

CATAWBA NUCLEAR STATION
EVACUATION ANALYSIS

EVACUATION TIME ESTIMATES

Prepared for:

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by

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CHAPTER 1. INTRODUCTION

PURPOSE OF THIS STUDY

The study summarized in this report was made to determine the time needed to evacuate the population of the Plume Exposure Pathway Emergency Planning Zone (EPZ) surrounding the Catawba Nuclear Station in York County, South Carolina.

LOCATION OF THE CATAWBA NUCLEAR STATION

The Catawba Nuclear Station is located on Wylie Lake in northeastern York County, South Carolina (Figure 1). The Catawba Station is 6 miles north of Rock Hill, South Carolina and 17 miles southwest of downtown Charlotte, North Carolina.

STATE AND LOCAL OFF-SITE PREPAREDNESS PLANNING

State and local preparedness plans have been developed by the State of South Carolina and York County, the only South Carolina county within the EPZ. Similarly, North Carolina and the two North Carolina counties in the EPZ (Gaston and Mecklenburg) have preparedness plans. These plans provide for resources and manpower needed for a successful evacuation of the area, specifically:

- Detailed evacuation plans, addressing notification, routing, manpower and resource requirements, confirmation of evacuation and transportation of non-vehicle-owning population (schools, households without vehicles, and persons in institutions)
- Communication within the EPZ, and between the plant, state agencies, the counties, and local governments within the EPZ
- Local (city and town) mobilization and decisionmaking
- Local notification procedures, including siren, public address, and telephone notification, procedures for radio and television information
- Detailed traffic control plan

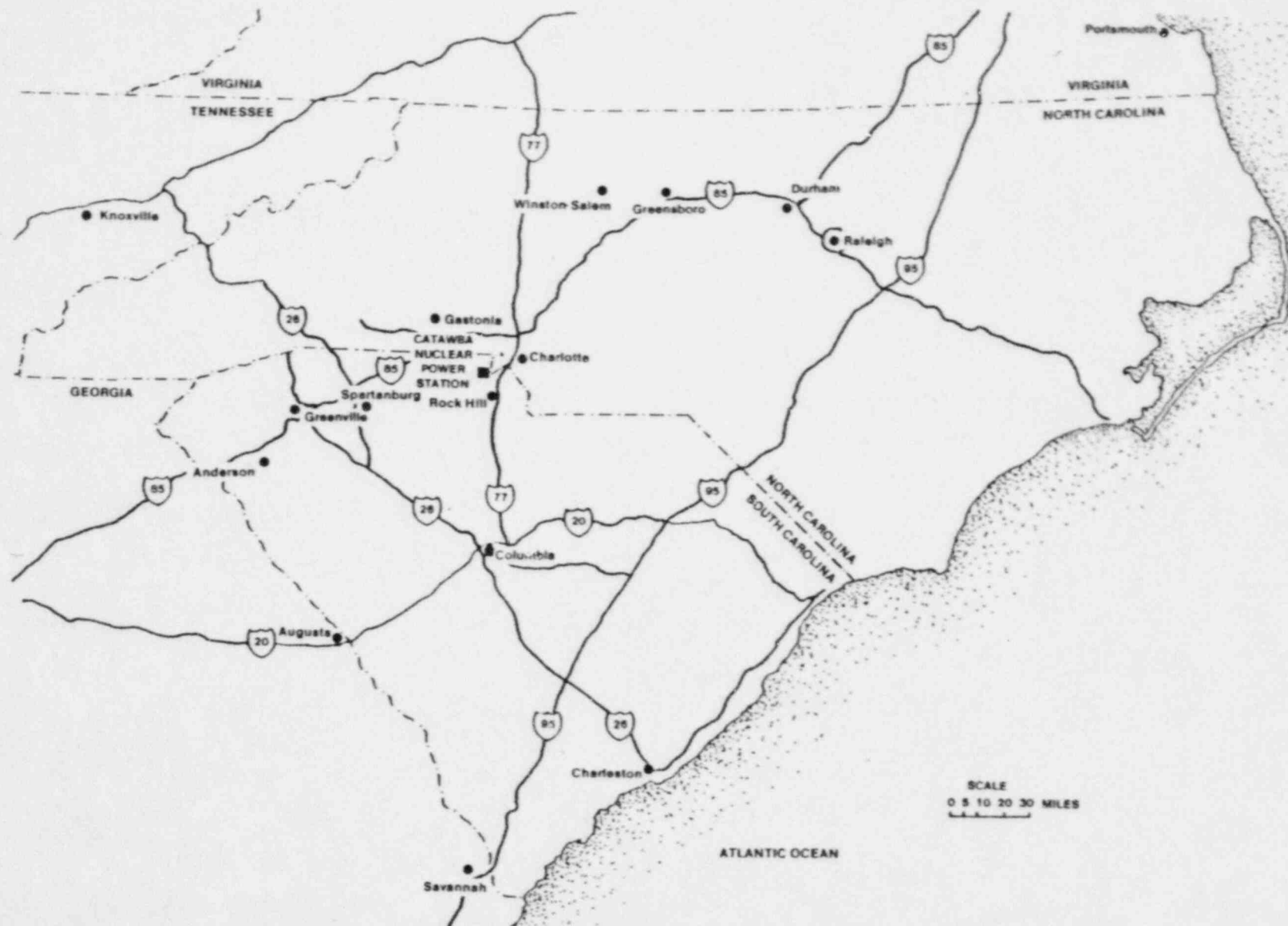


Figure 1. Location of the Catawba Nuclear Power Station

- Transportation for the school population
- Transportation for non-vehicle-owning population and persons in institutions
- Transportation for non-ambulatory population
- Reception centers¹ and procedures for clearing evacuated population through them
- Shelters¹ for temporary lodging of evacuees
- Manpower (traffic control, supervisory, security, and emergency services) for conducting the evacuation

SUMMARY OF THE METHOD FOR ESTIMATING EVACUATION TIMES

In developing these evacuation time estimates, the population is divided into three segments: (1) permanent resident population (2) transient population and, (3) special facility population. For each population segment, a series of discrete action steps is identified, and the completion time for each step determined.

The time for completing each step is then linked together statistically to yield the total evacuation time for that population segment.

The apparent advantage of this method is that travel time is estimated for each individual step of the evacuation sequence (for which data are more readily available) rather than for the entire evacuation as a single entity (for which data are non-existent).²

Two cases of evacuation time estimates are made: (1) for fall/winter weekday under normal weather conditions and, (2) a winter weekday under severe weather conditions.

-
1. In South Carolina, reception centers and shelters are separate facilities. In North Carolina, the reception and shelter functions are combined into a single facility, designated as "shelters." In North Carolina, the terms "reception centers" and "shelters" are synonymous.
 2. NUREG 0654, Appendix 4.

SUMMARY OF EVACUATION TIMES

Under normal weather and for the critical time period (weekday during school hours), the maximum evacuation time for the Catawba EPZ is four hours. Times are measured from the beginning of notification until all the population voluntarily leaving the EPZ has done so. The critical component in the evacuation is the permanent resident population; all other segments of the population can be evacuated in less than four hours.

Under severe weather conditions (winter storm) the evacuation time for the Catawba EPZ is 6 hours and 15 minutes, 156 percent of the time required for evacuation under normal weather conditions.

In normal weather, traffic congestion will occur on 11 of the 18 major routes out of the area. At the location of maximum congestion, congestion will occur for 2 hours and 15 minutes. In the worst case, a vehicle could spend 60 minutes in traffic delays when evacuating by that route.

On 8 of the 11 routes experiencing traffic congestion, the congestion will end before all permanent resident population has completed preparation to leave home. On these routes, evacuation time is not determined by traffic congestion but, rather, by the time needed to prepare for leaving home.

On 3 of the 18 routes, traffic congestion will continue until after the time that all the permanent resident population has completed preparations to leave home. On these routes, the maximum evacuation time is determined by the traffic congestion.

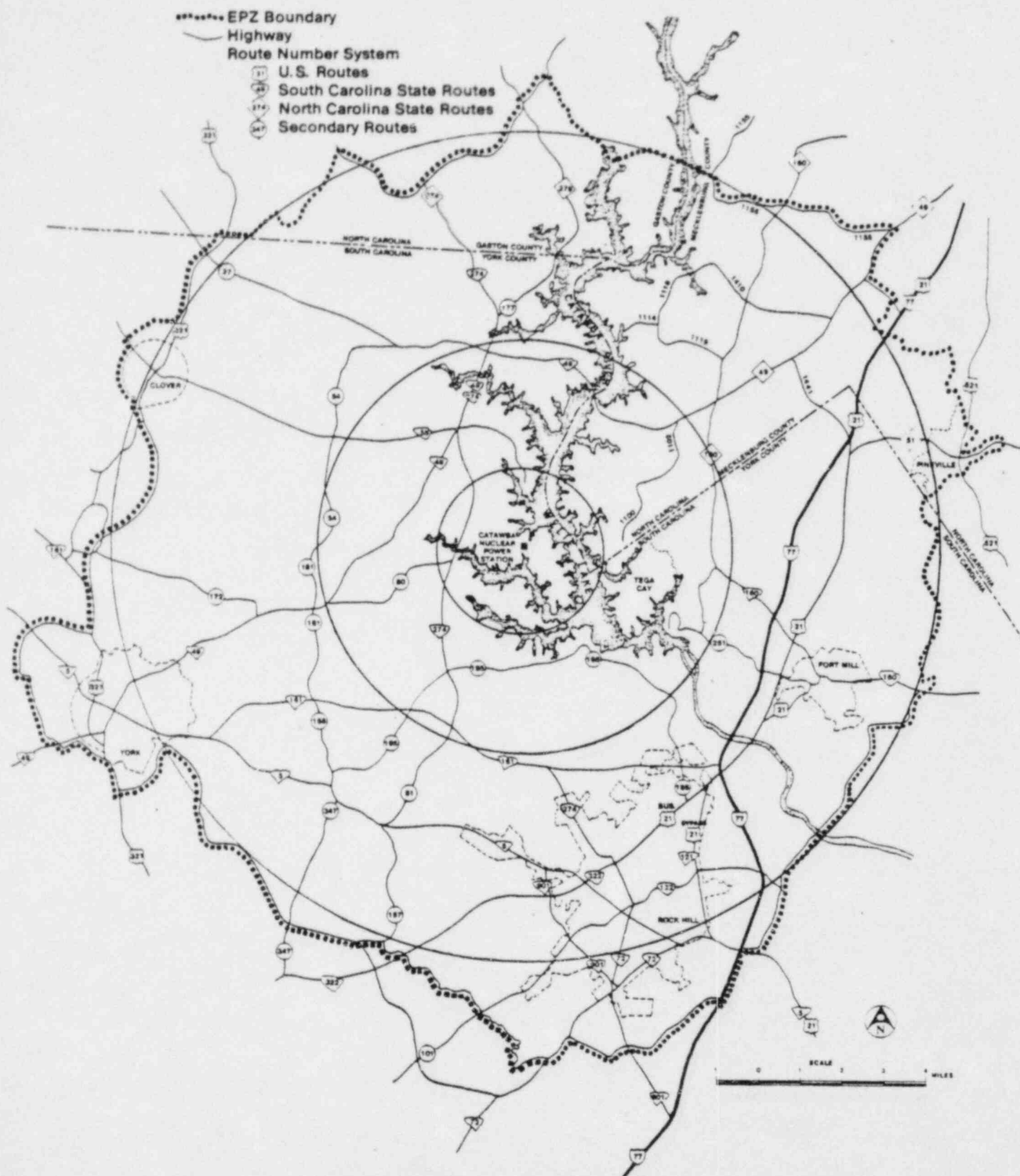


Figure 2. Highway System in the Vicinity of the Catawba Nuclear Power Station

Routes 901, 72, and 322 southbound, and State Routes 5 and 161 running both east and west.

In addition to the interstate, there are several segments of four-lane road in the Rock Hill area. Also, U.S. 321 leaving the EPZ to the northwest and U.S. 21 leaving in the southeast are four-lane roads.

OTHER TRANSPORTATION FACILITIES IN THE CATAWBA NUCLEAR STATION AREA

As Figure 3 shows, a Southern Railroad line crosses the southern part of the 10-mile area in an east-west direction and another runs through Rock Hill to Charlotte with an industrial spur just north of Pineville. Along the western edge of the EPZ are the tracks of the Carolina and Northwestern Railway.

GOVERNMENTAL JURISDICTIONS

Three counties—York, Gaston, and Mecklenburg—are included in the 10-mile radius of the Catawba Station (Figure 4). Six incorporated areas are at least partly within the 10-mile radius of the plant: Pineville, Fort Mill, Rock Hill, York, Clover, and Tega Cay.

SPECIAL FACILITIES WITHIN THE 10-MILE RADIUS OF THE CATAWBA NUCLEAR STATION

Figure 5 shows the location of the special facilities in the area. These consist of 43 schools (public and private), 23 day-care centers, 6 nursing homes, 2 hospitals, and the York County Prison. The schools include Winthrop University and York Technical College in Rock Hill. Nearly all of the schools are in or near the cities, with over one-half in the Rock Hill area. Two-thirds of the day-care centers are in the Rock Hill area, with the rest in Clover, Fort Mill, or York. The nursing homes are predominantly in Rock Hill. The prison is about two miles east of York on SC 55.

