENTION 11

Background Information

Q. PLEASE STATE YOUR FULL NAME AND BUSINESS ADDRESS.

A. My name is Thomas E. Potter. My business address is Pickard Lowe & Garrick, Inc., 1200 Eighteenth Street, N.W., Washington, D.C.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of this testimony is to compare the results of assessments of accident-related radiation dose performed for the Catawba plant to the results of comparable generic studies in NUREG-0396 which were used to support the establishment of a Plume Exposure Pathway Emergency Planning Zone (plume EPZ) radius of about 10 miles. Such a comparison shows whether features specific to the Catawba plant or site affect the validity of the plume EPZ distance of about 10 miles as applied to Catawba.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND AND RELEVANT JOB EXPERIENCE?

A. I have had a major role in preparing reactor accident probabilistic risk assessments for six different nuclear facilities. These facilities were Oyster Creek, Zion 1 and 2, Midland 1 and 2, Shoreham, Seabrook 1 and 2, and Indian Point 2 and 3. I have also performed other analyses, such as one to determine the importance of source term release severity assumptions on radiological

dose as a function of distance and release conditions. Please see also my current resume, which is attached to this testimony as Attachment A.

<u>EPC -11 Testimony</u>

Q. ARE YOU FAMILIAR WITH THE PLUME EPZ ESTABLISHED FOR THE CATAWBA NUCLEAR STATION?

A. Yes.

Q. HOW DID YOU ACQUIRE THIS FAMILIARITY?

A. I have studied the maps of the current plume EPZ and intervenors' proposed plume EPZ supplied by Applicants. These maps were attached as exhibits to the Applicants' November 3, 1983 filing with the Licensing Board and their January 12, 1984 filing with the Appeal Board. I have also studied NUREG-0396, which contains background material that went into the establishment of the plume EPZ radius at "about 10 miles."

Q. DID YOU PREPARE A REPORT AS A RESULT OF THIS WORK?

A. Yes. My report is attached to this testimony as Attachment B and is part of my testimony.

Q. PLEASE SUMMARIZE BRIEFLY THE CONSIDERATIONS FORMING THE BASIS FOR SELECTING 10 MILES AS A PLUME EPZ DISTANCE AND DESCRIBE HOW YOUR TESTIMONY RELATES TO THESE CONSIDERATIONS.

A. The basis for a plume EPZ of about 10 miles was developed in NUREG-0396, and is stated most succinctly in NUREG-0654:

> "The size (about 10 miles radius) of the plume exposure EPZ was based primarily on the following considerations:
>
> a. projected doses from the traditional design basis accidents would not exceed Protection Action Guide levels outside the zone [the Protective Action Guide is defined by the EPA as the projected dose to individuals in the population which warrants taking protective action; see Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA-520/1-75-001, Sept. 1975];
>
> b. projected doses from most core melt sequences would not exceed Protective Action Guide levels outside the zone;
>
> c. for the worst core melt sequences, immediate life threatening doses would generally not occur outside the zone; and
>
> d. detailed planning within 10 miles would provide a substantial base for expansion of response efforts in the event that this proved necessary.

My testimony addresses the first three of these four considerations and whether they are supported by analyses specific for Catawba.

Q. PLEASE SUMMARIZE BRIEFLY THE METHODOLOGY YOU USED IN YOUR ASSESSMENTS.

A. The approach used for testing consideration "a," identified in my previous answer, was different from that used for considerations "b," and "c." The Catawba

FSAR contains results of assessments of doses from design basis accidents that can be directly extrapolated to a distance of 10 miles, so little analysis was required.

For considerations "b," and "c," also identified in my previous answer, the probabilistic approach used in the NUREG-0396 analyses was followed in this study. This approach resulted in estimates of the probabilities of exceeding certain selected doses at different distances. The overall probability depends upon the probability of a core melt accident, the probability of each of the types of release (release categories) that might occur given a core melt accident, and the probability that meteorological conditions, given a certain type of release, limit atmospheric dispersion sufficiently to produce a dose exceeding the dose of interest at the distance of interest. For this analysis I used PWR release categories from the Reactor Safety Study to represent core melt releases from the Catawba plant. Available data indicate the Catawba core melt spectrum would be less severe than that calculated for the Reactor Safety Study, but these data are not comprehensive enough to permit complete quantification.

In practice, the analysis consisted of numerous (100 to 300) separate mathematical simulations of radiation dose consequences from each release category. Because the intent of the analysis is to determine the zones in which planning for protective action is needed, it was assumed in these simulations that no protective action is taken for twenty-four hours after the passage of airborne released material. Each simulation was based upon meteorological conditions determined by a randomly selected release time (month, day, and hour). Meteorological conditions for that release time were extracted from a one-year meteorological data base in hour-by-hour format. Meteorological conditions were permitted to change during release transport as determined by hour-to-hour changes in the meteorology data base. My analysis used meteorological data collected at the Catawba site.

The results in Tables 2 and 3 of my study are total absolute (i.e., overall) probabilities. In the NUREG-0396 analyses, results are expressed conditional on core melt. That is, the core melt is a given and its low probability is not included in the estimate of probability. (The low probability of a core melt accident is discussed separately in NUREG-0396.) Translation from one form of expression to the other is

straightforward and the discussion of my results and conclusions includes probabilities expressed in the NUREG-0396 convention. These Catawba-specific probabilities were then compared with those arrived at in NUREG-0396.

Q. HAVE YOU COMPLETED YOUR REPORT?

A. Yes, it is Attachment B to my testimony.

Q. IS THE BASIS FOR YOUR CONCLUSION CONTAINED IN YOUR REPORT?

A. Yes.

Q. DO YOU ADOPT THIS REPORT AS YOUR TESTIMONY FOR USE IN THIS PROCEEDING?

A. Yes.

Q. WHAT CONCLUSION DID YOU REACH?

A. Analyses related to the first three considerations (a, b, and c, identified above) are included in NUREG-0396. Plant-specific and site-specific analyses performed in the course of licensing various nuclear power plants support the conclusion that projected doses from traditional design basis accidents would not exceed upper Protective Action Guide doses beyond the 10-mile zone even based on assumption of poor dispersion conditions. Summaries of these analyses are included in

NUREG-0396. Data in the Catawba FSAR indicate that the conclusion applies to Catawba as well. See Catawba FSAR, Chapter 15.

The analyses I conducted also establish that there is no significant difference between the probabilities of exceeding Protective Action Guide doses or life threatening doses beyond 10 miles at Catawba and the comparable probabilities calculated in the generic core melt accident analyses contained in NUREG-0396. These probabilities were factors in the decision to establish a 10-mile plume EPZ. Thus, projected doses from most core melt sequences would not exceed the EPA's Protective Action Guide levels outside the Catawba plume EPZ. For the worst case core melt sequences, immediate life threatening doses would generally not occur outside the Catawba plume EPZ. This is also consistent with the generic analyses in NUREG-0396.

Thus, I conclude that the plume EPZ boundary for the Catawba facility has been properly determined in relation to radiological considerations in the basis for determination of plume EPZ size. Allowance for such site-specific factors as local meteorological conditions and the design of the Catawba facility does not affect

the validity of these considerations, and therefore does not justify extending the boundary of the plume EPZ in any direction.

TESTIMONY OF WALTER M. KULASH ON EMERGENCY PLANNING CONTENTION 11

Background Information

Q. PLEASE STATE YOUR FULL NAME AND BUSINESS ADDRESS.

A. My name is Walter M. Kulash. My business address is PRC Engineering, 1500 Planning Research Drive, McLean, Virginia.

Q. PLEASE STATE YOUR JOB TITLE.

A. Associate Vice-President, PRC Engineering.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND AND RELEVANT JOB EXPERIENCE.

A. My educational background and professional experience is summarized in the resume included as Attachment A to my testimony.

Q. ARE YOU FAMILIAR WITH THE RESPONSE PLANS IN SUPPORT OF THE CATAWBA NUCLEAR STATION?

A. I am familiar with those parts of the North Carolina and South Carolina plans, and the York County, Gaston County, and Mecklenburg County plans, that deal with evacuation routes and the transportation of individuals without vehicles.

Q. HOW DID YOU ACQUIRE THAT FAMILIARITY?

A. I attended meetings with representatives of the various jurisdictions in which evacuation routes in North and South Carolina were discussed, and I have

read those portions of the North Carolina plan, the South Carolina plan, and the county plans, which deal specifically with evacuation.

Q. HAVE YOU READ THE CESG/PALMETTO ALLIANCE CONTENTIONS DEALING WITH EMERGENCY PLANNING THAT HAVE BEEN ACCEPTED AS ISSUES IN THIS PROCEEDING?

A. I have read those contentions that deal with evacuation and the evacuation time study -- that is, Contentions 11, 14, and 15.

<u>EPC 11 Testimony</u>

Q. EMERGENCY PLANNING CONTENTION 11 ARGUES THAT SOME PARTS OF SOUTHWEST CHARLOTTE SHOULD BE INCLUDED IN THE PLUME EXPOSURE PATHWAY EMERGENCY PLANNING ZONE. AS AN EXAMPLE, IT IS SUGGESTED THAT HIGHWAYS 74 AND 16 IN SOUTHWEST CHARLOTTE MIGHT BE APPROPRIATE PLUME EXPOSURE EPZ BOUNDARY LINES. DID YOU DISCUSS WITH DUKE POWER COMPANY AND APPROPRIATE LOCAL OFFICIALS THE POSSIBILITY OF IDENTIFYING ALTERNATIVE EPZ BOUNDARIES WITHIN THE CITY OF CHARLOTTE?

A. Yes. The issue of alternative EPZ boundaries which would include part of southwest Charlotte was discussed. As a result of these discussions, PRC performed two studies relating to evacuation of areas beyond the EPZ as presently defined. One of these studies, entitled "Effect of 'Shadow' Evacuation on the Time to Evacuate the Catawba Nuclear Station

EPZ," evaluated the effect on EPZ evacuation traffic flow, of voluntary evacuation of the entire Charlotte area. In this analysis, we tested various combinations of voluntary evacuation percentages and notification times. A copy of this study is included as Attachment B to my testimony on Contention 11.

In addition, PRC considered evacuation times for 2 expanded EPZ's: first, the southwest third of Charlotte, encompassing an area out to 17 miles from the Catawba plant; and second, the entire city of Charlotte, extending 20-25 miles from Catawba. This study entitled "Catawba Nuclear Station Evacuation Analysis/Evacuation Time Estimate for the City of Charlotte," is included as Attachment C to my testimony on Contention 11.

Q. DO YOU ADOPT ATTACHMENTS B AND C AS PART OF YOUR TESTIMONY FOR USE IN THIS PROCEEDING?

A. I do.

Q. WHAT WERE THE FINDINGS IN THE VOLUNTARY EVACUATION STUDY?

A. Voluntary evacuation could, under certain conditions, hinder EPZ evacuation traffic on one route by 30 minutes. Such delay would occur only if more than 50% of the total Charlotte population chose to

evacuate, and if such population prepared to evacuate within 30 minutes of the time required by the EPZ population.