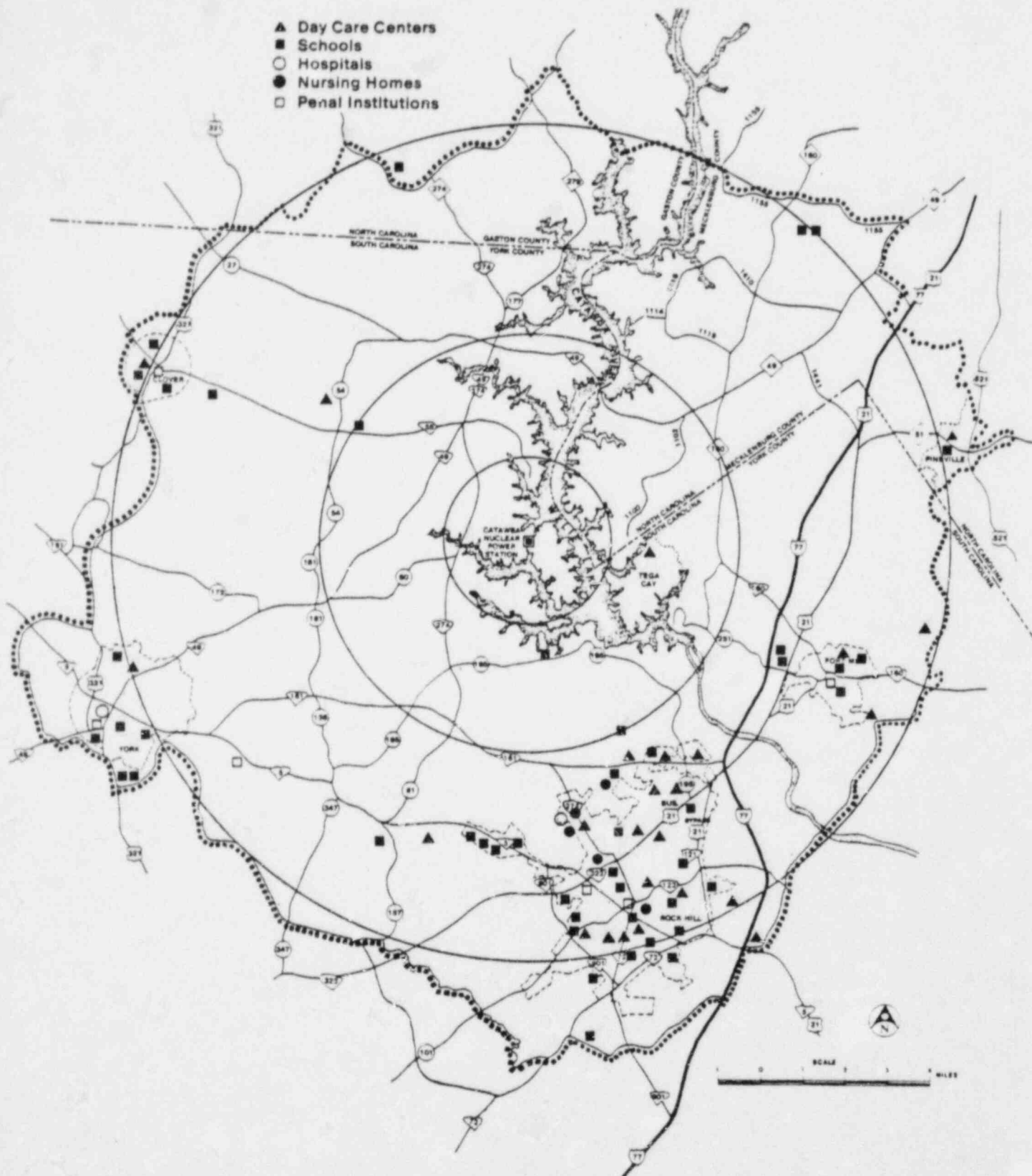


Figure 5. Location of Special Facilities

CHAPTER III. THE EMERGENCY PLANNING ZONE FOR THE CATAWBA NUCLEAR STATION

GUIDELINES FOR DEFINING THE EMERGENCY PLANNING ZONE (EPZ)

Federal regulations¹ define the Emergency Planning Zone (EPZ) as an area of about a 10-mile radius from the nuclear power station. Local preparedness planning concentrates on protecting the population of the EPZ from direct radiation exposure.

In defining the EPZ boundary for any particular site, some general guidelines are observed:¹

- The EPZ should include approximately the 10-mile radius of the power station. Exclusion of small, lightly populated areas at the 10-mile periphery is permitted when this simplifies the boundary definition.
- The EPZ must be easily identifiable. Rather than strictly following the 10-mile radius, the EPZ boundary should follow nearby natural features (shorelines, streams), man-made features (highways, railroads), governmental, and special district boundaries.
- The EPZ boundary should not split major coherent populations which fall at the 10-mile radius (for example, Clover). Rather, the EPZ boundary should either include or exclude such concentrations in their entirety.
- The EPZ boundary should be regular and consistent, with supportable reasons for including areas. Evacuation of large areas or population groups well beyond the 10-mile radius should be avoided.

THE EPZ BOUNDARY FOR THE CATAWBA NUCLEAR STATION

There are few dominant natural or political boundary features that could serve as portions of the EPZ boundary for the Catawba Nuclear Station. Consequently,

1. NUREG 0654, Appendix 4.

York, Gaston, and Mecklenburg Counties have identified an EPZ border that is based largely on state and local roads (Figure 6).

The resulting EPZ boundary includes at least the 10-mile radius from the Catawba Nuclear Station, except for some small areas totaling just a few square miles. All the areas within 10 miles of Catawba Nuclear Station, but excluded from the EPZ, contain negligible population.

Six incorporated areas—Clover, Fort Mill, Pineville, Rock Hill, Tega Cay, and York—are included in the Catawba EPZ. No incorporated area is divided by the boundary.

Table 1 summarizes the local governmental jurisdictions within the Catawba EPZ.

SELECTIVE EVACUATION ZONES

The division of the Catawba EPZ into selective evacuation zones (Figure 7) is based on the planning zones as established by the States of South Carolina and North Carolina, as well as the local preparedness agencies of Gaston, Mecklenburg, and York Counties. The radial boundaries for these zones are defined by:

- The state and county lines
- Rivers and streams such as the Catawba River
- Highways, such as York County 81 and South Carolina 161

The circumferential boundaries for these zones are generally defined by local roads.

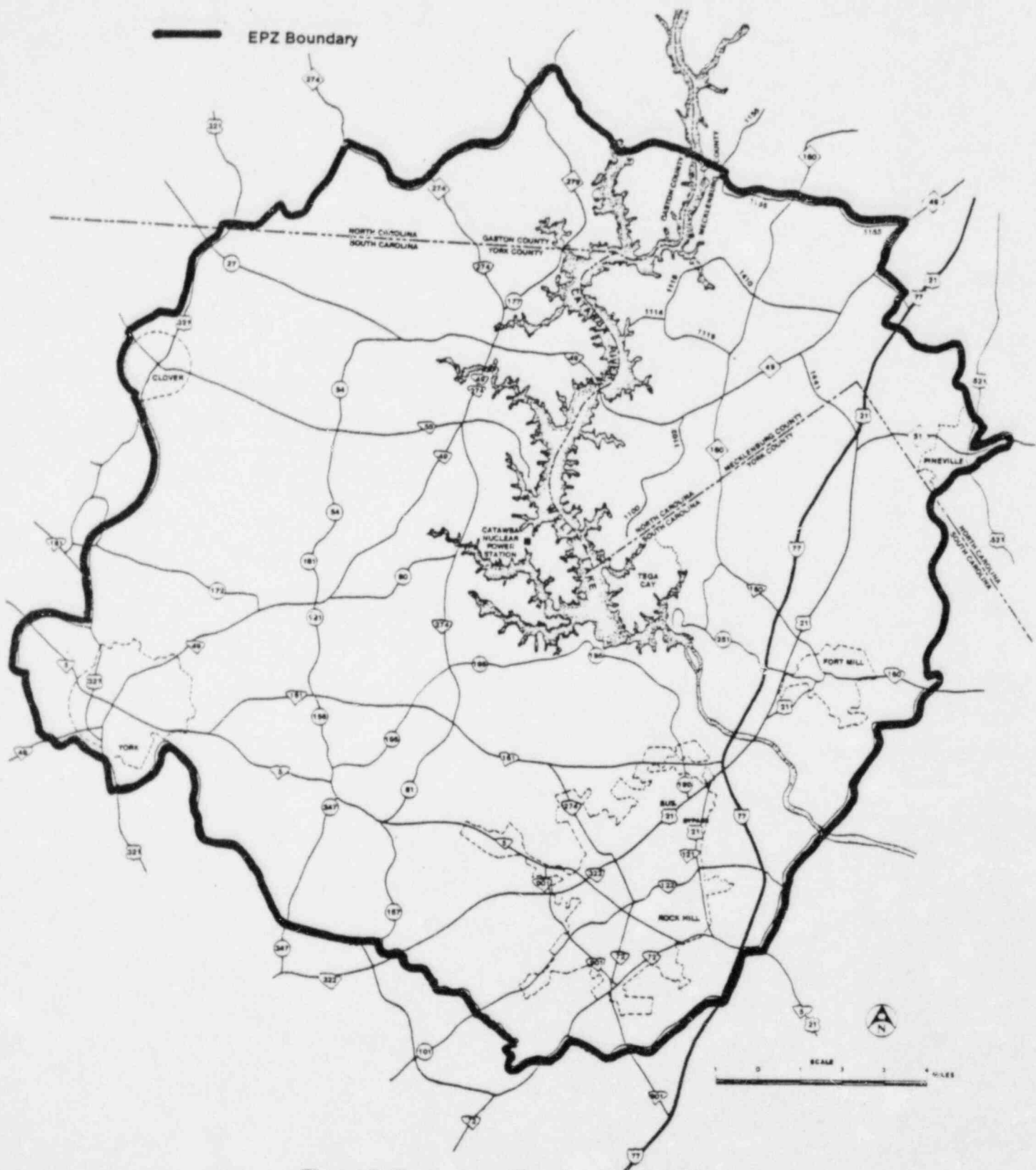


Figure 6. Emergency Planning Zone (EPZ)
for the Catawba Nuclear Power Station

TABLE 1. LOCAL GOVERNMENT UNITS WITHIN 10-MILE RADIUS
AND EPZ OF THE CATAWBA NUCLEAR POWER STATION

| | <u>Portion of Local Government Unit Within</u> | |
|--------------------------------|--|--|
| | <u>10-Mile Radius of Plant</u> | <u>Catawba Nuclear Station EPZ</u> |
| <u>Counties</u> | | |
| Gaston | Part | Part |
| Mecklenburg | Part | Part |
| York | Part | Part |
| <u>Incorporated Places</u> | | |
| Clover | Part | All |
| Fort Mill | All | All |
| Pineville | Part | All |
| Rock Hill | Part | All |
| Tega Cay | All | All |
| York | Part | All |

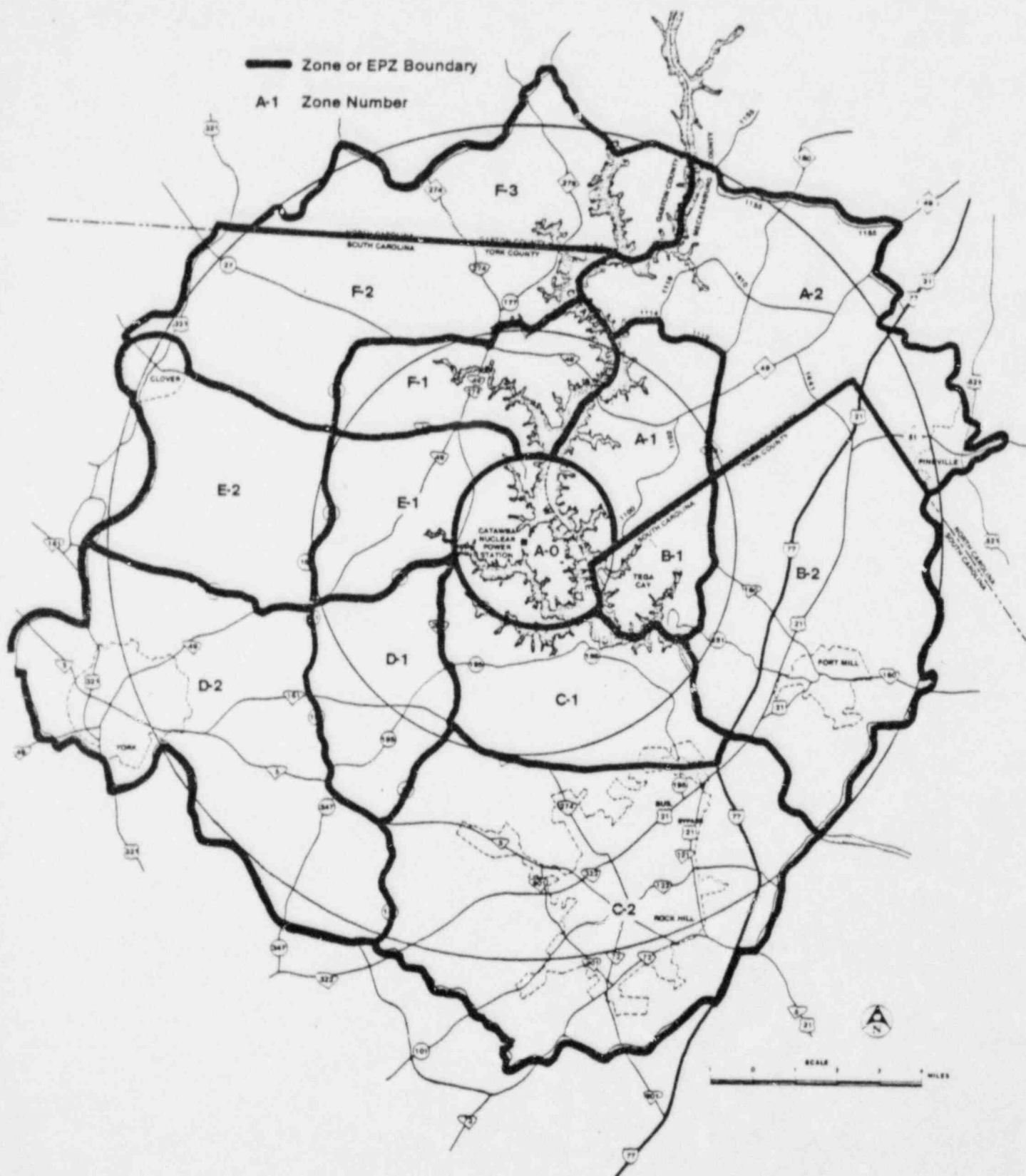


Figure 7. Selective Evacuation Zones for the Catawba EPZ

CHAPTER IV. POPULATION OF THE CATAWBA EPZ

POPULATION SEGMENTS

Separate evacuation time estimates are made for each of the following three components of population in the Catawba EPZ:

1. Permanent Resident Population — Those persons living full-time in the Catawba EPZ. Two subgroups of permanent residents are recognized:
 - Vehicle-Owning Population — Those permanent residents having a vehicle available for their evacuation from the EPZ.
 - Non-Vehicle-Owning Population — Those permanent residents not having a vehicle available for their evacuation from the Catawba EPZ and who, therefore, must be transported by other means.

There are an estimated 93,483 permanent residents in the Catawba EPZ (Table 2).

2. Transient Population¹ — Non-residents of the EPZ temporarily within it, primarily for the purpose of recreation. A maximum transient population of 89,669 persons in the EPZ (Table 2) was estimated from base year surveys and forecasts.
3. Special Facility Population¹ — Concentrations of population in institutions. This includes schools, university campus, hospitals, nursing homes, day care centers, and the prison. There is a reported special facility population of 36,134 persons in the EPZ on a weekday when schools are in session (Table 2).

SPECIAL FACILITY POPULATION

Table 3 lists the special facilities in the Catawba EPZ and gives their populations and subarea locations. As indicated in Table 3, the school population accounts for

1. Some elements of population may be counted twice, both as resident population and as transient/special population. This double-counting is immaterial to the estimates of evacuation time.