Q. WHAT WERE THE FINDINGS IN THE EXPANDED EPZ STUDY?

A. For the southwest third of Charlotte, extending to approximately 17 miles from the Catawba Nuclear Station, an evacuation time of 5 hours, 15 minutes is estimated. The critical determinant of this time is notification time and not traffic congestion. In other words, any traffic congestion on evacuation routes has dissipated by the time that all of the population in the expanded EPZ is notified and prepared.

For the entire city of Charlotte, extending to 20-25 miles from the Catawba Nuclear Station, an evacuation time of approximately 9 hours is estimated.

TESTIMONY OF MECKLENBURG COUNTY
(LEWIS WAYNE BROOME) ON
EMERGENCY PLANNING CONTENTION 11

Q. EMERGENCY PLANNING CONTENTION 11 ARGUES THAT SOME PART OF SOUTHWEST CHARLOTTE (ILLUSTRATED BY AN EXAMPLE OF THE BOUNDARIES OF HIGHWAYS 74 AND 16) SHOULD BE INCLUDED IN THE EPZ. WHERE IS THE EPZ IN MECKLENBURG COUNTY DISCUSSED IN THE MECKLENBURG COUNTY EMERGENCY RESPONSE PLAN?

A. Part 3, Section IV.B and Part 3, figure 4 and Annex I to the N.C. State Plan.

Q. DID YOU DISCUSS WITH DUKE POWER COMPANY OFFICIALS THE POSSIBILITY OF IDENTIFYING ALTERNATE EPZ BOUNDARIES WITHIN THE CITY OF CHARLOTTE?

A. This has been discussed, but there has been nothing in writing. Options were looked at. No alternate EPZ was defined.

Q. AS FAR AS YOU KNOW, IS DUKE POWER COMPANY OR YOUR OFFICE PROPOSING OR RECOMMENDING THE EXPANSION OF THAT EPZ?

A. Speaking for the Emergency Management Office, we have made no such recommendation.

Q. DO YOU BELIEVE THE 10-MILE EPZ IS ADEQUATE TO PROTECT THE CITIZENS OF MECKLENBURG COUNTY LIVING WITHIN THAT EPZ?

A. Based on the standards that local government have to go by with regard to planning for nuclear power plants, the term about ten miles -- we would consider that to be adequate especially in view of the NRC investigation which preceded the decision to set the EPZ radius at about ten miles.

Q. WOULD YOU PROVIDE ADDITIONAL TRAFFIC CONTROL SUPPORT IN THE AREA OF CHARLOTTE TO AID IN THE EVACUATION OF EPZ RESIDENTS THROUGH CHARLOTTE?

A. Yes, we would. If necessary, we would call in additional resources from the Charlotte police department to assist us in traffic management.

Q. ASSUMING THAT THE EPZ IS NOT EXPANDED, IF A SITUATION AROSE WHERE THERE WAS SOME POSSIBLE NEED TO TAKE PROTECTIVE ACTION WITH REPECT TO PEOPLE IN SOUTHWEST CHARLOTTE, DO YOU HAVE ANY EXISTING MECHANISM FOR DOING THAT?

A. Yes, we could utilize the All Hazards Plan, which is a combined Charlotte-Mecklenburg plan that addresses protective actions people could take and that city and county resources could implement. There is enough flexibility built into both the All Hazards Plan and the basic emergency plan for the Catawba Nuclear Station and the supporting documents that will be developed out of this office so that you can take the concept of operation that applies for a 10-

mile EPZ and expand it to 11 miles, 12 miles, 15 miles. The concept stays the same and the flexibility is there to expand the area of response, if needed. You're dealing with the same organizations, the same departments, the same people, you're just increasing the numbers in order to cope with 60,000 or 80,000 or 100,000. So, the concept remains the same and you would just would call in additional people and identify additional resources. You would look at mutual aid, which would be available from the surrounding counties. There's a fallacy in people thinking that you cannot expand on something once you have identified something.

Q. IS THE CITY OF CHARLOTTE ALREADY INVOLVED THROUGH THE CHARLOTTE-MECKLENBURG JOINT EMERGENCY PLANNING AGENCY IN PLANNING FOR THE PARTS OF MECKLENBURG COUNTY ALREADY IN THE EPZ?

A. That's correct.

Q. SO YOU DON'T HAVE TO BRING IN ANY NEW COORDINATING MECHANISM IN ORDER TO TAKE PROTECTIVE ACTION?

A. Absolutely not. It's in place.

Q. HAS THE CHARLOTTE-MECKLENBURG JOINT EMERGENCY PLANNING AGENCY PREVIOUSLY DONE PLANNING AND WRITTEN PROCEDURES FOR AT LEAST ONE OTHER NUCLEAR POWER PLANT?

A. That's correct. Developing procedures for Catawba has involved looking at a different geographic area than McGuire. We've looked at different problems and different resources, but the basic concept has remained the same. The basic concept is to ensure to the maximum extent possible the protection of the public.

Q. WOULD YOU AGREE THAT AN IMPORTANT DIFFERENCE BETWEEN CALLING AN AREA PART OF THE EPZ AND NOT CALLING IT PART OF THE EPZ IS SIMPLY THAT YOU DON'T HAVE FIXED SIRENS IN THE PART THAT IS NOT PART OF THE EPZ?

A. Well, that's one element. I guess the primary thing that a lot of people would look at is that inside the 10-mile EPZ, the magic line that is drawn, you are very, very specific with regard to function. Outside that, the specificity is not there, but the concept is there and the flexibility to expand on that is there. You've got a very detailed, well-identified plan for the 10-mile EPZ which looks at, for example, day-care centers and schools and hospitals and prisons and evacuation routes and this type of thing. Outside that 10-mile EPZ, you don't need to identify these matters in the specific terms that you do inside that, but that is not to say that you can't expand on it because you are dealing with a concept.

Q. WHEN YOU SAY EXPAND ON IT, DO YOU MEAN EXPAND ON IT IF THE OCCASION ARISES OR EXPAND ON IT THROUGH ADVANCE PLANNING?

A. I think if the situation were to arise, if regulations dictated it, or if the request from the city mandated it, you could expand it. It could be any number of things.

Q. ASSUMING THAT THERE WERE NO SIRENS, HOW WOULD YOU GO ABOUT ALERTING RESIDENTS IN SOUTHWEST CHARLOTTE OF THE NEED TO TURN ON THEIR RADIOS OR TELEVISION SETS?

A. First of all, you would go in and activate the Emergency Broadcasting System, which most cases and studies indicate would catch the majority of the people. In addition to that you would take specific law enforcement units and other emergency vehicles to patrol those areas down there and make the announcement with the siren, etc., to turn on their radio and television and listen for instructions that will be broadcast.

Q. IF YOU WERE GOING TO USE SOME KIND OF POLICE OR EMERGENCY VEHICLES TO DRIVE THROUGH NEIGHBORHOODS IN THE SOUTHWEST PART OF THE CITY OF CHARLOTTE, WOULD THEY KNOW WHERE TO GO?

A. If you are talking about outside the 10-mile EPZ there would be some minor logistics problems until there is some coordination and we could identify who

is going to be doing what in an EOC environment. Once that logistics problem has been clarified we could assign specific emergency teams to specified affected areas.

Q. THE ALL HAZARDS PLAN THAT YOU ALREADY HAVE IN PLACE IS NOT SPECIFIC TO RADIOLOGICAL EMERGENCIES AT NUCLEAR POWER PLANTS, IS IT?

A. All Hazards is just that -- all hazards. It just so happens that an accident at a nuclear power plant represents a potential hazard for the community.

Q. HOW DO YOU DETERMINE WHAT AREAS SHOULD BE ALERTED IN AN EMERGENCY?

A. Currently, the All Hazards Plan identifies evacuations by voting precincts. That is something that will have to be looked at because there is a great deal of the public out there that does not know what voting precinct they are in. Perhaps the best way to look at an evacuation for a situation would be to look at it within the context that occurred in the recent chemical fire emergency response this office was involved in. Law enforcement were sent in there with the sirens and PA systems. We did that. We had the flexibility there because we expanded the zone and we changed direction of the zone on several occasions. However, the function of the law enforcement, i.e., warning and notifying the public,

was carried out in such a manner that it didn't cause any undue concern on the part of the population in there. In addition to that, when it was identified or learned that X number of people did not have transportation, the law enforcement relayed back to us via radio in their cars that transportation was needed. We called in city buses, and from that standpoint, that operation went well.

Q. PLEASE DESCRIBE BRIEFLY WHAT HAPPENED WITH THE PEOPLE WHO WERE EVACUATED IN THE CASE OF THAT CHEMICAL FIRE.

A. They were transported to a shelter location. We had to change shelter locations because of the wind conditions and wind shifts. We extended the evacuation zone several times during the fire. A lot of people did not have transportation. City buses ran into the area and picked up the people who did not have transportation and transported those people to a shelter. We fed the people in the morning and we had sufficient shelter staff, we had sufficient people associated with the medical community to provide service if it was needed. The majority of the departments were city departments but we had certain county departments there that assisted in the operation. There were some logistics problems, and procedural problems, but nothing that would have an adverse effect on the general safety of the public

and for the most part the plan was implemented and it addressed the problems and was carried out in a very good manner.

Q. HOW MANY PEOPLE WERE EVACUATED?

A. Somewhere around 3,000 people. We had a little over 2,000 people to show up at shelters. We don't know how many people went to friends or relatives. Normally, when you look at that many people in a shelter you can probably add maybe another 20 or 30 percent to account for those people who go to relatives' home, because that's common in an evacuation.

Q. HOW LARGE AN AREA WAS INVOLVED IN THAT CHEMICAL FIRE?

A. Somewhere in the neighborhood of 3 1/2 to 4 1/2 square miles.

Q. DO YOU THINK THERE ARE ANY OTHER CHANGES THAT NEED TO BE MADE IN THE ALL HAZARDS PLAN TO ADAPT IT TO THE CONTINGENCY OF TAKING PROTECTIVE ACTION WITHIN CHARLOTTE?

A. I don't think so. I think there was a little bit of a problem associated with shelters but that has been addressed. We have simplified the shelter activation procedure to assure resources have been identified for shelter startup.

Q. ASSUMING THAT YOU ASKED THE POLICE AND OTHER EMERGENCY RESPONSE UNITS, SUCH AS CITY AND VOLUNTEER FIREMEN, TO NOTIFY THE PEOPLE IN SOUTHWEST CHARLOTTE TO TURN ON THEIR RADIO OR TELEVISION TO THE EMERGENCY BROADCAST STATION, HOW LONG DO YOU THINK THIS ALERTING PROCESS WOULD TAKE?

A. I would say about 2 to 3 hours, depending on resource capability. Actually resources would be increased with the time factor. The dispatchers or whoever is in command could look at what the resources are, who patrols the area and make the determination about the most capable units to patrol there to ensure proper coverage of that specific area.

Q. DO YOU HAVE AN ESTIMATE AS TO HOW LONG IT WOULD TAKE TO EVACUATE THE AREA DESCRIBED BY THE BOARD'S EXAMPLE OF HIGHWAYS 74 AND 16?

A. I would determine that you are looking at probably around 7 hours.

Q. DOES THAT INCLUDE THE ALERTING PROCESS THAT WE DESCRIBED BEFORE?

A. From the time the alerting process was instituted until the time the last person who was going to leave was out of the area, I would say you would be looking at about 7 hours, under normal weather conditions.

Q. WOULD THAT INCLUDE PERSONS WHO COULD BE MOVED FROM HOSPITALS?

A. Well, the hospital population might or might not be moved. It would depend on the recommendation of the medical community with regard to whether it would be safer for the patient to remain at the facility as opposed to trying to transport that individual. Those specifics, we would leave those to the experts in that field or attending physicians, the staff doctors and things of this nature, to make that determination.

Q. COULD YOU GET TRANSPORTATION TO THE HOSPITAL FOR THOSE WHO NEEDED IT AND COULD NOT MOVE?

A. There would be some delay, but yes, transportation would be available.

Q. WOULD THAT ADD TO THE OVERALL 7-HOUR ESTIMATE OR DO YOU THINK THAT THAT, TOO, COULD BE ACCOMMODATED WITHIN THE 7 HOURS?

A. I think probably within the 7 hours. You would be looking at specific resources there as opposed to general resources.

Q. IS THERE ANY HOSPITAL IN THAT AREA THAT WE ARE TALKING ABOUT?

A. Yes, there would be one hospital, Charlotte Memorial Hospital and Medical Center.

Q. IS THAT A SIZABLE HOSPITAL IN TERMS OF PATIENT POPULATION?

A. Very much so. It is one of the largest, probably the largest hospital from a bed standpoint in North Carolina.
Q. DOES IT HAVE ITS OWN EMERGENCY PLAN?
A. They have an internal emergency response plan that is required for continued accreditation, and they exercise it at least annually.
Q. ARE YOU REASONABLY CERTAIN THAT THEY COULD GET THOSE PATIENTS THAT CAN BE MOVED READY TO BE MOVED IN GOOD ORDER PROMPTLY?
A. Oh, I think so. Like I say, it's a hospital and medical center which means that they have a lot of trainees there, a lot of staff there, so I think they would be fairly capable of activating their plan, bringing in a lot of resources such as buses and taking the necessary action for developing and getting people ready to move.
Q. ARE THERE ANY OTHER SPECIAL FACILITIES IN THAT AREA THAT YOU CARE TO MENTION?
A. Well, there are numerous day care centers. I know that there are schools, both private and public, the hospital and rest homes. A city fire department is located in there.

Q. ARE YOU SATISFIED THAT FOR THE PEOPLE IN SOUTHWEST CHARLOTTE, ROUGHLY WITHIN THOSE APPROXIMATE BOUNDARIES THAT WERE USED AS AN EXAMPLE, EVACUATION COULD BE ACCOMPLISHED WITHIN ABOUT 7 HOURS?

A. I think so. I think that with the resource capability that is present in Charlotte-Mecklenburg County, plus what you could call in from the surrounding counties that would get here in less than the period of time that we spoke of, that it could be done. You could get them out of the area. I would note that you've got a basic document and you've got some basic concepts in place and I think the elements of continuity of operations and command and control functions eliminate a lot of the problems and a lot of the rumors. These elements give people more confidence when you tell them to do something that they are going to do it, and for that reason, I think that the majority of the people would listen to us and that we could evacuate that number of people within the time frame that was referenced with very little problem.

Q. HAS MECKLENBURG COUNTY EVER HAD TO MOVE A LARGE NUMBER OF PEOPLE OUT OF ANY AREA IN CHARLOTTE?

A. The largest population that we have ever had to evacuate was during the chemical fire.

Q. ARE YOU FAMILIAR WITH ANY OTHER EVACUATIONS IN OTHER CITIES WHERE YOU MIGHT HAVE HAD TO MOVE SOME COMPARABLE NUMBERS OF PEOPLE?

A. Well, yes, there was an incident that occurred a year and a half or two years ago in Missasaugus County, which is right outside of Toronto, Canada. They evacuated nearly a quarter of a million people in about 12 hours. There were no disabling automobile accidents and there were no serious injuries on the part of the evacuation people, and they got out of the area. I think it speaks well for the people, and I think it negates the panic factor.

RESUME

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Age: 36 Height: 6'0" Weight: 150 lbs.

FORMAL EDUCATION:
Clemson University: BSCE 1968
Clemson University: MS Water Resources Engineering 1970
Colorado State University: Graduate work in Environmental Engineering 1971-1972 (Part-Time)

ADDITIONAL TRAINING:
Engineering Economics - Duke Power Company
Management Development - Duke Power Company
Effective Management - Duke Power Company

PROFESSIONAL INVOLVEMENT:
Registered Professional Engineer - North Carolina 7578
Registered Professional Engineer - South Carolina 6086
Member - ASCE, ANS (Local), WPCF
Member - N.C. Water Resources Research Institute Advisory Committee
Member - Electric Power Research Institute Advisory Committee on Environmental Control Systems
Member - MIT Energy Lab Technical Committee on Environmental Management
Member - ANS Standards Committee 2.9 - Nuclear Power Plant Water Supply
Member - Utility Water Act Group (UWAG) Policy Committee

WORK EXPERIENCE:

FROM	TO	TITLE	PROGRAM	COMPANY
3/82	Present	Senior Engineer	Civil/Environmental	Duke Power

In charge of groups responsible for Environmental Engineering, Fire Protection, Coatings and Roofing. Duties included power plant siting, air and water quality studies, obtaining air and water permits, physical and mathematical modeling, conceptual design of air, water, and fire protection hardware and systems, as well as developing roofing and coating systems and specifications. Supervised 12-14 engineers and technicians.

FROM	TO	TITLE	PROGRAM	COMPANY
8/75	2/82	Supervising Design Engineer	Environmental Section	Duke Power

Supervised environmental engineering group responsible for environmental work described above.

12/74	7/75	Assistant Design Engineer	Staff Engineer	Duke Power

Assistant to Chief Engineer, Civil/Environmental Division, responsible for recruiting, training, and administrative duties for 200-person division.

10/72	11/74	Assistant Design Engineer/Engineer Associate	Environmental Section	Duke Power

Responsible for Environmental Report/EIS Preparation for two nuclear plants, environmental assessment and thermal modeling.

8/70	9/72	Lieutenant	Minuteman	USAF

Responsible for Combat Targeting Team involved in targeting and alignment of minuteman missiles.

MARK A. CASPER

PROFESSIONAL QUALIFICATIONS

DESIGN ENGINEERING DEPARTMENT

DUKE POWER COMPANY

I have been a Meteorologist with Duke Power Company, Design Engineering Departmtent, Civil/Environmental Section, since January 1981.

I received a BS degree in Meteorology from the University of Michigan in 1979. While an undergraduate, I participated in a study of the environmental impact of the once through cooling systems and subsequent emissions of waste heat and moisture into the atmosphere at the Cook and Palisades Nuclear Power Plants on Lake Michigan. My responsibilities included the processing and analysis of the meteorological data acquired near the plants.

I entered the graduate program at the University of Michigan in 1979, and was awarded an MS degree in Meteorology in 1980. In addition to continuing my association with the Cook and Palisades project, I participated in the solar and meteorological measurement program conducted at the University of Michigan under contract by the Solar Energy Research Institute. I was also a teaching assistant for a senior level meteorological synoptic lab class.

I accepted my present position in January 1981. In this position I conduct various meteorological analyses associated with Duke Power Company's electric generation operations at all facilities, both nuclear and fossil. Such meteorological aspects typically involve (a) diffusion applications involving estimates of atmospheric transport/diffusion of pollutants related to both coal-fired and nuclear electric generation including the development of transport/diffusion models for nuclear emergency response, and (b) synoptic applications involving estimates of specialized short-term weather forecasts. Diffusion applications also involve the transport/diffusion of excess water vapor associated with cooling tower and cooling pond releases.

I am a member of the American Meteorological Society, the Air Pollution Control Association, and the Utility Air Regulatory Group's Atmospheric Modeling Committee.

NAME

THOMAS E. POTTER

EDUCATION

M.S., Environmental Science (Radiological Health), University of Michigan, 1972.
B.S., Chemistry, University of Pittsburgh, 1963.

PROFESSIONAL EXPERIENCE

1973-Present Consultant, Pickard, Lowe and Garrick, Inc.

Consultant on health and safety aspects of nuclear power. Performing probabilistic analyses of off-site consequences of power reactor accidents as part of full-scope probabilistic risk assessments for nuclear power plants. Performing environmental dose assessments for nuclear power plant safety analysis, environmental reports and operating reports. Assisting clients in design and implementation of radiological or environmental monitoring programs and interpretation of results. Providing independent review of in-plant radiological protection programs and effluent analysis programs. Participated in design and development of the CRACIT code, a computer program for probabilistic assessment of power reactor accident consequences. Participated in an international comparison study of reactor accident consequence assessment models. Participated in a comprehensive assessment of off-site radiation from the Three Mile Island accident.

1972-1973 Consultant to Dr. G. Hoyt Whipple, University of Michigan

Consultant in radiological health aspects of nuclear power. Prepared radiological health section of safety analysis reports and environmental monitoring programs and evaluated data from those programs. Developed a mathematical model to predict radiation doses from nuclear power plant effluents.

1963-1970 Nuclear Materials and Equipment Corporation (NUMEC). License administrator, plutonium fuel facility health and safety supervisor.

License administrator, plutonium fuel facility health and safety supervisor. Provided radiologic[illegible] safety review of major facility modifications. Used these analyses and nuclear criticality analyses performed by others to prepare AEC special nuclear materials and byproduct license applications. Served as corporate contact with AEC in matters related to licensing. Organized and supervised a radiological protection program for a plutonium fuels fabrication facility and hot cell facility. Instituted personnel monitoring programs using thermoluminescent dosimetry and breathing-zone aerosol sampling in 1967.

Served as secretary of a plant safety committee which inspected all operations and reviewed detailed written procedures for operators. Served as member of a corporate safety committee which determined corporate policy regarding health and safety matters.

REPORTS AND PUBLICATIONS

Woodard, K., and T. E. Potter, "Consideration of Source Term in Relation to Emergency Planning Requirements," presented to the Workshop of Technical Factors Relating Impacts from Reactor Releases to Emergency Planning, Bethesda, Maryland, January 12-13, 1982.

Garrick, B. J., S. Kaplan, G. Apostolakis, D. C. Iden, K. Woodard and T. E. Potter, "Seminar: Probabilistic Risk Assessment of Nuclear Power Plants," PLG-0141, July 1980.

Garrick, B. J., S. Kaplan, G. E. Apostolakis, D. C. Bley, and T. E. Potter, "Seminar: Probabilistic Risk Assessment as Applied to Nuclear Power Plants," PLG-0124, March 1980.

Woodard, K., and T. E. Potter, "Modification of the Reactor Safety Study Consequences Computer Program (CRAC) to Include Plume Trajectories," presented to the 1979 ANS 25th Winter Meeting, San Francisco, California, November 11-15, 1979.

Woodard, K., and T. E. Potter, "Assessment of Noble Gas Releases from the Three Mile Island Unit 2 Accident," presented to the 1979 ANS 25th Winter Meeting, San Francisco, California, November 11-15, 1979.