TABLE 2. POPULATION OF THE CATAWBA EPZ AND ZONES

| Zone | Permanent Resident Population | | | Transient Population | Special Facility Population |
|---------------------------|-------------------------------|------------------------|--------------|-------------------------|-----------------------------------|
| | Vehicle- Owning | Non-Vehicle- Owning | Total | | |
| Central, NC Portion | 321 | 36 | 357 | 654 | 0 |
| Central, SC Portion | <u>327</u> | <u>36</u> | <u>363</u> | <u>5,552</u> | <u>0</u> |
| Subtotal, 0 to 2 Miles | 648 | 72 | 720 | 6,206 | 0 |
| A-1 | 476 | 53 | 529 | 10,187 | 0 |
| B-1 | 2,368 | 263 | 2,631 | 2,588 | 24 |
| C-1 | 5,545 | 616 | 6,161 | 16,827 | 1,544 |
| D-1 | 1,273 | 141 | 1,414 | 109 | 0 |
| E-1 | 386 | 43 | 429 | 0 | 0 |
| F-1 | <u>2,316</u> | <u>257</u> | <u>2,573</u> | <u>1,582</u> | <u>364</u> |
| Subtotal, 0 to 5 Miles | 13,012 | 1,445 | 14,457 | 37,499 | 1,932 |
| A-2 | 4,354 | 484 | 4,838 | 4,073 | 2,862 |
| B-2 | 8,794 | 977 | 9,771 | 46,826 | 3,094 |
| C-2 | 40,468 | 4,496 | 44,964 | 0 | 21,031 |
| D-2 | 8,252 | 917 | 9,169 | 0 | 4,023 |
| E-2 | 4,461 | 496 | 4,957 | 0 | 2,820 |
| F-2 | 2,390 | 265 | 2,655 | 650 | 0 |
| F-3 | <u>2,405</u> | <u>267</u> | <u>2,672</u> | <u>651</u> | <u>469</u> |
| TOTAL EPZ | 84,136 | 9,347 | 93,483 | 89,699 | 36,231 |

TABLE 3. SPECIAL FACILITIES POPULATION
IN THE CATAWBA EPZ

| <u>Facility</u> | <u>Population</u> | <u>Location (Zone)</u> |
|--|-------------------|----------------------------|
| Gaston County Schools | | |
| W.A. Bess | 469 | F-3 |
| Mecklenburg County Schools | | |
| Steele Creek Elementary | 777 | A-2 |
| Pineville Elementary | 844 | A-2 |
| Olympic High | 1,176 | A-2 |
| York County Schools | | |
| A. O. Jones School | 563 | B-2 |
| Alternative School | 76 | C-2 |
| Bellevue Elementary | 450 | C-2 |
| Bethel Elementary School | 364 | F-1 |
| Career Development Center | 862 | C-2 |
| Castle Heights Junior High | 960 | C-2 |
| Catawba School | 443 | C-1 |
| Clover High School | 1,008 | E-2 |
| Clover Junior High | 596 | E-2 |
| Clover Middle School | 561 | E-2 |
| Ebenezer Avenue Elementary | 431 | C-2 |
| Ebinport Elementary | 417 | C-2 |
| Edgewood Center | 116 | C-2 |
| Episcopal Church Home for Children | 62 | D-2 |
| Finley Road Elementary | 453 | C-2 |
| Fort Mill High School | 915 | B-2 |
| Fort Mill Junior High School | 250 | B-2 |
| Harold C. Johnson Middle School | 1,025 | D-2 |
| Jefferson Elementary | 715 | D-2 |
| Kinard Elementary School | 591 | E-2 |
| McCelvey Elementary | 686 | C-1 |
| Mount Gallant Elementary | 790 | D-2 |
| Northside Elementary | 454 | C-2 |
| Northwestern High School | 1,322 | C-2 |
| Oakdale Elementary | 448 | C-2 |
| Rawlinson Road Junior High | 1,251 | C-2 |
| Richmond Drive Elementary | 452 | C-2 |
| Riverview Primary and Elementary Complex | 1,292 | B-2 |
| Rosewood Elementary | 389 | C-1 |
| St. Anne's | 171 | C-2 |

Table 3, Continued

| <u>Facility</u> | <u>Population</u> | <u>Location (Zone)</u> |
|---|-------------------|----------------------------|
| York County Schools (continued) | | |
| Sullivan Junior High | 1,010 | C-2 |
| Sunset Park Elementary | 458 | C-2 |
| Sylvia Circle Elementary | 369 | C-2 |
| Trinity Christian | 324 | C-2 |
| Winthrop College | 4,881 | C-2 |
| York Christian School | 140 | D-2 |
| York Comprehensive High and Johnson Vocational | 1,070 | D-2 |
| York Road Elementary | 562 | C-2 |
| York Technical College | 2,850 | C-2 |
| Clinton College | 275 | C-2 |
| Day Care Centers | | |
| Adams Care Center | 21 | C-2 |
| Child Development Center | 62 | E-2 |
| Children's Christian | 119 | C-2 |
| Children's Wonderworld | 70 | C-2 |
| College Park Nursery | 30 | C-2 |
| Davis Day Care Center | 33 | C-2 |
| Ebenezer Day Care Center, Inc. | 32 | C-2 |
| Emmitt Scott Day Care | 85 | C-2 |
| Jimmy's Day Care | 40 | C-2 |
| Kiddie Kollege Child Development Center | 200 | C-2 |
| LaPetite Academy | 75 | C-2 |
| LaPetite Academy | 47 | C-2 |
| Little Fox Nursery | 33 | B-2 |
| Little Peoples Day Care | 60 | C-2 |
| Mt. Gallant Day Care | 49 | C-1 |
| Pine Grove Day Care Center | 30 | D-2 |
| R. H. Comprehensive Day Care | 114 | C-2 |
| Tega Cay Day Care | 24 | B-1 |
| Toddler House Nursery | 40 | C-2 |
| Wards Wonderland | 35 | B-2 |
| Wee Care Day Care Nursery | 68 | C-2 |
| Whiteheads Kiddie Kare | 45 | C-2 |
| Yours, Mine and Ours | 45 | D-2 |

Table 3, Continued

| <u>Facility</u> | <u>Population</u> | <u>Location (Zone)</u> |
|--|-------------------|----------------------------|
| Hospitals | | |
| Divine Savior Hospital | 51 | D-2 |
| Piedmont Medical Center | 160 | C-2 |
| Nursing Homes | | |
| Anne's Convalescence Home | 62 | C-2 |
| Divine Savior Home | 51 | D-2 |
| Fallow Residential Care | 37 | C-2 |
| Meadow Haven Nursing Center | 132 | C-2 |
| Rock Hill Convalescence Center | 141 | C-2 |
| Sunshine Homes | 10 | D-2 |
| Penal Institutions | | |
| Clover Detention Center | 2 | E-2 |
| Fort Mill Detention Center | 6 | B-2 |
| Rock Hill Detention Center (Cherry Road) | 14 | C-2 |
| Rock Hill Detention Center (City Hall) | 4 | C-2 |
| York County Prison | 45 | D-2 |
| York Detention Center | 6 | D-2 |

almost all of the special facility population. The other special facilities in the EPZ are day care centers, Piedmont Medical Center, Divine Savior Hospital, six nursing homes, and the York County Prison.

POPULATION DISTRIBUTION

The majority of the population in the Catawba EPZ is concentrated in the Rock Hill area. Zone C-2, which includes Rock Hill, has 44,964 residents, or 49 percent of the total residential population of the EPZ. The population center nearest to the Catawba Plant (approximately two miles) is Tega Cay with less than 3 percent of the EPZ population. Another 17 percent of the population lives in the incorporated areas on the fringe of the EPZ—Clover, Fort Mill, Pineville, and York.

York County contains 91 percent of the EPZ residential population (85,087 residents). Mecklenburg County contains another 6 percent (5,724 residents), and Gaston County contains the remaining 3 percent (2,672 residents).

CHAPTER V. THE EVACUATION SEQUENCE FOR THE CATAWBA EMERGENCY PLANNING ZONE (EPZ)

Evacuation is intended to remove the population of the Catawba EPZ as rapidly as possible. Evacuees are directed to designated reception centers where they are screened for radiological exposure. Evacuees are then lodged temporarily, or they go to destinations of their own choosing—primarily homes of nearby relatives and friends.

Wherever possible, the evacuating population will leave the EPZ in private automobiles. Persons without transportation will be transported by buses, ambulances, or other available vehicles.

Most motorists will leave the EPZ by the most direct route; that is, the shortest route out of the EPZ. Traffic direction at some key locations, particularly the U.S. 21 and I-77 interchange near Rock Hill and the intersection of S.C. 901 and S.C. 72, will help balance the traffic volumes on the evacuation routes. Except at those two locations, normal traffic flow will be observed, with streets open to all traffic and functioning in their usual manner.

Separate evacuation time estimates are made for the three population groups identified in Chapter IV: (1) permanent residents, (2) transient population, and (3) special facility population. Each of these groups follow a different procedure in evacuation:

- Permanent Resident Population — The vehicle-owning permanent resident population, after receiving the broadcast instructions to evacuate, assembles by family at home (except for children at school), prepares for evacuating the home, and drives out of the EPZ.

The non-vehicle-owning permanent resident population prepares for leaving their homes and will then be transported out of the EPZ in buses or other vehicles.

- Transient Population — The transient population, after receiving instructions to evacuate, will assemble the group (if any) that is traveling together, and will drive out of the EPZ, using their private

vehicles. Unescorted children at Carowinds Theme Park will be taken to reception centers in Mecklenburg County by Charlotte Transit System buses.

- Special Facility Population — The school population (public and private) is transported by school bus directly from the schools, and is under control of school staff.

Persons in institutions (hospitals, nursing homes, etc.) are prepared for evacuation, then transported out of the EPZ in buses, ambulances, emergency vehicles, and possibly other vehicles.

TIME PERIODS IN WHICH EVACUATION MIGHT OCCUR

The procedure for evacuating the Catawba EPZ will vary, depending on the time of day, day of week, and season of the year in which the evacuation occurs. Figure 8 illustrates the combinations of time, day, and seasons that are considered.

Day or Night Evacuation

In general, evacuation is likely to be more difficult in the daytime than in the nighttime.

During the day, there is a relatively large chance that families are not assembled at home but, rather, are dispersed at work, shopping, on personal business, etc. On school days, the school population is not at home for most of the daytime period. Also, more transients are in the EPZ during the day.

In a night evacuation, the notification process would be slowed by people having to wake up and comprehend the evacuation information being broadcast. Also, additional time (relative to the daytime situation) would be required to prepare vehicles for evacuation in the dark. On the other hand, for most of the population, the families would be intact at the time of notification, since schools are not in session and relatively few employees are on the job.

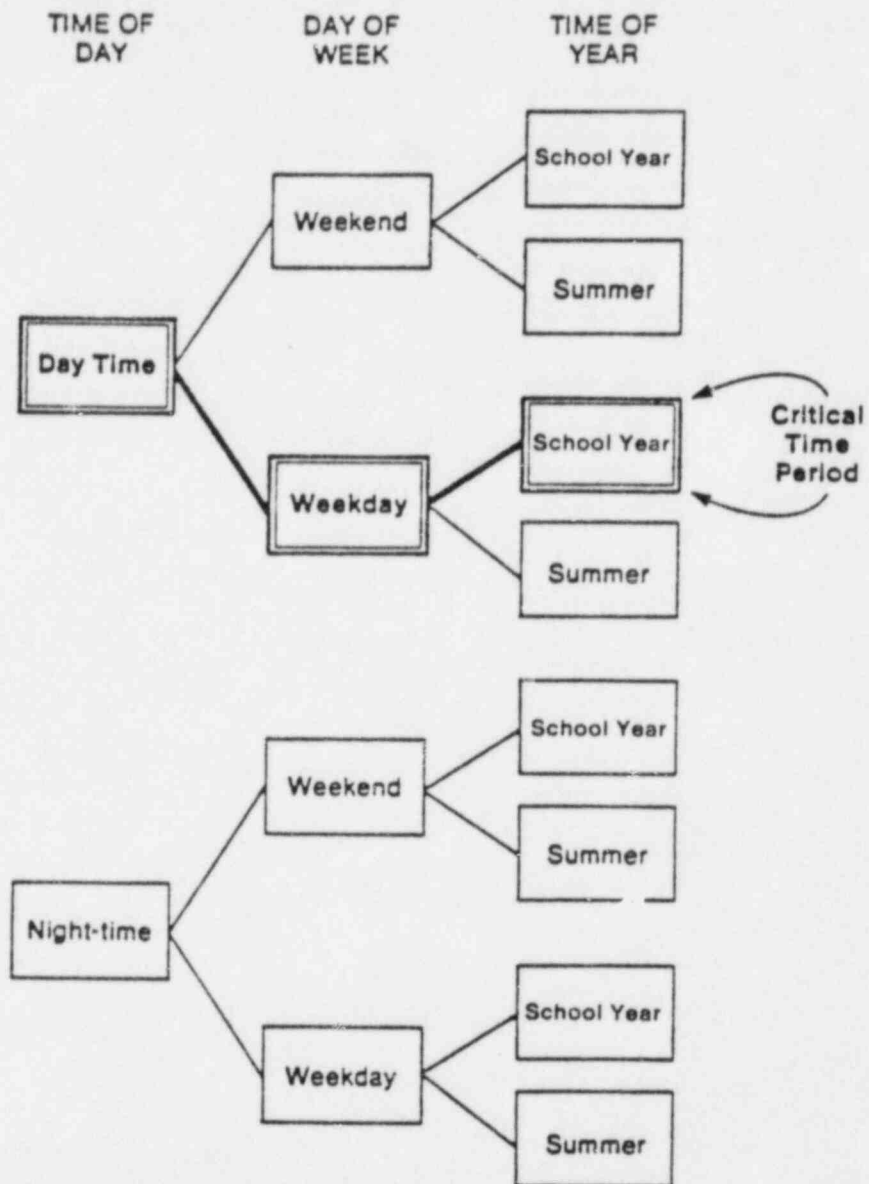


Figure 8. Time Periods In Which Evacuation Can Occur

Weekday or Weekend Evacuation

In general, a weekday evacuation is likely to be more difficult than one on a weekend.

On a typical weekday, much of the population is away from home, mainly at work. During the school year, the school population is also away from home during the day.

On the weekends, on the other hand, a number of people are away from the home for reasons other than work or school. However, the assembly of these people at home on a weekend does not present the same problem as assembling them on a typical work and school day, when a much larger percentage is not at home.

School Year or Summer Evacuation

In general, an evacuation during the school year period is more difficult than an evacuation during the summer season. When schools are in session, a weekday evacuation would have to involve evacuation of the school population. Also, the number of employees at work is at a maximum during the school year period when employment activity is at a maximum and few workers are on vacation.

In the summer period, evacuation can be complicated by the presence of non-residents around or on Lake Wylie and at Carowinds. However, these factors cause less difficulty in evacuation than that caused by the school population on a weekday when school is in session.