Garrick, B. J., S. Kaplan, P. P. Bieniarz, K. Woodard, D. C. Iden, H. F. Perla, W. Dickter, C. L. Cate, T. E. Potter, R. J. Duphily, T. R. Robbins, D. C. Bley, and S. Ahmed, "OPSA, Oyster Creek Probabilistic Safety Analysis," (Executive Summary, Main Report, Appendixes), PLG-0100 DRAFT, August 1979.

Woodard, K., and T. E. Potter, "Probabilistic Prediction of X/Q for Routine Intermittent Gaseous Releases," Transactions of the American Nuclear Society, Vol. 26, June 1977.

EPC 11
Potter Attachment B

RADIOLOGICAL CONSIDERATIONS RELATED TO THE CATAWBA PLUME PATHWAY EMERGENCY PLANNING ZONE DISTANCE

by Thomas E. Potter

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1.0 Introduction

The basis for a plume exposure EPZ of about 10 miles was developed in NUREG-0396 (Reference 1), and is stated most succinctly in NUREG-0654 (Reference 2):

"The size (about 10 miles radius) of the plume exposure EPZ was based primarily on the following considerations:

a. projected doses from the traditional design basis accidents would not exceed Protection Action Guide levels outside the zone;

b. projected doses from most core melt sequences would not exceed Protective Action Guide levels outside the zone;

c. for the worst core melt sequences, 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.

The NRC/EPA Task Force concluded that it would be unlikely that any protective actions for the plume exposure pathway would be required beyond the plume exposure EPZ. Also, the plume exposure EPZ is of sufficient size for actions within this zone to provide for substantial reduction in early severe health effects (injuries or deaths) in the event of a worst case core melt accident."

Analyses related to the first three considerations are included in NUREG-0396. Plant-specific and site-specific analyses performed in the course of licensing support the conclusion that projected doses from traditional design basis accidents would not exceed upper Protective

Action Guide doses beyond the 10-mile zone even based on assumption of poor dispersion conditions. Summaries of these analyses are included in NUREG-0396. Data in the Catawba FSAR indicate that the conclusion applies to Catawba as well (Reference 3).

Generic analyses included in NUREG-0396 support considerations b and c. These analyses consist of estimates of the probability (given a core melt release) that specified doses would be exceeded versus distance. Because the analysis was intended to show whether emergency response was appropriate, it was assumed for the analysis that people took no emergency response for 24 hours and were shielded only to the extent they would be in the course of normal activities. The results (NUREG-0396, Figures 1-11 and 1-13) showed that the probability given core melt release of exceeding the lower Protective Action Guide levels (1 rem whole body, 5 rem thyroid) was less than about 0.3 beyond 10 miles and the corresponding probability of exceeding the upper PAG levels (5 rem whole body, 25 rem thyroid) was somewhat lower. The results also showed that the probability, given melt release, of exceeding life threatening doses (200 rem whole body) at the 10-mile EPZ was low, about 0.03, and declined rapidly at greater distances. In this discussion "life threatening dose" should be interpreted to be the dose above which the probability of fatality from the acute radiation syndrome begins to be significant. These generic analyses were based on core melt release characteristics and release frequencies developed for PWR reactors in the Reactor Safety Study (RSS) and meteorology data collected for the six sites analyzed in RSS (Reference 4).

This study is designed to determine whether features peculiar to Catawba would affect considerations b and c, thereby affecting the selection of 10 miles as an appropriate plume pathway EPZ distance. This was achieved by calculating the probability, conditional on core melt release, of exceeding PAG and life threatening doses comparable to probabilities from NUREG-0396 generic studies except for use of meteorology data from the Catawba site.

The analysis described provides an estimate of exceeding a specified doses at a specified distance in any direction. Because the area in question in this contention is limited to a sector about 45 degrees in width, the probability of exceeding the specified doses in the contested area is lower. The analysis was extended to obtain an estimate of probability of exceeding the specified doses at a specified distance in the contested area.

2.0 Methodology

The first objective of this study is an assessment of the probability of exceeding specified doses from core melt releases. The methodology followed in this study was the same as that used for the generic study described in NUREG-0396, and is described briefly here. Minor departures from NUREG-0396 methodology are noted.

The doses calculated result from exposure to radiation emitted by airborne radioactive material during transport past the receptor or from exposure to radiation emitted by radioactive material inhaled during transport past the receptor or from radiation emitted by radioactive material deposited on surfaces during transport past the receptor. The doses calculated include the sum of the three components.

The probability depends upon the characteristics and probabilities of all core melt releases in the spectrum and upon exposure conditions assumed for the hypothetical stationary receptor.

The important exposure condition assumptions are the magnitude of dose reductions afforded by structures and the duration of exposure to radiation from radioactive materials deposited on surfaces during passage of the airborne material. The probability can also depend strongly upon the liklihood of different meteorological conditions during and following a release. These conditions determine the extent of atmospheric dispersion of released material. Common variations in meteorological conditions can result in large variations in dose.

In this analysis exposure conditions were assumed to be constant throughout. To be consistent with assumptions used in NUREG-0396, it was assumed that no emergency response occurs for a period of 24 hours following passage of airborne material and that doses are reduced only to the extent that would be expected in the course of normal activities. That is, no dose reduction was assumed for inhalation dose and factors of 0.75 and 0.33 were applied to the direct doses from airborne material and material deposited on surfaces.

The spectrum of core melt releases is represented by a set of release categories. Each release category is a release for which important characteristics are calculated explicitly. The important characteristics include the release magnitude for various isotope groups (expressed as a fraction of core inventory), the time between the initiating event and release to the atmosphere, release duration, height, heat content, and warning time prior to release. The probability of each release category is calculated by adding the calculated probabilities of all accident sequences that would lead to a release similar in characteristics. The release category spectrum fully reflects the entire core melt release spectrum while keeping the number of discrete releases manageable for analytical purposes.

The influence of variable meteorological conditions on the probability of exceeding specified doses is determined by performing a large number of computer simulations of each release category with a randomly selected release start time (month, day, and hour) for each simulation. Meteorological data for the corresponding time are selected from a one-year hourly data base. Sequential hourly measurements are used to calculate trajectory and concentration changes during transport downwind. The approach permits simulation of the effects of changing meteorological conditions on transport and dispersion along the trajectory. The number of simulations for each release category ranges from 100 to 300 to assure adequate sampling from the range of meteorological conditions. Life threatening doses more than a few miles

from the plant can occur only for the most severe release categories and, even then, only in unlikely meteorological conditions. The larger number of simulations is usually reserved for the most severe release categories to assure adequate sampling of these meteorological scenarios.

The probability, conditional on occurrence of the release category, of exceeding a specified dose at a specified distance is simply the number of simulations producing that result divided by the number of simulations made for the release category. The absolute probability of exceeding the specified dose at the specified distance is the probability, conditional on release, times the probability of occurrence of the release category. The total absolute probability of exceeding the specified dose at the specified distance is the sum of the absolute probabilities of all release categories.

Results in NUREG-0396 are expressed conditional on core melt release. This is the total absolute probability divided by the probability of core melt. The expression of results conditional on core melt release reflects the fact that such release categories range from minor to severe and reflect the finding that minor release categories are the most likely. For purposes of illustration, assume that it is found that life threatening doses at 10 miles occur only for a severe release category and that the probability conditional on release category of exceeding the dose at 10 miles is 0.08. Then assume that it is found that only 10 percent of the core melt releases fall into this severe category. That is the same as saying that the probability of a severe release, conditional on a core melt release, is 0.1. In this illustration then, the probability of exceeding a life threatening dose at 10 miles, given a core melt release, is 0.08 x 0.1 = 0.008.

The CRAC (Calculation of Reactor Accident Consequences) computer model was used in the NUREG-0396 probabilistic dose analysis. It was developed by the Nuclear Regulatory Commission for the Reactor Safety Study (Reference 4). The CRAC code was the first developed to perform a

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comprehensive probabilistic assessment of consequences of a severe reactor accident. It included simulation of plume rise, wet and dry deposition, and changes in meteorological conditions (except for wind direction) during transport downwind.

A modified version of CRAC called CRACIT (Calculation of Reactor Accident Consequences Including Trajectories) was used for this analysis. The major improvement in CRACIT relevant to its application in this analysis is the incorporation of variable wind direction. (Other substantial differences between CRAC and CRACIT are related to modeling of dispersion at deep river valley and coastal sites and modeling of evacuation trajectories, but those differences are not relevant to this analysis.) Minor improvements were also made in the dispersion model to better simulate limitation of dispersion by a stable layer aloft, buoyant penetration of the stable layer aloft, and effects of buildings on suppression of buoyant plume liftoff in high wind speed situations. The CRACIT code has been used in full-scope probabilistic risk assessments for reactors at six sites and has been used in several other more limited applications.

Another derivative of CRAC, called CRAC2, is very similar to CRAC in its dispersion model and is also commonly used in accident consequence assessment.

Comparisons of results from CRAC, CRAC2, and CRACIT exercised on benchmark problems have shown only small differences in probabilistic distribution of dose and health effects even though results for individual simulations occasionally varied markedly (Reference 5). Details of the three codes are described in the PRA Procedure Guide (Reference 6).

In this study, CRACIT was selected based upon its more realistic treatment of atmospheric dispersion. But CRAC2 was used for one run for release category PWR-2 to examine whether modeling code differences affect the estimates of probabilities of exceeding PAG or life

fhreatening doses in the range of 10 to 20 miles. Estimated probabilities from the two codes varied by less than 20 percent. Therefore, it may be concluded that model differences do not affect the results of this study.

3.0 Data

The meteorological data used in this analysis was a one-year data base of sequential hourly measurements from the Catawba site meteorological monitoring program towers. The data were collected during the period December 17, 1976 through December 16, 1977 and submitted as part of a two-year data base in the Catawba FSAR. Wind speed and direction data collected at the 10 meter level were used in this analysis. Atmospheric stability classification was based on the vertical temperature difference measured between the 40 meter and 10 meter levels. The period of record selected for use in this analysis was recommended by the utility meteorologist as a representative period during which recovery of data was high (Reference 7). Certain characteristics of the dispersion meteorology at the Catawba site were noted in the NRC Final Environmental Statement (Reference 8). These characteristics are reflected in the data base used in this analysis. Winds blow from the south-southwest and southwest sectors approximately 27 percent of the time and wind speeds during stable conditions are low.

Release characteristics and probabilities for the spectrum of core melt releases for typical light water reactors were developed as part of the Reactor Safety Study (Reference 4). One set of release categories was developed for Surry, the model PWR, and one set was developed for Peach Bottom, the model BWR. Characteristics for these PWR core melt release categories are shown in Table 1. No comprehensive assessments of core melt release characteristics or probabilities for the Catawba plant are available and performance of such an assessment is beyond the scope of this limited study. Available studies for plants similar to Catawba were reviewed to determine the most appropriate set of release categories

(References 9, 10, and 11). These studies indicate that the core melt release spectrum for Catawba would be less severe than that calculated in the RSS but the studies are not comprehensive enough to permit complete quantification. Therefore, RSS PWR releases and probabilities were used in this study.

4.0 Results and Conclusions

The probability of exceeding Protective Action Guide Doses (1 rem whole body or 5 rem thyroid) and life-threatening dose (200 rem whole body) was computed for three distances--10, 12 and 16 miles. The RSS PWR release categories and probabilities were used with meteorology data from the Catawba site. Results expressed as total absolute probabilities are shown in Table 2. Results from the NUREG-0396 analyses are included for comparison.

Inspection of Table 2 shows that results from the Catawba analysis are quite similar to those from NUREG-0396. The results clearly show that the probability of exceeding Protective Action Guide doses is very low and the probability of exceeding life threatening doses is substantially lower.

The low probability of occurrence of a core melt accident is an important component of the low probabilities in Table 2 which are based on a core melt accident probability of 6×10^{-5} per reactor year. Although there is considerable uncertainty in the estimate of core melt probability, recent probabilistic risk assessments which include estimates of uncertainty indicate that the probability of core melt is low even considering the uncertainty (Reference 12). The experience of operating power reactors in the free world also indicates that the probability of core melt is low. Approximately 1600 reactor-years of operation have been accumulated to date (Reference 13).

The absolute probabilities can be expressed as probabilities conditional on core melt release by dividing them by the probability of a core melt accident, the sum of release category probabilities in Table 1, 6×10^{-5} per reactor year. This shows that even if a core melt accident should occur it is likely that Protective Action Guide doses would not be exceeded beyond 10 miles. The probability of exceeding these doses is about 0.25 given a core melt accident. It also shows that even if a core melt accident should occur the probability of exceeding a life threatening dose beyond 10 miles is very low, about 0.03.

The analysis described above estimates the probability of exceeding doses in any direction at the specified distances. Because the area in contention in this case is limited to a sector approximately 45 degrees in width, the probability of exceeding doses at specified distances in the contested area is lower than indicated in Table 2. Analysis limited to the sectors of interest results in probabilities approximately 30 percent of those in Table 2. This finding is consistent with the observation that wind blows in the direction sectors of interest about 30 percent of the time. The probability of exceeding Protective Action Guide doses and life threatening doses for distances of 10, 12 and 16 miles in the zone in contention are shown in Table 3. These absolute probabilities can be translated to probabilities conditional on a core melt accident by dividing by the core melt accident probability. This shows that even if a core melt accident occurred, the probability of exceeding Protective Action Guide doses in the zone in contention would be low, about 0.1 and that the probability of exceeding a life threatening dose in the zone in contention would be very low, about 0.01.

These findings lead to the conclusion that the considerations based on NUREG-0396 generic core melt accident analyses that were factors in the decision to establish a 10-mile plume pathway Emergency Planning Zone are supported as well by a similar analysis performed for the Catawba plant at the Catawba site:

- Projected doses from most core melt sequences would not exceed PAG levels outside the zone.

- For the worst case core melt sequences, immediate life threatening doses would generally not occur outside the zone.

These findings also lead to the conclusion that even if a core melt accident should occur, the probability of requiring protective action in the zone in contention is low (about 0.1) and the probability of exceeding life threatening doses in the zone in contention without protective action is very low (about 0.01).

TABLE I

SUMMARY OF RSS RELEASE CATEGORIES FOR PWR CORE MELT RELEASES[a]

Release Category	Probability per Reactor-yr	Time of release (hr.)	Duration of release (hr.)	Warning Time (hr.)	Elevation of release[b] (meters)	Energy of release (10^6 Btu/hr)	Fraction of core inventory released[c]						
							Xe-Kr	I[d]	Cs-Rb	Te-Sb	Ba-Sr	Ru[e]	La[f]
PWR-1	$9x10^{-7}$	2.5	0.5	1.0	25	20 and 520[g]	0.9	0.7	0.4	0.4	0.05	0.4	$3x10^{-3}$
PWR-2	$8x10^{-6}$	2.5	0.5	1.0	0	170	0.9	0.7	0.5	0.3	0.06	0.02	$4x10^{-3}$
PWR-3	$4x10^{-6}$	5.0	1.5	2.0	0	6	0.8	0.2	0.2	0.3	0.02	0.03	$3x10^{-3}$
PWR-4	$5x10^{-7}$	2.0	3.0	2.0	0	1	0.6	0.09	0.04	0.03	$5x10^{-3}$	$3x10^{-3}$	$4x10^{-4}$
PWR-5	$7x10^{-7}$	2.0	4.0	1.0	0	0.3	0.3	0.03	$9x10^{-3}$	$5x10^{-3}$	$1x10^{-3}$	$6x10^{-4}$	$7x10^{-5}$
PWR-6	$6x10^{-7}$	12.0	10.0	1.0	0	N/A	0.3	$8x10^{-4}$	$8x10^{-4}$	$1x10^{-3}$	$9x10^{-5}$	$7x10^{-5}$	$1x10^{-5}$
PWR-7	$4x10^{-5}$	10.0	10.0	1.0	0	N/A	$6x10^{-3}$	$2x10^{-5}$	$1x10^{-5}$	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$	$2x10^{-7}$

[a]WASH-1400, App. VI.

[b]A 10-m elevation is used in place of zero representing the midpoint of a potential containment break. Any impact on the results would be slight and conservative.

[c]Background on the isotope groups and release mechanisms is presented in the Reactor Safety Study, Appendix VII (USNRS, 1975).

[d]Organic iodine is combined with elemental iodine in the consequence calculations. Any error is negligible since the release fraction of organic iodine is relatively small for all large release categories.

[e]Includes Ru, Rh, Co, Mo, Tc.

[f]Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

[g]Accident sequences within the PWR-1 category have two distinct energy releases that affect consequences. The PWR-1 category is subdivided into PWR-1A, with a probability of 4×10^{-7} per reactor-year and an energy of release of 20×10^{-6} Btu/hr; and PWR-1B, with a probability of 5×10^{-7} per reactor-year and an energy of release of 520×10^6 Btu/hr.

TABLE 2

PROBABILITY OF EXCEEDING SPECIFIED DOSES VERSUS DISTANCE

WASH-1400 PWR RELEASES - NO EMERGENCY RESPONSE FOR 24 HOURS[a]

ORGAN	DOSE (REM)	PROBABILITY OF EXCEEDING DOSE (PER REACTOR YEAR)					
		10 MILES		12 MILES		16 MILES	
		CATAWBA[b]	NUREG-0396[c]	CATAWBA	NUREG-0396	CATAWBA	NUREG-0396
WHOLE BODY	1 (PAG)	1.5E-05[d]	1.8E-05	1.4E-05	1.6E-05	1.4E-05	1.4E-05
THYROID	5 (PAG)	1.5E-05	1.6E-05	1.4E-05	1.6E-05	1.4E-05	1.4E-05
WHOLE BODY	200	1.7E-06	1.8E-06	1.4E-06	1.3E-06	4.8E-07	2.4E-07

[a]Based on core melt probability of 6E-05 per reactor year. See Table 1.

[b]Catawba site meteorology.

[c]Based on data from NUREG-0396, Figures 1-11, 1-13.

[d]Probability numbers should be interpreted as follows:

1.0E-05 = 1 in 100,000 per reactor year
1.0E-06 = 1 in 1,000,000 per reactor year
1.0E-07 = 1 in 10,000,000 per reactor year

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TABLE 3

PROBABILITY OF EXCEEDING SPECIFIED DOSES VERSUS DISTANCE IN CATAWBA ZONE IN CONTENTION

WASH-1400 PWR RELEASES - NO EMERGENCY RESPONSE FOR 24 HOURS[a]

ORGAN	DOSE (REM)	PROBABILITY OF EXCEEDING DOSE (PER REACTOR YEAR)		
		10 MILES	12 MILES	16 MILES
WHOLE BODY	1 (PAG)	4.5E-06[b]	4.2E-06	4.2E-06
THYROID	5 (PAG)	4.5E-06	4.2E-06	4.2E-06
WHOLE BODY	200	5.1E-07	4.2E-07	1.4E-07

[a]Based on core melt probability of 6E-05 per reactor year. See Table 1. Catawba site meteorology.

[b]Probability numbers should be interpreted as follows:

1.0E-05 = 1 in 100,000 per reactor year
1.0E-06 = 1 in 1,000,000 per reactor year
1.0E-07 = 1 in 10,000,000 per reactor year

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Education	North Carolina State University, B.S., Industrial Engineering
	University of North Carolina, M.S., Business Administration
	Northwestern University, Candidate for Doctor of Civil Engineering in Transportation and Systems Analysis
Previous Positions	Kurt Salmon Associates, Management Consultants, 1965-1968. Staff Consultant
	Northwestern University Transportation Center, 1970. Research Assistant

Experience

Emergency Management Planning. Directed the independent evacuation time assessments for the Federal Emergency Management Administration (FEMA) at the Seabrook and Zion Nuclear Power Plants. The methodology developed for these assessments has been incorporated into the FEMA regulatory guide NUREG 0654. Directed evacuation feasibility studies for three nuclear power plant sites for Duke Power and arranged for appropriate technology transfer to facilitate Duke Power staff to independently assess alternative emergency scenarios. Currently, project manager for the emergency response and preparedness plan development in northeastern Ohio. This planning effort includes basic plan preparation, resource assessment, training, and development of standard operating procedures.

Management. Directed a study to develop a TSM plan for the Pittsburgh, Pennsylvania, Central Business District. Included in the plan are improvements to vehicular traffic, transit, pedestrian travel, and parking. Responsible for management of multimodal transportation studies in various U.S. and foreign locations. Managed regional PRC Voorhees office in Buffalo, New York.

Multimodal Transportation Planning. Conducted a study of multimodal passenger travel improvement in the Cross Florida Transit Corridor Study. Performed internal circulation planning, community impact, and facility staging for planned new towns; internal circulation, transit, pedestrian, and parking planning for university/medical complexes; and transportation master plans for various small cities. Managed Maryland Statewide Aviation Study, with surveys of air passengers and cargo, projection of ground access requirements, and modeling of airport access.

Transit Planning. Conducted study of bus priority treatments for Caracas, Venezuela; analysis of rapid transit alternatives in

Buffalo, New York. Was project manager for Buffalo Station Areas Impact Study, involving neighborhood impact and access requirements for twelve rapid transit stations. Conducted rapid transit patronage estimation and community forum presentation of patronage impacts in Buffalo, and ridership and scheduling impacts of reduced fares for the elderly in Chicago. Developed short-range transit alternatives to meet community needs in Pittsburgh. Evaluated short- and medium-range bus priority measures, in Cleveland, and transit improvement alternatives for a transit-dependent semi-rural area in Geauga County, Ohio; and the new town of Audubon, New York. Integrated Buffalo rapid transit station into a high-activity medical center.

Traffic Planning and Engineering. Incorporated traffic flow with bus priority treatments in Caracas. Developed areawide traffic improvement plans (TOPICS) in Buffalo, New York, and New Brunswick, New Jersey. Conducted numerous traffic impact studies for new communities, industrial parks, and shopping centers, and presented court testimony on impact of Interstate Highway facilities on site access and market areas, projected arterial street volumes, and on community impact of a Planned Unit Development.