Critical Time Period Adopted for the Catawba Station Evacuation

In estimating the evacuation time for the Catawba EPZ, the critical time period—the time period for which evacuation is likely to require the most time—is daytime during the school year (Figure 8). During this period, the time needed to assemble family units is likely to be at a maximum since most employees are at

work at this time. Also, the likelihood of being away from home for other reasons (for example, shopping, personal business, etc.) is fairly high during this period. Finally, evacuation during the school year raises issues of school population evacuation which do not exist in other time periods.

POPULATION SEGMENTS TO BE EVACUATED

Separate evacuation time estimates are made for each of the three population groups identified in Chapter IV:

- Permanent Residents, who evacuate either in private automobiles (if they are vehicle-owning population) or are transported out in school buses or other vehicles (if they are non-vehicle-owning)
- Transient Population, who evacuate primarily in private automobiles
- Special Facility Population, who are transported out of the EPZ in school buses, other public vehicles and, in some cases, in private automobiles

Family Units

Families (excluding children in school) evacuate as units. On weekdays, family members return home from their jobs, shopping, etc. On weekends, many families are already assembled and can immediately prepare to leave home. Non-resident families (for example, recreational visitors) are already assembled and evacuate with almost no further preparation.

EVACUATION ACTION STEPS

For each population segment, the evacuation sequence consists of a series of clearly defined actions, performed in a predictable sequence (see Figure 9).

Subdividing the evacuation process into these discrete steps improves the accuracy of the estimates of time needed for the entire evacuation. In place of a single estimate of the entire evacuation process, for which data are not available, this

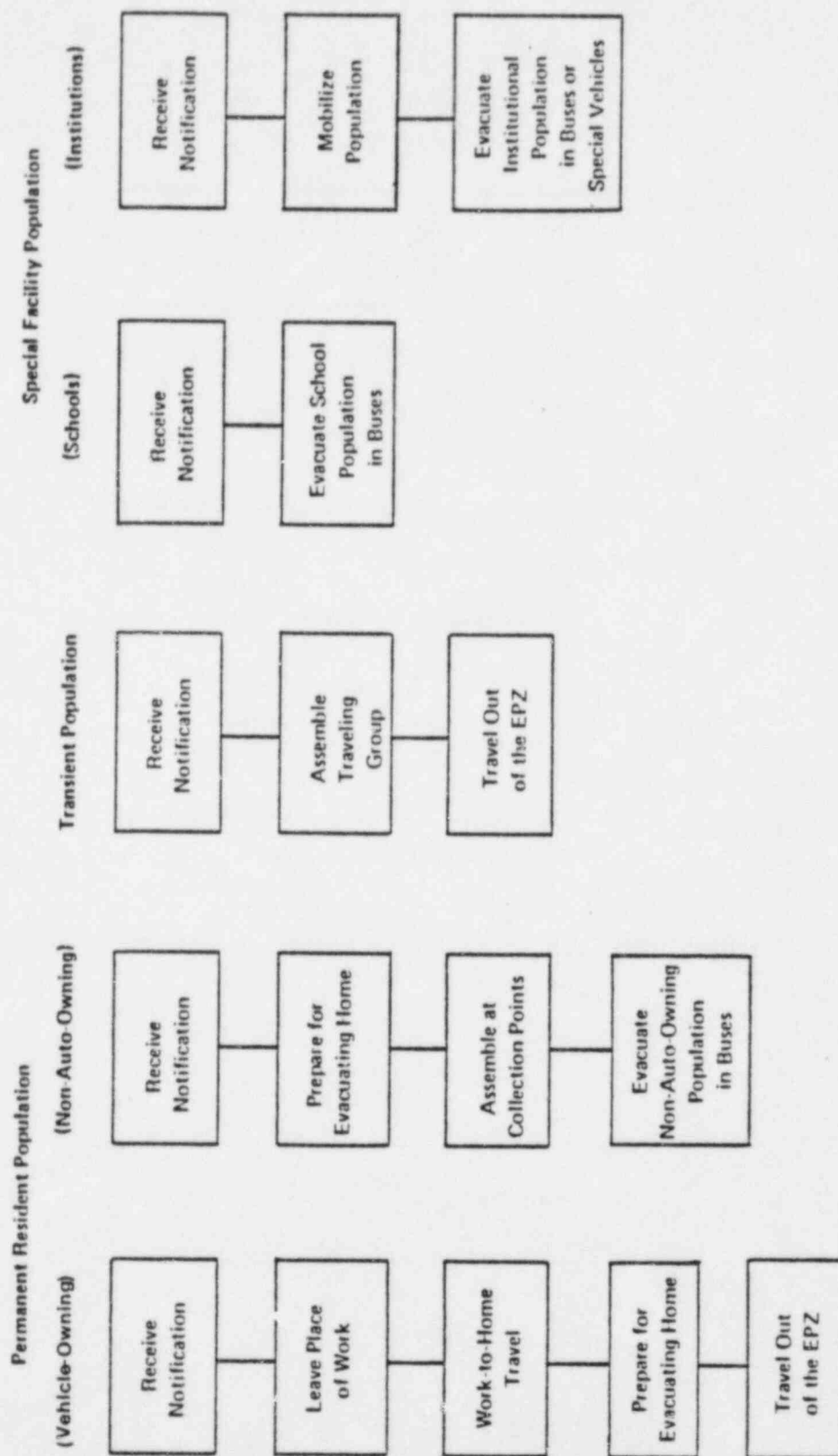


Figure 9. Population Segments and Evacuation Sequences

process permits the estimation of time for each individual step, for which data are more readily available, or for which reasonable estimates can be made.

Public Agency and Private Steps

Some of the evacuation steps identified in Figure 9 are performed by public agencies or quasi-public bodies, such as volunteer fire departments. For all population groups, the "Receive Notification" action is the responsibility of public agencies. For those persons evacuated by means other than privately owned vehicles, public agencies have the additional responsibility for the actual transportation out of the EPZ; for example, "Evacuate School Population in Buses," "Evacuate Non-Vehicle-Ownning Population in Buses," etc. For most populations in institutions, the "Mobilize Population" step is also a public agency responsibility.

Those action steps not the responsibility of public agencies are done at the initiative of the individuals being evacuated. For the vehicle-owning population, all steps after the initial "Receive Notification" are private actions; that is, they are initiated by the individuals being evacuated. Similarly, some steps in the evacuation of non-vehicle-owning households are private steps.

EVACUATION OF PERMANENT RESIDENT POPULATION (VEHICLE-OWNING)

The following sections describe the sequence of evacuation for the resident vehicle-owning population of the Catawba EPZ during the fall-winter weekday period.

Receive Notification

The first activity in the evacuation process is the notification of the public that an emergency exists. This includes the sounding of sirens, followed by Emergency Broadcast System (EBS) information, and some direct notification by NOAA radio alert.

Various other back-up measures are used to inform the population which might not be reached by the above means. Mobile sirens and public address units will supplement the siren alerting system. Mobile public address units mounted on boats or aircraft will notify boaters on Lake Wylie.

This notification alerts the public that an emergency exists, and that they should tune in to radio and television broadcasts for further information. The notification, by itself, does not inform the public of the nature of the emergency nor of the response that they should make.

Information on the nature of the emergency and instructions on evacuation are given through radio and television broadcasts over cooperating local stations in the Emergency Broadcast System (EBS).

Leave Place of Work

The rate at which area workers will leave their jobs to return home to prepare for evacuation depends on the particular work environment and upon the responsibility level of the worker. It is to be expected that most of the work force will be able to leave their jobs almost immediately, quite similar to a normal departure from work at the end of the workday. A number of workers, however, will require some job "close-down" time in work situations; for example, those that involve chemical processes, construction equipment, or cash registers in retail sales establishments. Supervisory employees, managers, and independent business operators will generally require the greatest amount of time to secure their place of work and to assure that all employees and others on the premises have departed.

Work-to-Home Travel

Travel of the employees from their place of work to home is identical to the daily work-to-home travel pattern. The maximum length for work trips for people living and working in the EPZ is not likely to exceed 20 miles. An average travel speed of 20 to 30 miles per hour is typical for the work-to-home travel for area workers.

This movement of workers, because of the short time over which it occurs, can be expected to cause some traffic congestion similar to that occurring during the twice-daily work travel peak. The road system can handle this volume of traffic with essentially the same level of service as during the peak hours on a typical working day.

Prepare for Evacuating Home

People can be expected to react differently to any emergency situation, and there is likely to be great differences in the amount of time that residents will spend in preparing to leave their homes. Three factors, in particular, affect the amount of time needed to prepare for evacuating a household:

1. Whether or not adults are at home when notice to evacuate is received. If so, preparation time is shortened (compared to households where no adults are at home) since preparation for evacuation can begin before workers arrive home.
2. Number of children and other dependents at home. These increase the time needed to prepare the household for evacuation.
3. The amount of property to be secured. Farms are the extreme case and may require up to two hours to secure. On the other hand, small households can be prepared for evacuation in minutes.

Travel Out of the EPZ

After households are secure, residents of vehicle-owning households will drive out of the EPZ. Most motorists will use the most direct route available.

Public agencies will give routing advice for this travel, by means of preparedness plans prior to the emergency and through information broadcasts during the actual evacuation. Law enforcement officers will also channel flow of traffic at critical locations as defined in local preparedness plans and in response to actual conditions.

The vehicle-owning resident population will drive to reception centers established outside the EPZ where they will be checked for contamination and reunited with other family members. Evacuees will then either go to a shelter, where they will be lodged temporarily, or to other destinations (homes of friends or relatives) of their own choosing.

During the evacuation, normal traffic operations will prevail. Specifically, roads will continue in two-way operation, traffic signals will continue to function, and so forth. At key locations, mainly intersections, traffic control will be under direction of law enforcement officers or other personnel as designated by local evacuation plans.

On most roads, traffic will flow freely, although at reduced speeds. However, at certain locations and during certain portions of the evacuation period, traffic congestion is expected. The location and extent of this traffic congestion is discussed in Chapter VII of this report.

EVACUATION OF PERMANENT RESIDENT POPULATION (NON-VEHICLE-OWNING)

Receive Notification

The procedure for receiving broadcast information is the same as for vehicle-owning population (above). This includes the sounding of sirens followed by broadcast information and supplemented by mobile public address.

Prepare for Evacuating Home

This step is the same as for vehicle-owning population (above). As in the case of vehicle-owning population, primary factors in the time required for this action or whether or not an adult is at home at the time of notification, the number of dependents to be evacuated, and the extent of property to be secured.

Evacuate Non-Vehicle-Owning Population in Buses

A significant fraction of the non-vehicle-owning population (perhaps as much as 50 percent) will be evacuated as passengers in private vehicles driven by family, neighbors, or friends. This component of the non-vehicle-owning population is considered as part of the vehicle-owning population, and their evacuation procedure follows that of the vehicle-owning population described above.

Persons from non-vehicle-owning households who do not evacuate as passengers in private vehicles will be transported out of the EPZ in publicly owned vehicles, dispatched by the County preparedness agencies.

In York County, South Carolina, and Gaston County, North Carolina, the primary source of vehicles are school buses. Transit buses from Charlotte will be the primary source of vehicles in Mecklenburg County.

EVACUATION OF TRANSIENT POPULATION

Receive Notification

Most of the industrial transient population will be notified by tone alert receivers, telephone calls, and the siren system. Transient recreational visitors around Lake Wylie are notified by the siren system. Some boaters on the lake will be notified by mobile public address systems.

Assemble Traveling Group

The traveling group (usually family) is assembled. Preparations for evacuating (for example, closing a cabin, docking a boat) are made.

Travel Out of the EPZ

After assembling their traveling group, the transient population will drive out of the EPZ using their private vehicles.

Transient population will be directed to a reception center. After clearing the reception center, they will return to their homes outside the EPZ.

Public agencies will give routing advice for this travel through information broadcasts during the evacuation. Law enforcement officers will also direct traffic flows out of the EPZ.

Unescorted children at Carowinds Theme Park will be taken by bus to a reception center in Mecklenburg County where they will be screened for radiological contamination and reunited with their parents.

EVACUATION OF SPECIAL FACILITY POPULATION (SCHOOLS)

Receive Notification

Following the decision to evacuate, the counties notify schools directly of the need for evacuation. This is done through the siren system and telephone calls directly to the schools.

Evacuate School Population in Buses

The school population is transported directly by bus from school to reception centers. An entire school will be transported to the same reception center. School children will not return home prior to evacuation. The picking up of school children at school by their families is discouraged.

All buses normally used within the Catawba EPZ will be used for evacuation. These will be supplemented by buses from outside the EPZ, but within the three-county area.

EVACUATION OF SPECIAL FACILITY POPULATION (INSTITUTIONS)

Receive Notification

Following the decision to evacuate, the local preparedness agencies will notify institutions directly by telephone calls.

Mobilize Population

The institutional population is instructed to evacuate by the staff of that particular institution. Necessary personal effects are assembled. Essential medical records are gathered.

Evacuate Institutional Population in Buses or Special Vehicles

Buses will pick up ambulatory hospital patients, nursing home residents, and other persons not requiring ambulance transportation. These passengers will be transported directly to the alternate relocation facilities.

Non-ambulatory persons will be transported directly from institutions by emergency vehicles normally based within the EPZ, supplemented by emergency vehicles from outside the EPZ.

SUMMARY OF THE EVACUATION PROCESS

In order to examine the "worst case" for which evacuation times are at a maximum, the evacuation is assumed to occur during the daytime during the school year.

Three population groups, having distinctly different evacuation methods, are recognized:

- Permanent residents who will evacuate in private vehicles (if vehicle-owning) or who will be transported in transit vehicles (if non-vehicle-owning)

- Transient population who will evacuate in private vehicles
- Special facility population who are transported out of the EPZ in school buses, public transit buses, other public vehicles and, in some cases, private automobiles

For each population group, the evacuation sequence consists of a number of clearly defined action steps as summarized in Table 4.

TABLE 4. SUMMARY OF EVACUATION ACTION STEPS

| Population Segment | Action Steps and Description |
|---|--|
| Permanent Resident Population (Vehicle-Ownng) (All members of households, except school children, having a private vehicle available for evacuation) | <ol style="list-style-type: none"> 1. RECEIVE NOTIFICATION, including instructions for evacuating 2. LEAVE PLACE OF WORK 3. WORK-TO-HOME TRAVEL, similar to normal work trip 4. PREPARE FOR EVACUATING HOME (close house, secure property) 5. TRAVEL OUT OF THE EPZ in private vehicles, using most direct routes |
| Permanent Resident Population (Non-Vehicle-Owning) (Persons not having a private vehicle available for evacuation) | <ol style="list-style-type: none"> 1. RECEIVE NOTIFICATION, including instructions for evacuating 2. PREPARE FOR EVACUATING HOME (close house, secure property) 3. EVACUATE NON-VEHICLE-OWNING POPULATION IN BUSES from county school system |
| Transient Population (Workers, recreational visitors) | <ol style="list-style-type: none"> 1. RECEIVE NOTIFICATION, including instructions for evacuating 2. ASSEMBLE TRAVELING GROUP 3. TRAVEL OUT OF THE EPZ in private vehicles |
| Special Facility Population (Schools) | <ol style="list-style-type: none"> 1. RECEIVE NOTIFICATION, including instructions for evacuating 2. EVACUATE SCHOOL POPULATION IN BUSES |
| Special Facility Population (Institutions) | <ol style="list-style-type: none"> 1. RECEIVE NOTIFICATION, including instructions for evacuating 2. MOBILIZE POPULATION, prepare population for evacuation 3. EVACUATE INSTITUTIONAL POPULATION IN BUSES OR SPECIAL VEHICLES |

CHAPTER VI. EVACUATION ROUTES

DESIGNATED EVACUATION ROUTES

In the event evacuation is necessary, people in the EPZ will be instructed to leave the area using the fastest route available. No attempt will be made to limit evacuation traffic to a few selected roads (as is sometimes done for security or to channel evacuees to reception centers). Thus, every road out of the EPZ will carry some evacuation traffic. The most significant of these are shown in Figure 10.

To facilitate movement to the reception centers, where location may be unfamiliar to some evacuees, the emergency preparedness officials for Gaston, Mecklenburg, and York Counties and the States of North and South Carolina have designated, or will designate, a series of evacuation routes leading from the EPZ boundary to the reception centers. Maps showing these routes will be widely distributed in the EPZ to guide people expeditiously to their designated reception center.

CAPACITIES OF THE EVACUATION ROUTES

In general, the capacity of an evacuation route is determined by the capacities of its intersections, rather than by the capacity of the road at non-intersection locations. For most of the evacuation routes, the capacity is determined at a critical intersection, or "bottleneck" location. These are locations where: 1) the evacuation route has a high traffic volume, and 2) cross-street traffic volume at the intersection is high, reducing the amount of time available for the major evacuation flow to enter the intersection.

The capacity of an intersection is based on maximum vehicular flow of 1,500 vehicles per lane hourly, with full assignment of the right-of-way (that is, 1,500 vehicles hourly if there is no intersecting traffic).¹ At the critical intersections

1. Highway Capacity Manual, 1965, Highway Research Board Special Record Number 87.

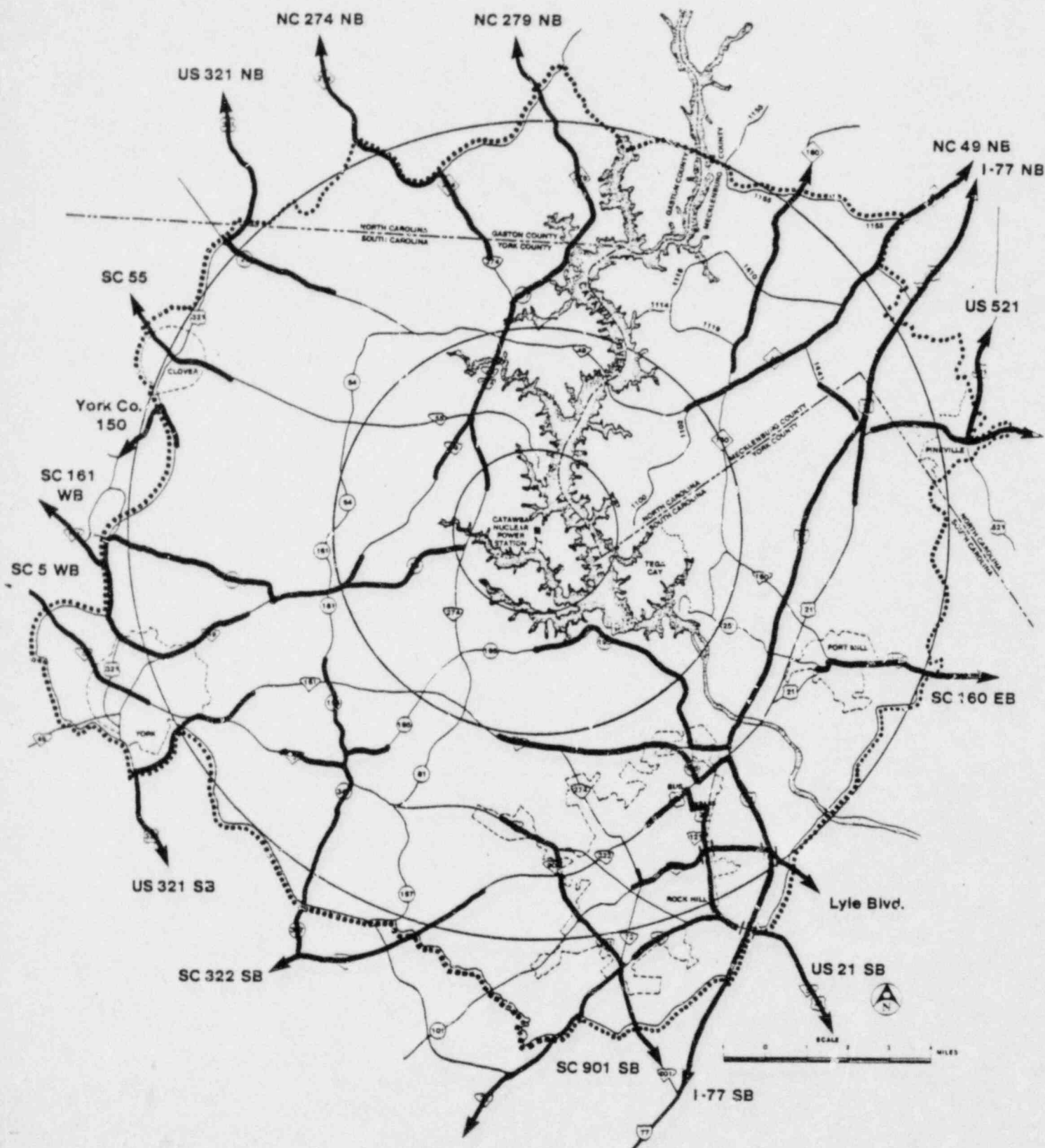


Figure 10. Major Routes Leading out of the EPZ of the Catawba Nuclear Power Station

which are establishing the capacity on the evacuation routes, the total capacity is adjusted downward to 80 percent of the maximum to allow for intersecting traffic. The resulting capacity is 1,200 vehicles per lane per hour.

The capacities of each of 18 major routes out of the EPZ are indicated in Table 5.

EVACUATION TRAVELSHEDS

The travelshed of a particular evacuation route is the "catchment" area of population for that route; that is, the area for which that route is the fastest means of exit from the EPZ.

The travelsheds for the evacuation routes in the Catawba EPZ are determined by extending the major evacuation routes, as identified in Figure 10, so that all of the road systems in the EPZ connect to one or another of the evacuation routes. This process is simple for those sections of roadway immediately adjacent to the major evacuation routes, where it is obvious which sections of roadway feed any given evacuation route. For sections more distant from the major evacuation routes, the evacuation path is not as clear, and routings are made on the basis of travel time estimates. Some sections of roadway are midway between evacuation routes, and are equally well served by two different routes. These areas define the boundaries between the travelshed areas for different evacuation routes as indicated in Figure 11.

DISTRIBUTION OF TRAFFIC TO THE EVACUATION ROUTES

The population of the travelshed area for each evacuation route was determined in two steps. First, the EPZ was subdivided into 160 segments, each defined by its distance and direction from the nuclear station. Census data for 1980 was used to determine the population of each segment. The population within each segment was then apportioned to the routes leading from that segment out of the EPZ. Table 6 shows the population of the travelshed for each of the major routes.

TABLE 5. CAPACITY OF MAJOR EVACUATION ROUTES

| <u>Evacuation</u> | <u>Number of Lanes¹</u> | <u>Type of Road</u> | <u>Outbound Capacity²</u> |
|-------------------|--|----------------------------------|--|
| Lyle Boulevard EB | 4 | Urban Arterial | 2,400 |
| I-77 SB | 4 | Interstate | 3,000 |
| US 21 SB | 4 | Semi-Rural Arterial ³ | 2,400 |
| SC 901 (SC 72) SB | 4 | Semi-Rural Arterial | 2,400 |
| SC 322 SB | 2 | Rural Arterial | 1,200 |
| US 321 SB | 2 | Rural Arterial | 1,200 |
| SC 5 WB | 2 | Rural Arterial | 1,200 |
| SC 161 WB | 2 | Rural Arterial | 1,200 |
| York 150 WB | 2 | Rural Secondary | 1,200 |
| SC 55 WB | 2 | Rural Arterial | 1,200 |
| US 321 NB | 4 | Rural Arterial | 2,400 |
| NC 274 NB | 2 | Rural Arterial | 1,200 |
| NC 279 NB | 2 | Rural Arterial | 1,200 |
| NC 160 NB | 2 | Rural Arterial | 1,200 |
| NC 49 NB | 2 | Rural Arterial | 1,200 |
| I-77 NB | 4 | Interstate | 3,000 |
| US 521 NB | 2 | Rural Arterial | 1,200 |
| SC 160 EB | 2 | Rural Arterial | 1,200 |

1. Total lanes, both directions.

2. Hourly vehicles, outbound only. Obtained from Highway Capacity Manual, 1965, Highway Research Board Special Report Number 87.

3. Semi-rural areas are characterized by light density development along roadside.

4. SC 901 changes from four to two lanes near EPZ boundary, but SC 72 provides a lane to carry half the traffic the rest of the way out of the EPZ.

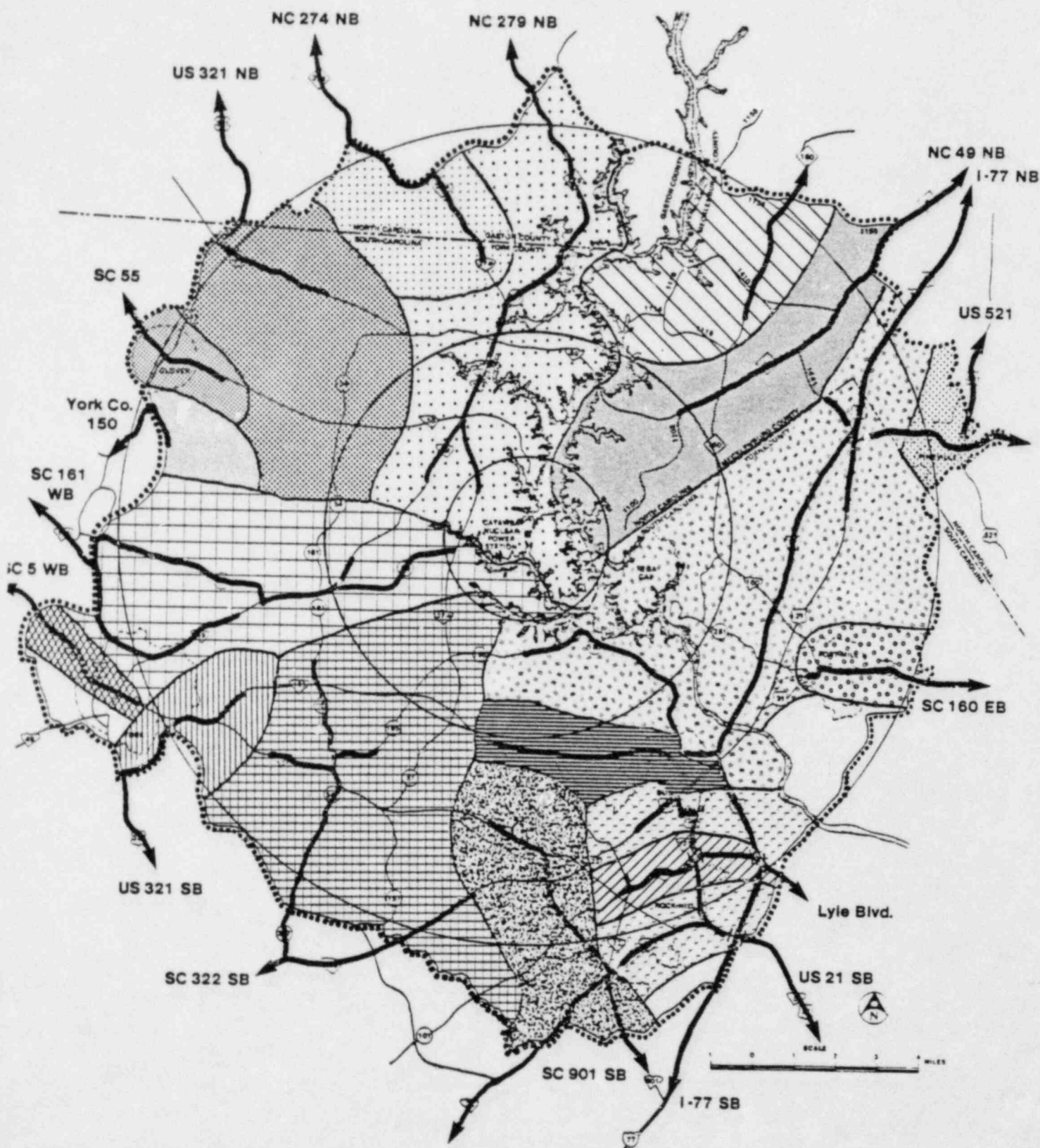


Figure 11. Travel Sheds for Routes Leading Away From the Catawba Nuclear Station

TABLE 6. TRAFFIC VOLUMES AND CAPACITIES
FOR MAJOR EVACUATION ROUTES

| Evacuation Route | Population Assigned to Route ¹ | Vehicles Assigned to Route ² | Hourly Vehicle Capacity | Hours of Traffic Flow ³ |
|---------------------|---|---|-------------------------------|--|
| Lyle Boulevard EB | 4,459 | 1,917 | 2,400 | 0.8 |
| I-77 SB | 8,079 | 3,473 | 3,000 | 1.2 |
| US 21 SB | 15,897 | 6,835 | 2,400 | 2.8 |
| SC 901 (SC 72) SB | 13,556 | 5,829 | 2,400 | 2.4 |
| SC 322 SB | 5,284 | 2,272 | 1,200 | 1.9 |
| US 321 SB | 2,281 | 980 | 1,200 | 0.8 |
| SC 5 WB | 1,763 | 758 | 1,200 | 0.6 |
| SC 161 WB | 2,468 | 1,061 | 1,200 | 0.9 |
| York 150 WB | 1,470 | 632 | 1,200 | 0.5 |
| SC 55 WB | 1,286 | 552 | 1,200 | 0.5 |
| US 321 NB | 3,275 | 1,408 | 2,400 | 0.6 |
| NC 274 NB | 1,068 | 459 | 1,200 | 0.4 |
| NC 279 NB | 4,529 | 1,947 | 1,200 | 1.6 |
| NC 160 NB | 1,721 | 739 | 1,200 | 0.6 |
| NC 49 NB | 2,213 | 951 | 1,200 | 0.8 |
| I-77 NB | 10,298 | 4,428 | 3,000 | 1.5 |
| US 521 NB | 1,525 | 655 | 1,200 | 0.6 |
| SC 160 EB | 4,926 | 2,118 | 1,200 | 1.8 |

1. Based on apportionment of population (Chapter IV) to the evacuation travelshed areas (Figure 11).
2. Based on vehicle ownership data from the 1980 census (Appendix B).
3. Assumes continuous flow of all traffic assigned to that route.