Affiliations

American Society of Civil Engineers
Institute of Transportation Engineers

Prepared for
Duke Power Company

Effect of "Shadow" Evacuation on the Time to Evacuate the Catawba Nuclear Station EPZ

Prepared by
PRC Engineering
1500 Planning Research Drive
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February 1984

EFFECT OF "SHADOW" EVACUATION ON THE TIME TO EVACUATE THE CATAWBA NUCLEAR STATION EPZ

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February 1984

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LIST OF EXHIBITS

EXECUTIVE SUMMARY

Four main roads leading out of the Catawba EPZ pass through the Charlotte metropolitan area: I-77, US 521, NC 160, and NC 49. If some or all of the Charlotte area population were to voluntarily evacuate because of an emergency at the Catawba Nuclear Station, severe congestion could occur in the downtown area and on main roads leading north and east from the City. If one assumes the average Charlotte evacuee leaves home an hour later than the average EPZ evacuee, the congestion in the Charlotte area does not delay anyone from leaving the EPZ. If one assumes that the Charlotte evacuees depart only half an hour after the EPZ evacuees, there would still be no impediment to evacuating the EPZ on three of the four routes. On the fourth route, I-77, backups could extend into the EPZ if 70 percent or more of the Charlotte area residents were to evacuate and if no mitigating traffic control actions were taken. In that case, if 70 to 80 percent of the Charlotte residents evacuated voluntarily, some EPZ evacuees using I-77 northbound would be delayed up to half-hour. Total time to evacuate the EPZ would, however, remain at 4 hours. If 100 percent of the Charlotte residents evacuated voluntarily, the EPZ evacuees using I-77 would be delayed 1 hour, delaying completion of the entire EPZ evacuation by 30 minutes.

STUDY OBJECTIVES

In April of 1983, PRC Engineering used computer modeling to estimate the time required to evacuate the plume exposure emergency planning zone (EPZ) surrounding Duke Power's Catawba Nuclear Station. The results of that analysis are summarized in Exhibit 1. Those estimates were based on the assumption that evacuees could exit the EPZ unimpeded by traffic congestion outside the EPZ.

Subsequently, Duke asked us to determine whether voluntary evacuation of people living outside the EPZ in the Charlotte area could create enough traffic congestion to delay traffic leaving the EPZ. This report describes our analysis of that question and presents our findings.

EXHIBIT 1. SUMMARY OF EVACUATION TRAFFIC FLOWS
(4/83 PRC Study)

Routes Out of EPZ	Population Carried	Vehicles Carried	Maximum Evacuation time (Hours)[1]
* I-77 NB	10,298	4,428	3:25
SC 901	13,556	5,829	3:30
Lyle Boulevard	4,459	1,917	3:25
US 21 SB	15,897	6,835	4:00
SC 322	5,284	2,272	3:25
US 321	2,281	980	3:25
SC 5 WB	1,763	758	3:25
SC 161 WB	2,468	1,061	3:25
I-77 SB	8,079	3,473	3:45
YC 150	1,470	632	3:25
SC 55	1,286	552	3:25
US 321 NB	3,275	1,408	3:25
NC 247 NB	1,068	459	3:25
NC 279	4,529	1,947	3:25
* US 521	1,525	655	3:25
* NC 49	2,213	951	3:25
SC 160 EB	4,926	2,118	3:25
* NC 160 NB	1,721	740	3:25

* Routes leading to Charlotte area

1 Winter weekday, daytime, normal driving conditions

ANALYSIS PROCEDURES

The analysis was conducted using the same traffic simulation model, QUEUE, used in the original evacuation study. Except as noted in the next section, the underlying assumptions were also unchanged. The analysis proceeded in the following steps:

1. Develop a departure time distribution, an estimate of the fraction of the population leaving home in each time interval after the evacuation has been announced.

2. Identify the evacuation routes. These are the main roads heading away from Catawba Nuclear Station. As part of this step, the intersections are identified where people get on to the routes.

3. Determine Highway Capacities for each segment (between consecutive intersections) of the evacuation routes.

4. Assign the population to the routes. In this step, each person in the study area is assigned to the evacuation route and intersection that provide him the most direct exit from the area.

6. Estimate the number of vehicles per evacuee

7. Estimate for each area the fraction of the population that evacuates

8. Determine recommended traffic control actions such as expressway ramp closings, traffic redirection, etc.

9. Conduct the simulation using PRC Engineering's QUEUE model. The model simulates the flow of vehicles over the evacuation routes and determines when all the evacuation traffic on each route has left the area. The model takes into account the fact that evacuees leave home at different times and that highway capacity is limited. For each time period and each intersection, the model determines the length of the traffic queue waiting to get through the intersection.

10. Examine the queue lengths to determine when the backups on each route no longer extend into the EPZ.

ASSUMPTIONS USED

Our analysis consisted of a series of simulations made with different assumptions. The assumptions we varied were the fraction of the non-EPZ population that

evacuates voluntarily and the time at which those people leave home. The other assumptions were the same in all the simulations.

Departure Time Distribution

For EPZ residents, we used the same departure curve as in our April 1983 study. That curve, shown graphically in Exhibit 2, indicates that half the evacuees leave home within 1 hour and 10 minutes after the start of evacuation and the rest within 3 hours and 10 minutes of the start. The derivation of this departure time distribution is discussed at length in our earlier report.

Charlotte area evacuees would leave later and more gradually than the EPZ evacuees, for two reasons. First, since there will be no siren sounding or other government efforts to notify Charlotte residents of the emergency, people in Charlotte will become aware of the situation more slowly than people in the EPZ. Second, once aware of the situation they are likely to more fully ascertain the need to evacuate. That is, their decision will involve more extensive information gathering and attempts at confirming the need to evacuate. The effect of the later, more gradual departure of Charlotte residents is to reduce the congestion experienced by EPZ evacuees. In fact, it could be that EPZ evacuation would be complete before congestion outside the EPZ becomes significant.

Since the amount of this lag between the Charlotte area evacuation and the EPZ evacuation is unknown, we conducted two sets of simulations, one using an assumed lag of 1 hour and the other set using an assumed lag of 30 minutes.

Evacuation Routes

Exhibit 3 shows the evacuation routes used in this study. Only routes used by both EPZ and Charlotte evacuees were modeled; congestion on routes used only by Charlotte evacuees would not affect EPZ evacuation times.

Exhibit 2.
Departure Time Distributions for Evacuees

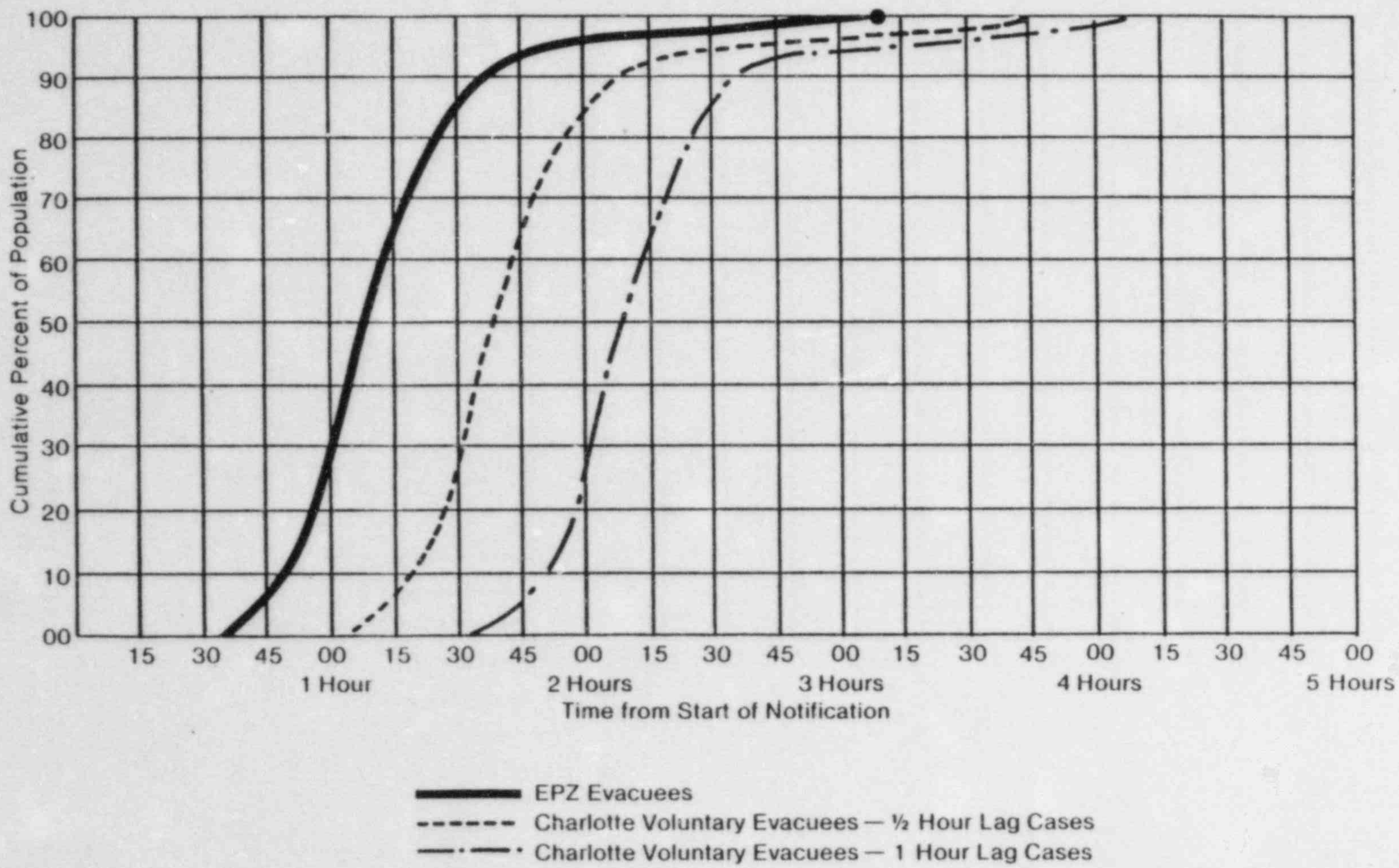
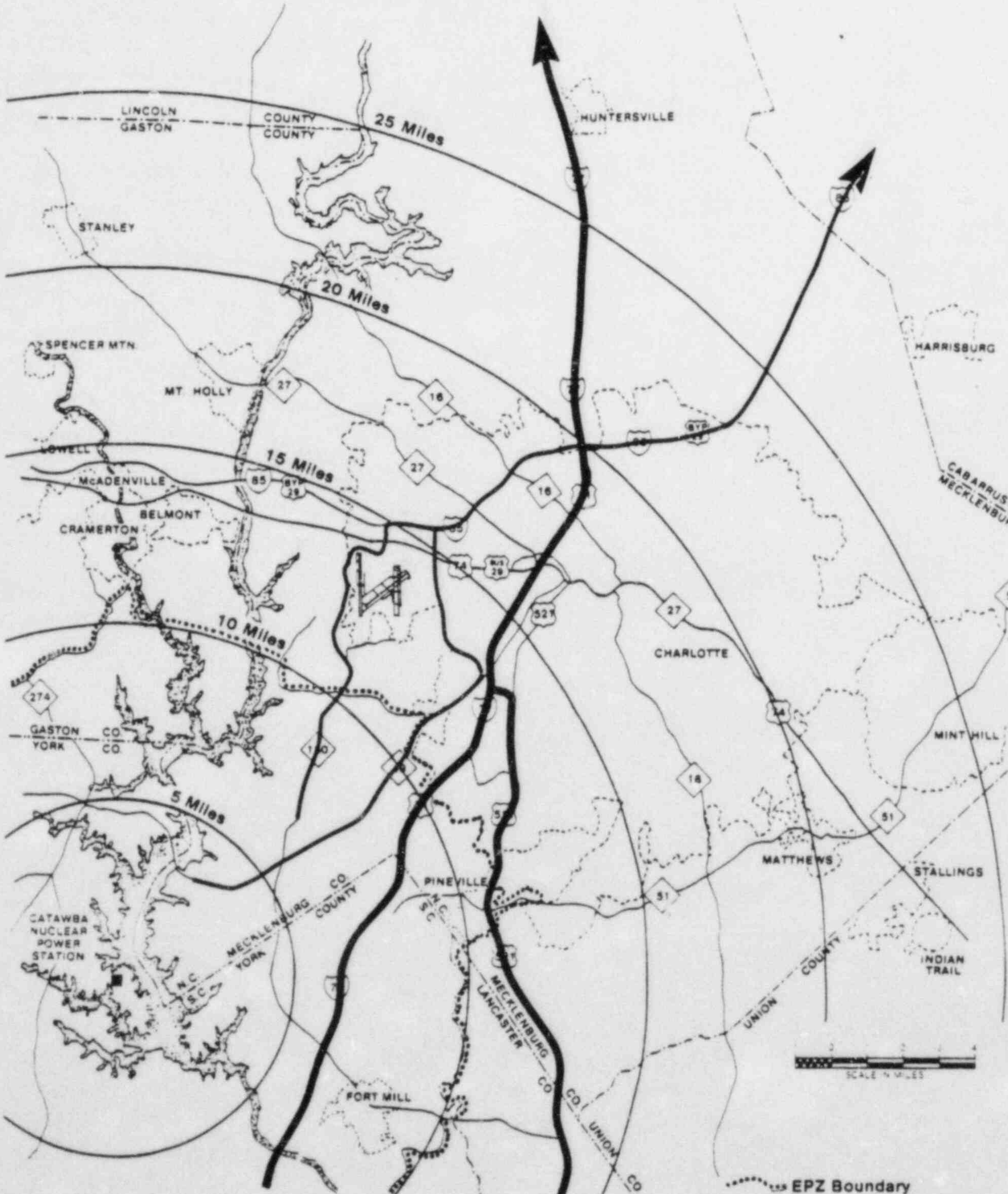