RELATIONSHIP OF EVACUATION TRAFFIC VOLUMES AND ROUTE CAPACITIES

Table 6 summarizes, for each of the 18 individual evacuation routes, the traffic capacity of the route and the volume of evacuation traffic assigned to that route. The resulting hours of traffic flow are then calculated. This measure does not represent the total evacuation time; for example, it does not include the time needed for notification or for preparing to leave home. Rather, the "Hours of Traffic Flow" statistic is an indication of the level of traffic congestion that can be anticipated on the route.

CHAPTER VII. SUMMARY OF EVACUATION TIME ESTIMATES

CONDITIONS AND TIME PERIODS

Evacuation time estimates are made for two conditions:

1. Fall/winter day, with normal weather conditions. This condition, as explained in Chapter V, represents the "critical" time period for which evacuation times are likely to be at their maximum. The maximum transient population is assumed to be in the EPZ at this time.
2. Fall/winter day, with severe weather conditions (defined as a winter storm, with icy road conditions). This case represents the "critical" time period (as explained in Chapter V) under unfavorable weather conditions which further extend the required evacuation times.

Detailed evacuation times are first calculated for the "fall/winter day" (normal weather) conditions, then adjusted to yield the "fall/winter" day (severe weather) conditions.

METHOD FOR ESTIMATING EVACUATION TIME

Population Segments

Evacuation time is estimated separately for each of the three population groups discussed earlier: (1) permanent resident population, (2) transient population and, (3) special facility population.

These evacuation time estimates assume that effective local preparedness plans are in operation, and that virtually complete coverage of the EPZ population with a prompt alerting and notification system is achieved. This notification time reflects the siren coverage expected with the system already designed.

Action Steps

Each population segment follows a specific sequence of action steps in evacuating the EPZ. (See Chapter V for a detailed discussion of these steps.) The time needed to complete each of these steps is stated as the distribution relating the fraction of the population completing a particular step to the elapsed time after that action step is first started.

Time Required for a Series of Action Steps

The total evacuation time is calculated by linking together the time required to complete the individual steps. The resulting total time for evacuation is calculated (as are the times for the individual steps) as a distribution of time, showing the fraction of the population which completes the total evacuation process within a given amount of elapsed time. The EVACURVE program (Appendix C) is used to compute these elapsed times.

Distribution of the Traffic to the Evacuation Routes

The evacuation traffic is distributed to the available roads out of the EPZ (Chapter VI). Delays due to traffic congestion are calculated, and the evacuation times are adjusted to reflect these delays.

EVACUATION TIME FOR THE PERMANENT RESIDENT POPULATION (VEHICLE-OWNING), FALL/WINTER WEEKDAY, NORMAL WEATHER CONDITIONS

The evacuation sequence for the permanent resident vehicle-owning population includes five steps: (1) Receive Notification, (2) Leave Place of Work, (3) Work-to-Home Travel, (4) Prepare for Evacuating Home and, (5) Drive Out of the EPZ. The time required to complete each of these steps is established. Then, a total evacuation time for the vehicle-owning population is obtained by combining the time required for each of the five action steps.

Receive Notification

Some of the vehicle-owning permanent resident population receives the broadcast information almost immediately; for example, 10 percent of this population is assumed to receive broadcast information in 15 minutes (Table 7). These are individuals who immediately comprehend the notification and promptly tune into the EBS broadcasts. This group also includes individuals already listening to radio and television broadcasts and are, therefore, informed immediately of the emergency and the need to evacuate the EPZ.

TABLE 7. TIME DISTRIBUTION FOR
"RECEIVE NOTIFICATION" STEP

| <u>Time After Start of Notification</u> | <u>Estimated Percentage of Population Receiving Notification</u> |
|---|--|
| 15 minutes | 10 |
| 20 minutes | 10 |
| 25 minutes | 30 |
| 30 minutes | 30 |
| 35 minutes | 10 |
| 40 minutes | 5 |
| 45 minutes | 5 |

A large fraction of the population of the EPZ is estimated to receive the broadcast information between 20 and 30 minutes after the start of notification. These individuals require several minutes to comprehend the notification, and then several more minutes to tune into the EBS broadcasts.

At the high end of the range, some of the population (10 percent of the total) are assumed to require over 35 minutes to receive the broadcast information. These

are mainly persons not reached immediately by the notification system, not understanding the significance of the siren warning, or without access to a radio or television set. This element of the population is notified, in general, by supplementary methods, such a mobile public address, etc.

It is estimated that all of the population receives the broadcast information within 45 minutes of the start of notification.

Leave Place of Work

It is estimated that a sizeable portion of the permanent resident vehicle-owning population can leave work within 10 minutes after receiving the broadcast information, or after this information is conveyed to them by their employer (Table 8). In general, these are workers not having managerial responsibility or whose jobs do not require shutdown time.

TABLE 8. TIME DISTRIBUTION FOR
"LEAVE PLACE OF WORK" STEP

| <u>Time After Start of Notification</u> | <u>Estimated Percentage of Workers Leaving Place of Work</u> |
|---|--|
| 10 minutes | 50 |
| 15 minutes | 30 |
| 20 minutes | 10 |
| 30 minutes | 5 |
| 45 minutes | 5 |

Another large group of workers (an estimated 40 percent of the total) will need between 10 and 20 minutes to leave their place of work. These are employees whose jobs require some shutdown time, and managers who remain until other employees have left.

At the high end of the range, an estimated 5 percent of the workers require over 30 minutes to prepare for leaving work. These individuals are mainly managers, persons responsible for securing cash or property, and persons needed to shut down industrial processes.

All employees complete preparation to leave their place of work within 45 minutes of receiving the broadcast information (Table 8).

Work-to-Home Travel

The time needed for this step is similar to that needed for the daily trip home during the afternoon peak hour. This time depends primarily on the distance from work to home. This distribution of estimated travel-to-home time is for only those workers having their residence and place of work in the EPZ. At the low end of the range, an estimated 50 percent of the workers can complete the trip home within 5 minutes (Table 9). Another large group of workers live within 5 miles of their job and can return home in 10 to 15 minutes. At the upper end of the range, an estimated 20 percent of all employees will need more than 15 minutes for their travel home.

TABLE 9. TIME DISTRIBUTION FOR
"WORK-TO-HOME TRAVEL" STEP

| <u>Time After Workers Begin to Leave Place of Work</u> | <u>Estimated Percentage of Workers Arriving at Home</u> |
|--|---|
| 5 minutes | 50 |
| 10 minutes | 30 |
| 15 minutes | 10 |
| 20 minutes | 10 |

Some employees working outside the EPZ, particularly at locations near the EPZ boundary, will return home before the EPZ is closed to entering traffic and will

evacuate in the same manner as vehicle-owning households. However, employees who work at some distance outside the EPZ may not be able to enter the EPZ since incoming traffic will be restricted as soon as possible after the start of the evacuation.

Prepare for Evacuating Home

The time needed to prepare for evacuating the home depends on three factors: (1) whether or not an adult member of the household is home at the time of notification, (2) the number of dependents in the household, and (3) the amount of household property to be secured prior to evacuation.

At the low end of the range, an estimated 15 percent of all the vehicle-owning population can prepare for evacuating their households within 20 minutes after the arrival of the workers from their jobs (Table 10). These are generally households with an adult member present at home, with few dependents, and no property to be secured.

TABLE 10. TIME DISTRIBUTION FOR
"PREPARE FOR EVACUATING HOME" STEP

| <u>Time After Workers Arrive Home</u> | <u>Estimated Percentage of Vehicle-Owning Population Leaving Home</u> |
|---|---|
| 15 minutes | 10 |
| 20 minutes | 5 |
| 25 minutes | 10 |
| 30 minutes | 15 |
| 35 minutes | 15 |
| 40 minutes | 25 |
| 50 minutes | 10 |
| 60 minutes | 5 |
| 95 minutes | 5 |

An estimated 80 percent of the vehicle-owning population can prepare to leave home within 40 minutes of the arrival of household workers. These are likely to be households with dependents at home and a typical single-family residence to secure.

At the upper end of the range, an estimated 20 percent of the population requires over 40 minutes to prepare for evacuating their homes. Generally, these are households with more than one dependent and extensive household property to be secured (for example, a farm).

Final Departure Curve

Figure 12 illustrates the distribution of time needed by the EPZ population to complete each of the evacuation steps. The final departure curve (that is, the time needed to complete all action steps except the final driving from the EPZ) is completed at 3 hours, 10 minutes after the start of notification.

Drive Out of the EPZ

The time needed for the final step, "Drive Out of the EPZ," depends on the level of traffic congestion encountered on the specific evacuation route taken. On routes with no traffic congestion, a maximum of 15 minutes is needed to drive out of the EPZ, and for such routes the total evacuation time is 3 hours, 25 minutes (3 hours, 10 minutes as noted in Figure 12, plus 15 minutes driving time). On some routes with traffic congestion, driving times will be determined by traffic delays, as discussed below.

Routing — Most motorists will drive out of the EPZ on the designated evacuation routes as identified in Chapter VI of this report. Some motorists will drive out on roads not designated as evacuation routes.

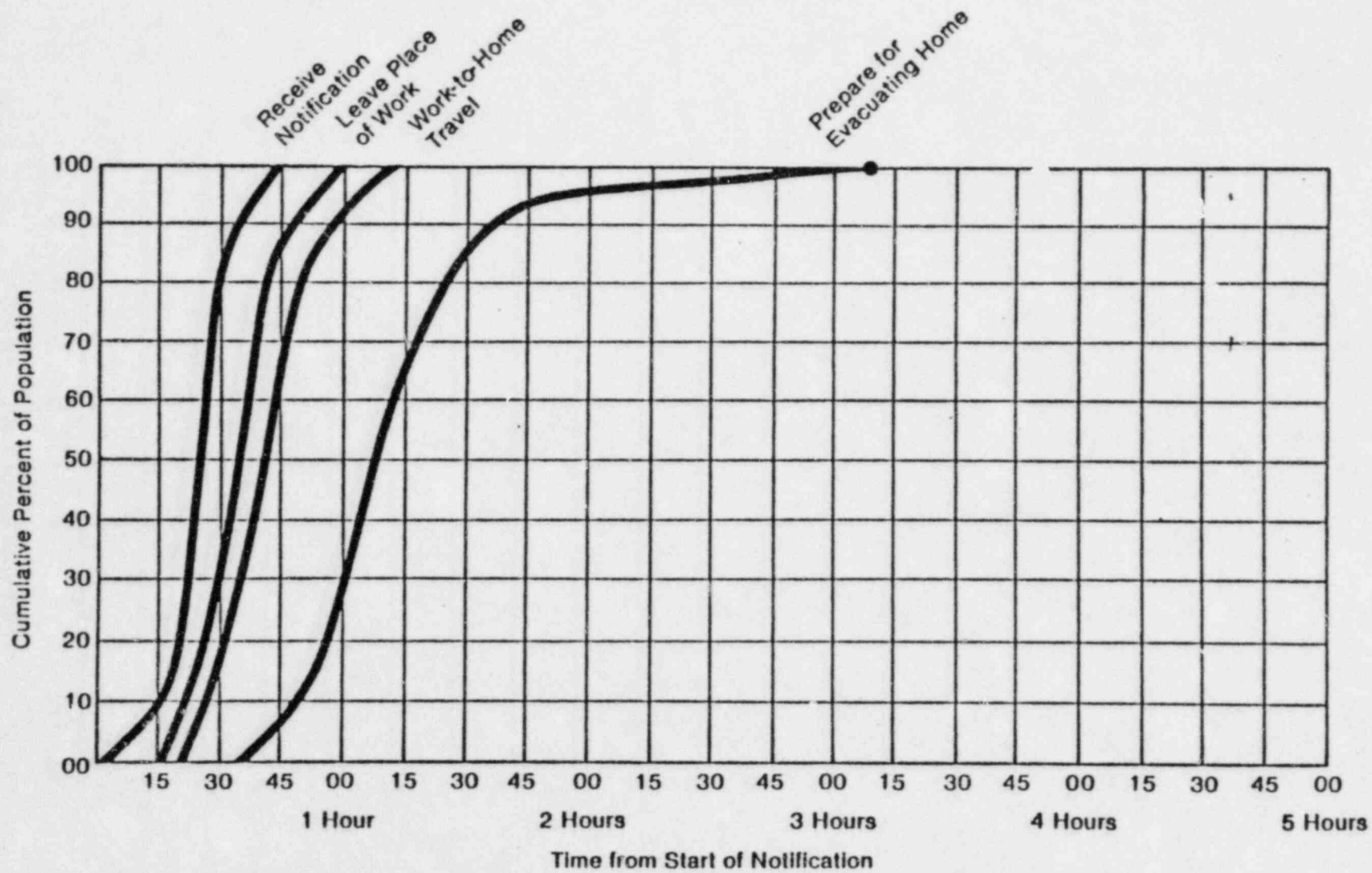


Figure 12. Evacuation Time for the Permanent Resident Population (Auto-Ownning)

Public agencies will give routing advice for this travel by means of preparedness plans prior to the emergency and through information broadcasts during the actual evacuation.

Traffic Control — At critical locations—primarily key intersections within the EPZ—traffic will be controlled by State and local law enforcement agencies as established in local preparedness plans. This traffic control will accomplish two purposes: (1) ensure orderly traffic flow at that particular location, and (2) direct motorists to the best available route out of the EPZ.

During the evacuation, normal traffic control will continue, two-way streets will operate in their usual manner as two-way streets, and traffic control devices, such as signals, will continue to function. The only exception will be the replacing of traffic signal control at some key intersections with traffic direction by law enforcement officers.

Method for Analyzing Evacuation Traffic Flows — The evacuation traffic flow is analyzed with a computer program package consisting of two modules:

1. EVACURVE, which calculates the final departure curves (Figure 12) giving the distribution of times at which the vehicle-owning population completes preparations to leave home and enters the road system.

The EVACURVE module calculates the departure curve from the series of time distributions for completing each step of the evacuation sequence. Statistically, each time distribution for an individual step is a conditional probability distribution; the final departure curve is obtained by computing the joint probability distribution of all the steps.

2. The QUEUE module, which simulates the flow of traffic through the evacuation routes, and identifies the location and extent of traffic congestion.

Inputs to the QUEUE module are the evacuation network and the distribution of traffic onto this network. The program then calculates the arrival and departure of traffic at all locations throughout the evacuation network. This simulation is iterative, being repeated for 15-minute intervals of the evacuation period.

The QUEUE module identifies locations at which traffic congestion occurs, and calculates the extent of such congestion. Measures which are computed include the time period over which congestion occurs at a particular location, the maximum delay experienced by a vehicle passing through any congested location and the extent (distance) of congestion on the evacuation road network.

Traffic Congestion — The QUEUE program shows that on 6 of the 18 major routes out of the EPZ, the road capacities exceed the rate at which vehicles leave households. On these routes, there is no congestion at any point in the evacuation process, and the time needed to drive out of the EPZ is determined solely by the free-flow travel time.

On 11 of the 18 major routes, traffic back-ups (queues) will form during some part of the evacuation process. These are caused as the vehicle-owning population completes the necessary preparations to leave their homes and enters the street system at a rate greater than the capacity of that street system to carry them. As a consequence, traffic begins to back up, starting at critical intersections, where:

1. Substantial volumes of evacuating traffic converge onto the evacuation route
2. The capacity of the evacuation route is restricted by a bridge, ramp, pavement width, etc.
3. Cross street traffic is substantial, reducing the amount of time available for the movement of evacuating traffic at that point

Traffic congestion first appears as the volume of traffic entering the street system begins to increase sharply, at about 1 hour, 40 minutes after the start of notification. Once started, congestion spreads rapidly in the upstream direction, blocking traffic attempting to enter the evacuation route from side roads. In the worst case, congestion spreads generally throughout an area, with all arterial and collector streets and even some local streets blocked.

During the period in which this congestion is occurring, the rate of evacuation is fixed by the capacity of the street system and is no longer determined by the rate at which the population finishes preparations to leave their households. Motorists

leaving their homes and entering the street system during such a period are simply "stored" in traffic queues in the street system.

Possible Levels of Traffic Congestion — Three possible conditions of traffic congestion are analyzed in Figure 13. In the instance with no traffic congestion (Type "A" in Figure 13), the departure from the EPZ depends solely on the rate at which people prepare to leave their households and drive, in a free-flow manner, out of the EPZ. At no point in the evacuation period does traffic congestion slow this progress out of the EPZ. Seven routes out of the Catawba EPZ have this pattern of traffic flows.

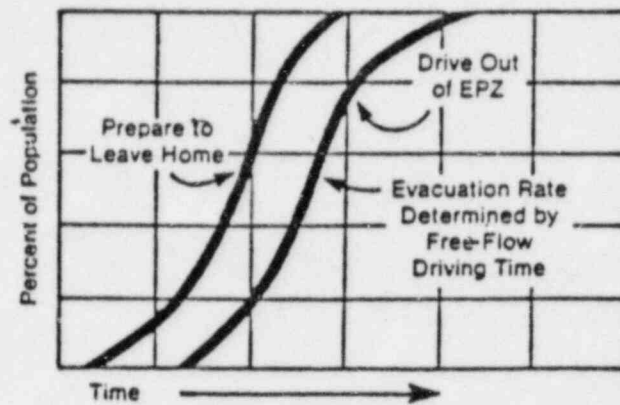
On routes where traffic congestion occurs (Types "B" and "C" in Figure 13), traffic congestion appears when the rate of vehicles entering the street exceeds the capability of the street to carry them. Congestion continues to build as long as the rate of vehicles entering the street system continues to exceed the vehicular capacity of the evacuation route.

At some point in the evacuation process, the rate at which vehicles enter the street system reaches a maximum and begins to decrease.

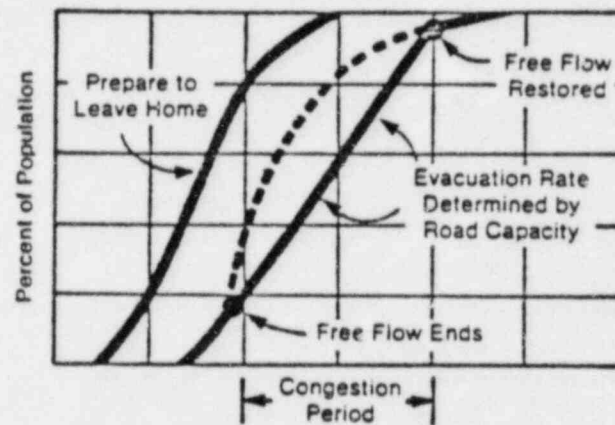
Congestion begins to diminish as the rate of vehicles entering the street system begins to fall below the capacity of the evacuation route to carry them. This decrease in traffic congestion continues until the queues disappear and free traffic flow is restored on the evacuation route.

In less severe instances of congestion (Type "B" in Figure 13), this occurs before the population has finished preparations to leave home. From the point at which congestion ends until the completion of evacuation, the rate of evacuation is once again determined by the rate at which households complete their preparation to leave home and enter the street system. Eight routes out of the Catawba EPZ have this traffic pattern.

A. FREE TRAFFIC FLOW, NO CONGESTION



B. CONGESTION OCCURS AND ENDS BEFORE ALL POPULATION LEAVES HOME



C. CONGESTION CONTINUES AFTER ALL POPULATION LEAVES HOME

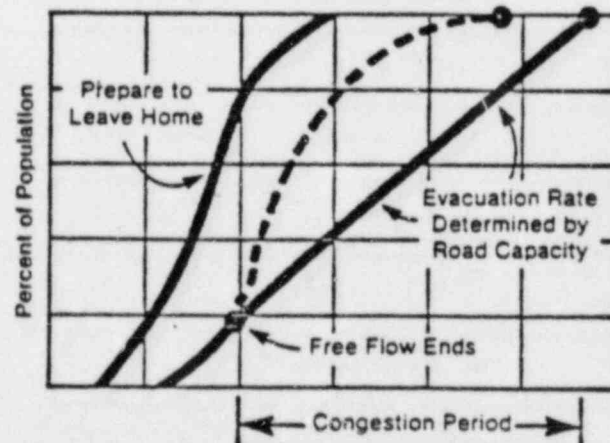


Figure 13. Possible Levels of Traffic Congestion

In the more severe instances of congestion (Type "C" in Figure 13), the traffic back-ups continue even after all the population has completed preparations to leave home. In this type of congestion, the back-ups are too large to be discharged before all population has completed preparations to leave home. In this case, evacuation times are no longer dictated by the time at which preparations for leaving home plus a free-flow driving time but, rather, by the traffic capacity of the evacuation route. Three routes out of the Catawba EPZ have this traffic pattern.

Location of Traffic Congestion — Figure 14 illustrates the location of traffic congestion in the Catawba EPZ, and indicates the extent of the anticipated congestion when it is at a maximum. As indicated in Figure 14, the greatest traffic congestion occurs on US 21 southbound in Rock Hill.

Summary of Evacuation Times for the
Permanent Resident Population (Vehicle-Owning)

Of the total of 18 major evacuation routes in the Catawba EPZ, 14 have a total evacuation time of 3 hours and 25 minutes (Figure 14). This evacuation time occurs on routes where there is either no traffic congestion at all, or where there is some traffic congestion which ends before all the resident population completes preparations to leave home.

On the remaining three routes, the evacuation time reflects a level of congestion that is not dissipated by the time that the population has completed preparations to leave home. On those routes, congestion continues after the population has completed preparations to leave home, and this congestion then determines the total evacuation times. Evacuation time for US 21 is 4 hours, time for I-77 is 3 hours 45 minutes, and SC 901 is 3 hours 30 minutes.

EVACUATION TIME FOR THE PERMANENT RESIDENT POPULATION (NON-VEHICLE-OWNING)

The evacuation of the non-vehicle-owning population includes three steps: (1) Receive Notification; (2) Prepare for Evacuating Home; and (3) Evacuate Non-Vehicle-Ownning Population in Buses. The time required to complete each of these steps is established, and the total time for the evacuation of the non-vehicle-owning population is obtained by combining the time required for each of the steps.

Receive Notification

Notification times and the explanation for these times are the same as for the permanent resident vehicle-owning population discussed above. All of the non-vehicle-owning population is notified within 45 minutes of the start of notification.

Prepare for Evacuating Home

The time needed to prepare for evacuating the home depends on: (1) whether or not an adult member of the household is home at the time of notification; (2) the number of dependents in the household; and (3) the amount of household property to be secured before the family can evacuate.

It is estimated that 20 percent of the non-vehicle-owning population can prepare to leave home within 20 minutes of receiving notification to evacuate (Table 11). Typically, these are small households with few dependents and no property to secure before leaving.

At the upper end of the range, it is estimated that 50 percent of the non-vehicle-owning population needs 30 to 45 minutes to prepare for leaving home. These are generally households with a dependent at home and a residence to secure before leaving.

TABLE 11. TIME DISTRIBUTION FOR
"PREPARE FOR EVACUATING HOME" STEP
FOR NON-VEHICLE-OWNING POPULATION

| <u>Time After Receiving Notification</u> | <u>Estimated Percentage of Population Completing Preparations to Leave Home</u> |
|--|---|
| 15 minutes | 10 |
| 20 minutes | 10 |
| 25 minutes | 10 |
| 30 minutes | 20 |
| 35 minutes | 20 |
| 40 minutes | 20 |
| 45 minutes | 10 |

Evacuate Non-Vehicle-Owning Population in Buses

A bus fleet large enough to carry the non-vehicle-owning population in less than two round trips per bus out of the EPZ is assumed in estimating the evacuation time. Local plans call for this fleet to be drawn from school buses from York, Mecklenburg, and Gaston Counties, other nearby counties, and from the public transit system in Charlotte.

It is estimated that one-half of the non-vehicle-owning population can be evacuated by 2 hours and 5 minutes after the start of notification (Table 12). The remainder of the non-vehicle-owning population is estimated to be evacuated by 3 hours after the start of evacuation.

TABLE 12. TIME DISTRIBUTION FOR "EVACUATE
NON-VEHICLE-OWNING POPULATION IN BUSES" STEP

| <u>Time After Start of Notification</u> | <u>Estimated Percentage of Non-Vehicle-Ownig Population Evacuated in Buses</u> |
|---|--|
| 1 hour, 45 minutes | 25 |
| 2 hours, 5 minutes | 25 |
| 2 hours, 25 minutes | 25 |
| 3 hours | 25 |

Summary of Evacuation Times for the Permanent Resident Population
(Non-Vehicle-Ownig)

The time required for completion of the various steps in the evacuation of the non-vehicle-owning population is summarized in Figure 15. The determining factor in the time needed for the evacuation of the non-vehicle-owning population is the time needed for this population to complete preparations for leaving home and to assemble at the collection points.

EVACUATION TIME FOR THE TRANSIENT POPULATION

The evacuation sequence for the transient population includes three steps: (1) Receive Notification, (2) Assemble Traveling Group, and (3) Drive Out of the EPZ. The time required to complete each of these steps is established. A total evacuation time for the transient population is obtained by combining the time required for each of the three action steps.

Receive Notification

Notification times and the explanation for these times are the same as for the permanent resident vehicle-owning population discussed previously. All of the

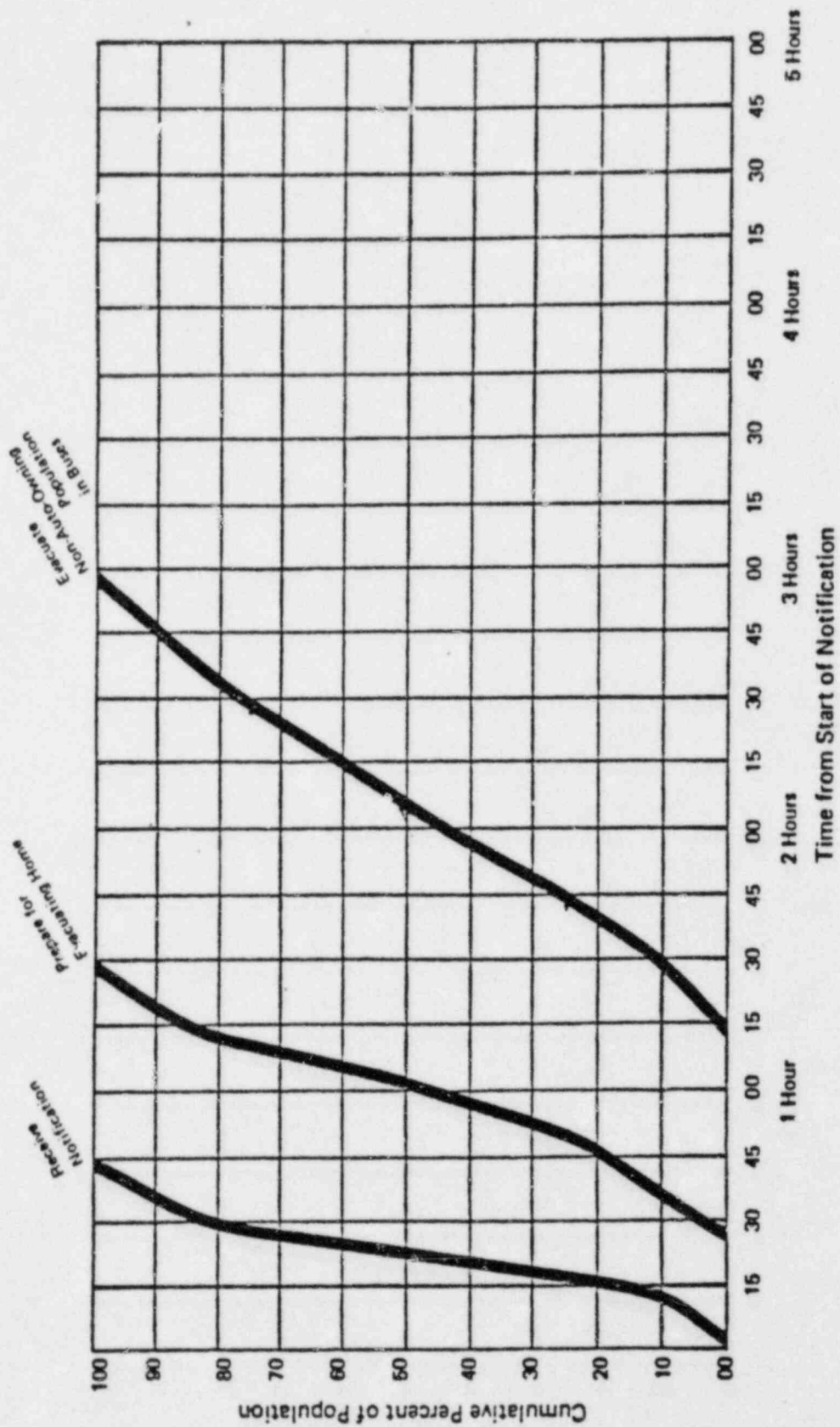


Figure 15. Evacuation Times for the Permanent Resident Population (Non-Auto-Owning)

transient population is assumed to be notified within 45 minutes of the start of notification.