Exhibit 3. Evacuation Routes



As the routes indicate, all evacuees are assumed to travel radially away from the power plant until they are at least 25 miles away. Since government officials will be recommending evacuation out to only ten miles or less, and since many evacuees will know of friends, relatives, or hotels in the Charlotte area, it is unlikely that all evacuees will travel to the 25-mile mark. If they do not, congestion on the segments further from the EPZ will be less than our simulation predicts.

Highway Capacities

Following generally accepted traffic engineering practice, we assumed that expressways carry 1,800 vehicles per lane per hour and other roads 1,200 vehicles per lane per hour. (Expressway ramps are assigned an intermediate capacity of 1,500 vehicles per hour.) These capacities do not reflect the delays caused by congestion at the modeled intersections; that delay is computed separately by the QUEUE model.

Population Assignment

As noted earlier, each potential evacuee is assigned to the most direct route that will take him 25 miles away from the power plant. If preliminary simulation shows that our initial assignments give congestion that is much worse on one of two parallel routes than on the other, the population assignments are adjusted to reflect drivers' preference for the less congested route.

Vehicles Per Evacuees

We assumed 0.43 vehicles per evacuee (2.33 people per vehicle), the same as in the earlier study. That figure was developed using household auto ownership for EPZ residents. Since cities normally have fewer cars per household than rural areas, it is likely that the average number of vehicles used by Charlotte evacuees would be less than for EPZ evacuees. If the vehicles per evacuee were adjusted downward to account for this, the result would be less highway congestion than our simulation predicts.

Fraction of Population Evacuating

All simulation runs evacuated 100 percent of the EPZ residents and a portion of the Charlotte area residents. The fraction of the Charlotte residents choosing to evacuate was varied between 40 to 100 percent.

The fact that we did not simulate cases with less than 40 percent of Charlotte residents evacuating does not mean that we expect at least 40 percent to evacuate voluntarily. Forty percent was the smallest value tried because it did not produce congestion that delayed people from leaving the EPZ. Therefore, it is clear that smaller numbers of Charlotte evacuees would also not delay the EPZ evacuees.

Traffic Control

As in our earlier studies, traffic is allowed to flow normally with a minimum of special controls. No special traffic control measures were assumed to be used outside the EPZ.

SIMULATION RESULTS

The simulations showed that, even if everyone in the Charlotte area evacuated, the traffic backups would not extend into the EPZ on routes US 521, NC 160, and NC 49. For the remaining route out of the EPZ into Charlotte, I-77, the simulation predicted backup into the EPZ under certain conditions. If backups occurred, they would delay the time that the last EPZ residents using I-77 northbound would leave the EPZ.

We used the QUEUE model to estimate the delay to EPZ evacuees for several different scenarios. Exhibit 4 summarizes the cases studied and the associated delay. As noted in the discussion of assumptions, the simulations overestimate the delay because they use a high estimate of Charlotte residents' auto ownership, keep all evacuees on the evacuation route until they are 25 miles from the power plant, and assume no special traffic control. To mitigate the congestion delaying EPZ

evacuees on I-77, the ramps onto I-77 northbound could be closed by the police at the first three exits north of the EPZ, giving EPZ residents exclusive use of that segment of I-77. (Voluntary evacuees who would otherwise use those ramps would have to use US 521 and Nations Ford, both which are parallel to I-77 for a few miles.)

EXHIBIT 4. DELAY TO EPZ RESIDENTS EVACUATING VIA I-77 NORTHBOUND

Fraction of Charlotte Area Residents Voluntarily Evacuating (Shown in Percent)	If Charlotte Depatures Lag EPZ Departures by One-Half Hour	If Charlotte Depatures Lag EPZ Departures by one Hour
60	No Delay	No Delay
70	15 Minutes	No Delay
80	30 Minutes	No Delay
90	45 Minutes	No Delay
100	1 Hour	No Delay

Note that our April 1983 report showed that all evacuees using I-77 northbound could be out of the EPZ 30 minutes before the evacuation was complete on one other route. Therefore, an extra 30 minutes on I-77 would not change the time to evacuate the entire EPZ. In the case producing a delay of 1 hour, the time to evacuate the entire EPZ would be increased by 30 minutes.

CONCLUSION

Voluntary evacuation could delay EPZ evacuation on just one route and only under very unfavorable assumptions about the extent and timing of the voluntary evacuation.

Prepared for
Duke Power Company

— EPC 11 KULASH ATTACHMENT C

Catawba Nuclear Station Evacuation Analysis

Evacuation Time Estimate for the City of Charlotte

PRC Engineering
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April, 1984

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SUMMARY OF THE METHOD FOR ESTIMATING EVACUATION TIMES

The estimates of evacuation time for the City of Charlotte in combination with the 10-mile EPZ surrounding the Catawba Nuclear Power Station are based on 1980 population data.

The methodology used in the derivation of these evacuation time estimates is the same as that used for the EPZ around the plant site. Specifically, for each population segment, a series of discrete action steps is identified and the completion time for each step is estimated. The advantage of this method is that time is estimated for each individual step of the evacuation sequence rather than for the entire evacuation as a single activity. Thus, an erroneous assumption about the time required for a particular step has only a very limited effect on the overall results.

The key sequence of events in an evacuation of the City of Charlotte is as follows:

- Notification of the area population that an evacuation is recommended
- Propagation of the alert information throughout the City population
- The departure from work and return home of the work force prior to evacuation
- Preparation for an evacuation including assembly of family members and collection of essentials
- Driving out of the area

THE AREA TO BE EVACUATED

The analyses described in this technical memorandum relate to the evacuation of the City of Charlotte. The parameters used in establishing the boundaries for the area, the determination of the population to be considered, and the distance to be traversed to exit the area, are as follows:

- In addition to the basic EPZ (nominal 10-mile radius area around the Catawba plant) the area considered for evacuation includes the entire area within the city limits of Charlotte.

- The time estimate for evacuation is based upon the premise that the entire population is to be moved to a point 30 miles distant from the plant. This distance consideration applies only to northeast sectors of the area that encompasses the City of Charlotte.

- The population between not within the City limits and the 30-mile-distance radius of the plant are not considered in this analysis. People between the 10-mile EPZ and the city limits are included.

- The 1980 population in the City of Charlotte is estimated at 314,447.[1]

- The geographic allocation of this population to subareas comprising one mile rings and 22.5 degree sector was conducted on the basis of detailed maps and the available geographic subdivisions of the U.S. Census data.

A separate analysis has been conducted for a southeast subarea of the City that is nearer to the Catawba plant. This subarea is bounded by routes 16 and 74 along the east and north and by the City limits on the south and west.

The population within this area is estimated to be 124,000.[1]

DEPARTURE CURVES FOR CHARLOTTE

<u>Assumptions</u>

1. It can be expected that 25 percent of all households will have either radio or television in use during daytime hours.[2] During evening hours about 65 percent of all households will have radio or television in use.

2. It is assumed that about 5 percent of the households will have <u>both</u> radio and television in use simultaneously.

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[1] U.S. Census, 1980.

[2] Nielsen Research, 1982. Arbitron Survey, 1981.

3. It is expected that 90 percent of all listeners are tuned to local radio and television stations.

4. It is assumed that all local stations would relay the evacuation recommendations transmitted over the Emergency Broadcast System (EBS).

5. The following relevant statistics were obtained from the 1980 U.S. Census for the Charlotte metropolitan area:

   a. Average persons per households = 2.76
   b. Total number of households = 226,200
   c. Family households = 143,400
   d. Non-family households = 8,400
   e. Female householders and one person households = 74,400
   f. Civilian labor force = 347,900
      Economic participation rate = 54.5 percent
   g. Total metropolitan population = 637,218
   h. Percent of City of Charlotte no-worker households = 8.5
   i. Percent of City of Charlotte 2+ worker households = 60.0
   j. Percent of City of Charlotte 1-worker households = 31.5

6. It is assumed that 50 percent of the households have no one at home during the day time.

7. Based on limited data from the Radio Advertising Bureau it is assumed that in 50 percent of the work places in the City there is at least one worker that has a radio turned on.

8. Based on U.S. Census data[1] a small percentage of all business establishments have by far the largest numbers of employees. Based on the assumption that the larger the number of employees the greater the likelihood that one worker has a radio turned on, it is estimated that the 50 percent of workplaces noted above employ 69 percent of the labor force.

Percentage of Population Within Immediate Reach of EBS

Households — During the day, approximately 25 percent of households are timed in to radio and the same percentage are watching television. With the assumptions that 5 percentage of the households have both radio and television on the total number of "tuned in" households is 47.5 percent. Of this total, it is assumed that

[1] County and City Data Book, 1983.

only 90 percent are tuned to local stations; i.e., about 43 percent. Therefore, 43 percent of the households would be reachable directly via EBS messages to advise the residents of an alert status or the need to evacuate.

It is assumed that 50 percent of the households would have no one at home. These are primarily multiple wage earner households. The remaining 7 percent of the households with persons at home would not be directly reachable through the EBS message broadcast.

Workers – It has been assumed that at about 50 percent of the work places one or more employees will be turned in to a radio and will be immediately apprised of an alert condition through an EBS message. It is also assumed that an alerted employee will pass the information to all co-workers within a period of 30 minutes. Because of the increased probability that a worker in a large estabishment will have a radio turned on, it is estimated that 69 percent of the work force will be notified in this way.

It is expected therefore that 69 percent of the work force will be alerted within 30 minutes following the EBS message broadcast.

Information Dissemination to Non-Alerted Workers and Households

It is estimated that 43 percent of family households would be alerted directly through the EBS messages. It is expected that these households will attempt to contact the family wage-earner(s) at their place of work. Although the telephone system may be stressed beyond capacity, it is expected that an additional 13 percent of the non-alerted workers will be notified through direct or indirect calls from alerted persons from households that were tuned to either radio or television. "Direct telephone contact" means that a household member speaks directly to the wage earner at work. "Indirect telephone contact" means that a household member speaks with someone other than the wage earner at his place of

work. This process of notification would leave about 18 percent of the work force not alerted. There is a threshold level of time in which members of the work force interact with members of the community at large. These thresholds are set by normal breaks in the workday at lunch, at the end of the day, and intermittent business contacts during the day. On average, therefore, this threshold time period is assumed to be about 3 hours. It is within this time frame that the remaining 18 percent of the work force would be notified of an alert condition.

In addition to this EBS information dissemination, the existing Protective Response Plan for All Hazards for the City of Charlotte contains provisions for public alerting via mobile units and aerial units. The mobile units are largely based at five stations and can therefore be mobilized immediately. The helicopter units are expected to be mobilized within a time period of 30 minutes.

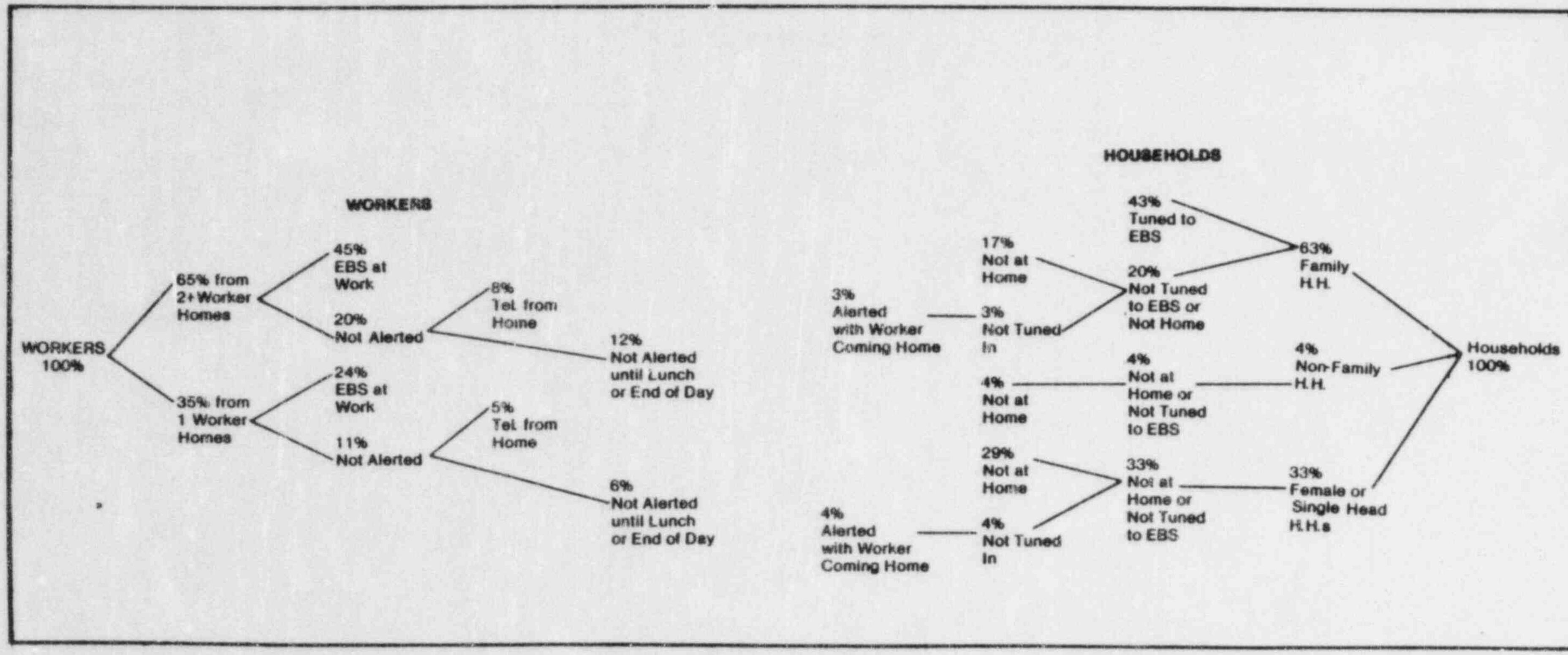
A summary of the EBS notification tree is shown in Exhibit 1 for a daytime evacuation.

Estimated Time When Population is Alerted

For purposes of this analysis, it has been assumed that the plant condition has led to the decision to evacuate the EPZ (approximate 10-mile radius area) and the City of Charlotte simultaneously. The established alerting system within the EPZ is expected to provide notification to the public largely within 15 minutes, and with an expected notification time of 45 minutes within which the entire EPZ population is alerted. This notification process is based upon prompt EBS broadcasting of appropriate messages to the public.

With the inclusion of the City of Charlotte in an evacuation decision, the EBS messages to be broadcast would reflect this decision and appropriately alert the City population to prepare to evacuate. Those households in the City that are tuned in to an EBS station would be alerted within about 5 minutes. For purposes of this study it was assumed that these households would be alerted within 15 minutes, to allow for the opportunity to listen to the message for a second time.

Exhibit 1. EBS Notification Tree



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At those places of work and business where a worker has a radio turned on, one or more workers would be alerted within about 5 minutes, similarly as with households noted above. To allow for some confirmation, a time period of about 15 minutes has been assumed for purposes of this analysis. The dissemination of the alert information throughout the work place to all employees and patrons is estimated to require 30 minutes, with appropriate allowance for notification of management at the work place, confirmatory action and actual alerting of the employees.

The spread of information from this basic group (comprised of about 43 percent of the households and 69 percent of the workers) can be expected to involve active "word-of-mouth" dissemination. With a significant attempt to contact relatives and public places to confirm the alert information, the phone system may become overloaded. It is likely, however, that some notification of workers via telephones will take place by calls from household members that were alerted very early at home via the EBS broadcast. Based upon the estimate that 43 percent of the households will be alerted by the first EBS message, an estimated 13 percent of the workers may become alerted through telephone contact from home. It is estimated that this could take place within about 30 minutes following the receipt of information by the household members.

The remaining 18 percent of the work force are estimated to receive the alert information over a period ending 3 hours following the initial broadcast over the EBS system.

At the household level there may be an estimated seven percent of the residential units where people are at home but have not received the broadcast information. This percentage of households would become alerted, if not notified otherwise, at the time that the wage earner returned home from his place of work.

A summary of notification times is shown below:

Time Following Beginning of Notification Process	Percentage of Population Alerted
15 minutes	28
45 minutes	72
180 minutes	100

EVACUATION ROUTES

The evacuation routes selected for the time estimate analyses are the major thoroughfare facilities through the City and that provide a logical pattern of travel in the northerly, northeasterly, and easterly direction. A summary of the routes is listed below:

Route	Capacity
Interstate 77	3,600
N.C. 51	1,200
Interstate 85	3,600
N.C. 27	2,400
U.S. 21	1,200
N.C. 29	2,400
N.C. 115	1,200
N.C. 16 NB	1,200
N.C. 49	1,200
N.C. 84	1,200
U.S. 74	2,400

These primary routes constitute the exit constraint on capacity. Within the City, the overall road capacity is by major orders of magnitude greater than the available exit capacity. This capacity availability within the City allows for shifts in queueing patterns from those estimated to occur on the major facilities, but those internal dynamics of route changes by evacuees do not alter the limiting capacity of the major exit routes.

SUMMARY OF RESULTS

The results of the evacuation time estimate analyses for the City of Charlotte are presented in two segments:

- Time Estimate to Evacuate the entire City of Charlotte
- Time Estimate to Evacuate the Southeast Sector of the City of Charlotte

Evacuation Time for the Entire City of Charlotte

As noted earlier, the evacuation time estimate includes the evacuation of both the EPZ (10-mile area around the plant) plus the entire City of Charlotte. The scenario selected for this analysis is a typical weekday.

The analysis results show that the overall evacuation of the City, plus the EPZ, would involve a time period of about 9 hours. The evacuation time is primarily controlled by the exit capacity of the roadway system. Although notification of the population is a key factor in initiating the evacuation process, the magnitude of the number of evacuees diminishes the impact on overall evacuation time of the notification process. For example, if the rate of notification of the public was slower than that outlined in earlier sections of this memorandum, it is unlikely that the evacuation time would be altered, since the change would only produce a shorter route congestion time but not an overall increase in evacuation time. Similarly, a more rapid rate of notification would increase congestion time, but would not have a significant effect on overall evacuation time.

The analysis results are shown below, by major route. It should be recognized that significant time differences between routes would be more closely balanced in an actual evacuation through relatively simple and readily implementable diversions as the evacuation of the City is approaching completion.

Route	Evacuation Time
I-77	9 hrs. 30 min.
I-85	8 hrs. 30 min.
U.S. 21	10 hrs.
N.C. 16 NB	5 hrs. 15 min.
N.C. 27	7 hrs. 45 min.
N.C. 29	8 hrs. 30 min.
N.C. 51	11 hrs. 45 min.
U.S. 74	11 hrs. 45 min.
N.C. 16 SB	6 hrs. 15 min.
N.C. 115	8 hrs. 15 min.
N.C. 49	9 hrs.

This analysis is a time estimate, not a local preparedness plan. Therefore, it does not include an in-depth review of the operational and other issues that would be required to thoroughly prepare for such an evacuation.

The results indicate that an evacuation of the City of Charlotte could be completed within a time frame of about 9 hours.

Evacuation Time of the Southeast Sector of the City of Charlotte

The time to evacuate the EPZ and the southeastern third of Charlotte is only 5 hours and 15 minutes. Unlike the more massive evacuation described above, this evacuation would not produce congestion that would extend beyond the departure time for the last evacuees. Therefore, the evacuation time is simply the time required to warn the last evacuee (3 hours) plus the time for that evacuee to complete the other steps in the evacuation (2 hours, 15 minutes). These remaining steps include the time to drive out of the area, but no delay due to traffic congestion.