Assemble Traveling Group

The traveling group (usually family or co-workers) is assembled and prepared for evacuation. It is assumed that some groups (for example, employees at work) can assemble and prepare for evacuation almost immediately. This is reflected in the distribution in Table 13, which estimates that 50 percent of the transient population can assemble their traveling group and prepare to depart within 15 minutes after receiving instructions to evacuate.

TABLE 13. TIME DISTRIBUTION FOR
"ASSEMBLE TRAVELING GROUP" STEP
FOR TRANSIENT POPULATION

| <u>Time After Receiving Notification</u> | <u>Estimated Percentage of Population Assembling Traveling Group</u> |
|--|--|
| 10 | 20 |
| 15 | 30 |
| 20 | 30 |
| 30 | 20 |

At the other end of the distribution, some transient groups will require up to an estimated 30 minutes to assemble their groups and prepare to evacuate. Examples of this situation are residents at seasonal homes at Lake Wylie who would have to complete certain preparations, such as securing boats and cabins, before evacuating the area.

Drive Out of the EPZ

After assembling their traveling group and completing preparations to evacuate, the transient population will drive out of the EPZ using their private vehicles.

In evacuating the EPZ, the transient population will encounter free-flow traffic conditions (i.e., no congestion) throughout their trip out of the EPZ. This is a result of the small size of the transient population and the early stage at which they begin to evacuate. All transient population is evacuated from the EPZ before the major part of the traffic build up from the permanent resident population begins to occur.

Summary of Evacuation Times for the Transient Population

It is estimated that some of the transient population in the EPZ evacuates within 45 minutes of the start of notification (Figure 16). The transient population is estimated to complete their trips out of the EPZ at 1 hour and 45 minutes after the start of notification.

Unusual Concentrations of Transients

In some situations, unusually large concentrations of transient population may be present within the EPZ at: (1) Carowinds Theme Park and (2) PTL grounds in York County.

Evacuation times were estimated for both locations, under assumption of their maximum reported attendance. For both locations, maximum reported attendances can be evacuated in less than the 3 hours and 25 minutes of the required time for vehicle-owning households in a congestion-free evacuation). Consequently, it can be established that evacuation of unusual concentrations of transient population for Carowinds or PTL will not result in extending evacuation times beyond that required by permanent resident population.

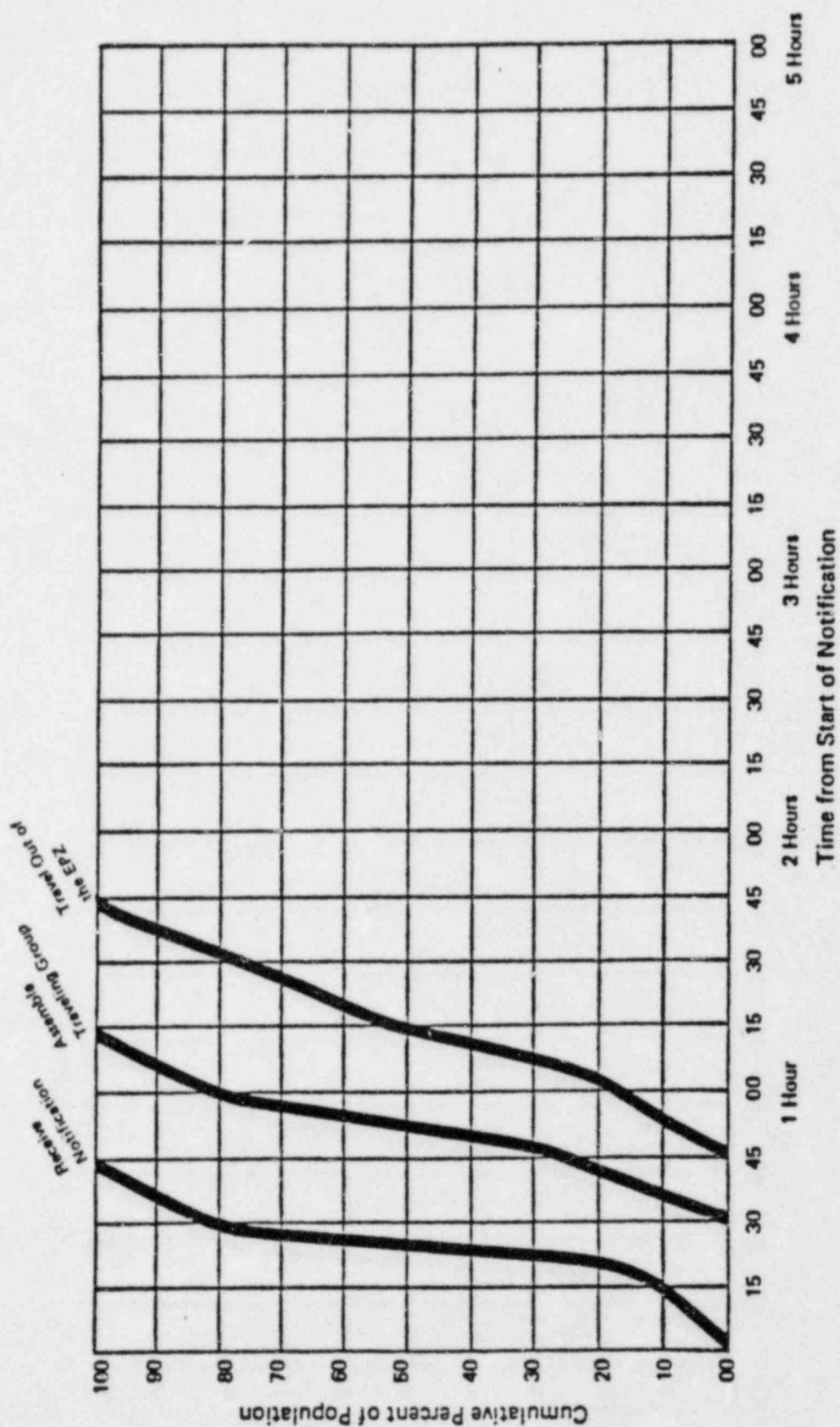


Figure 16. Evacuation Times for the Transient Population

EVACUATION TIME FOR THE SPECIAL FACILITY POPULATION (SCHOOLS)

The evacuation sequence for the school population includes two steps: (1) Receive Notification and (2) Evacuate School Population in Buses.

Receive Notification

School administrations will be notified immediately through radio and telephone calls. Student bodies will then be notified immediately through school public address systems. After notification, preparation to leave the school premises is almost immediate (similar to a routine fire drill).

The majority of the school population is assumed to be notified within 15 minutes of the start of notification (Table 14). All school population is assumed to be notified within 25 minutes of the start of notification.

TABLE 14. TIME DISTRIBUTION FOR
"RECEIVE NOTIFICATION" STEP
FOR SCHOOL POPULATION

| <u>Time After Start of Notification</u> | <u>Estimated Percentage of Population Receiving Notification</u> |
|---|--|
| 10 minutes | 10 |
| 15 minutes | 40 |
| 20 minutes | 20 |
| 25 minutes | 10 |

Evacuate School Population in Buses

The determining factor in the time needed for evacuation of the school population in buses is the time required for mobilizing the bus fleet and bringing buses to the schools.

A bus fleet sufficiently large to carry the entire school population is assumed in estimating the evacuation time. This fleet will be drawn from York, Mecklenburg, and Gaston Counties, and from other nearby counties if necessary.

As indicated in Table 15, an estimated 20 percent of the school population can be transported out of the EPZ within 1 hour after the start of notification. These students are transported in vehicles in regular use in the school districts in the EPZ and which can be readily mobilized. Another 60 percent of the school population is assumed to be transported out of the EPZ by 1 hour and 30 minutes after the start of notification.

TABLE 15. TIME DISTRIBUTION FOR
"EVACUATE SCHOOL POPULATION IN BUSES" STEP

| <u>Time After Start of Notification</u> | <u>Estimated Percentage of School Population Evacuated by Bus</u> |
|---|---|
| 60 minutes | 20 |
| 1 hour, 15 minutes | 35 |
| 1 hour, 30 minutes | 25 |
| 1 hour, 45 minutes | 20 |

The students evacuated in these later stages are those riding in buses which are brought from outside the EPZ.

All students are evacuated from the EPZ within 1 hour and 45 minutes after start of notification.

The distribution of the evacuation time for the school population is given in Figure 17.

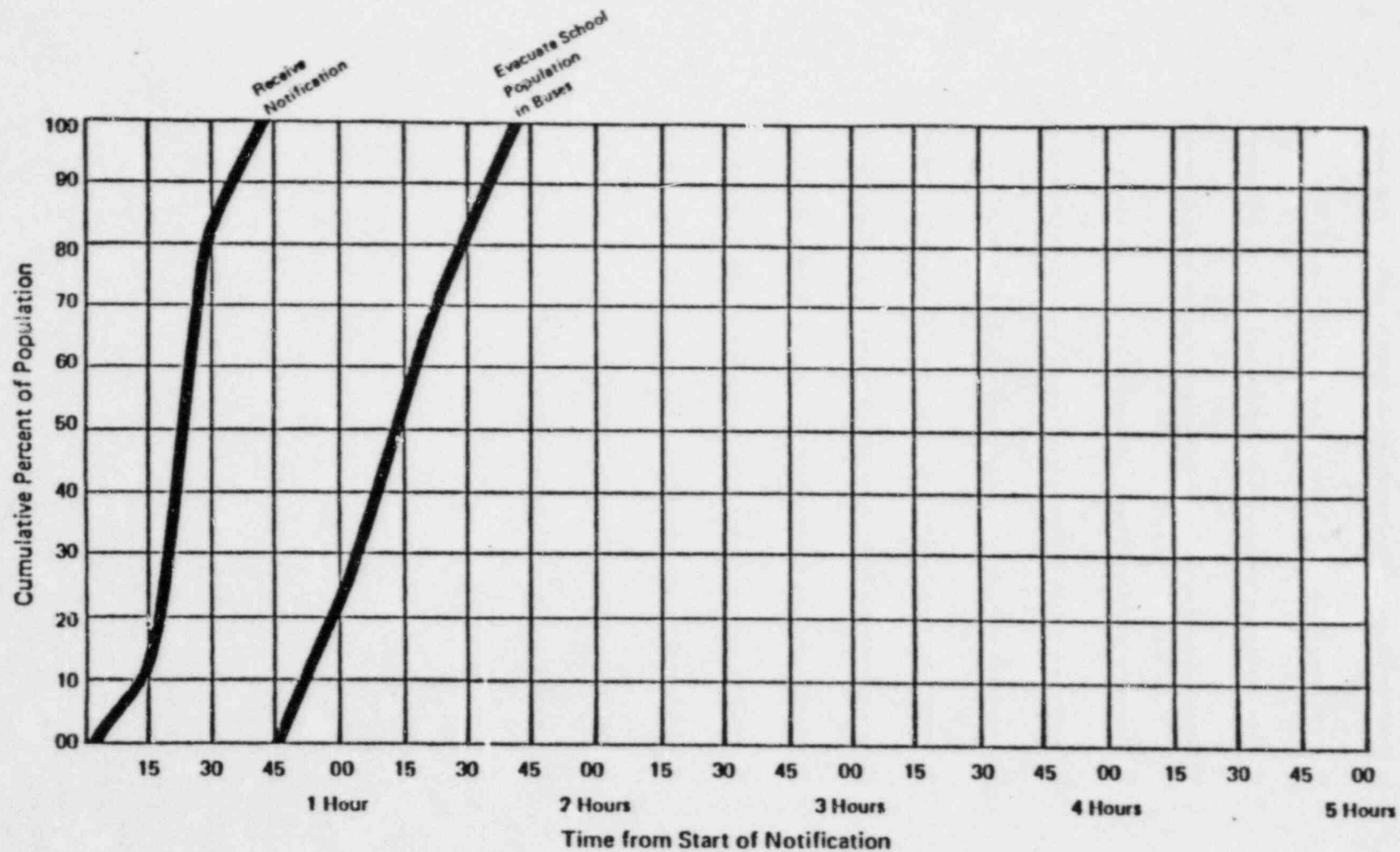


Figure 17. Evacuation Times for the Special Facilities Population (Schools)

EVACUATION TIME FOR THE SPECIAL FACILITY POPULATION (INSTITUTIONS)

The evacuation of the population in institutions involves three steps: (1) Receive Notification; (2) Mobilize Population; and (3) Evacuate Institutional Population in Buses or Special Vehicles. The time needed to complete each of these steps is established, and the total time for the evacuation of the population in institutions is obtained by combining the time required for each of the three steps.

Receive Notification

Notification time is the same as for the vehicle-owning population discussed above. All of the population in institutions is assumed to be notified within 45 minutes after the start of notification.

Mobilize Population

For a significant part of the population in institutions, mobilization can be accomplished almost immediately after notification of the need to evacuate. For example, it is estimated that 70 percent of the population in institutions can be mobilized to evacuate within 20 minutes after the start of notification (Table 16). This element of the population is typically ambulatory patients in hospitals.

TABLE 16. TIME DISTRIBUTION FOR
"MOBILIZE POPULATION" STEP
FOR POPULATION IN INSTITUTIONS

| <u>Time After Receipt Of Notification</u> | <u>Estimated Percentage Of Population in Institutions Mobilized</u> |
|---|---|
| 10 minutes | 30 |
| 20 minutes | 40 |
| 30 minutes | 30 |

At the upper end of the range, it is estimated that 30 percent of the population in institutions requires up to 30 minutes for mobilization (Table 17). Typically, these

are non-ambulatory patients in hospitals, or other persons (such as prisoners in jails) for whom special treatment is necessary.

Evacuate Institutional Population in Buses or Special Vehicles

A fleet of buses and emergency vehicles (ambulances, rescue vehicles, vans, etc.) large enough to carry out the institutionalized population of the EPZ in a single round trip (buses) and two round trips (emergency vehicles) is assumed in estimating the evacuation times. The fleet of emergency vehicles will be drawn from operators in the EPZ and surrounding areas.

It is estimated that 50 percent of the ambulatory population in institutions can be evacuated by bus by 1 hour and 35 minutes after the start of notification. The remainder of the ambulatory population can be evacuated by 2 hours (Table 17).

It is estimated that 50 percent of the non-ambulatory population can be evacuated by emergency vehicle by 1 hour and 50 minutes after the start of notification. The remainder of the non-ambulatory population can be evacuated by 2 hours and 45 minutes (Table 17).

TABLE 17. TIME DISTRIBUTION FOR "EVACUATE INSTITUTIONAL POPULATION IN BUSES AND SPECIAL VEHICLES" STEP

| <u>Time After Start of Notification</u> | <u>Estimated Percent of Population in Institutions Evacuated in Buses and Special Vehicles</u> |
|---|--|
| Ambulatory Persons (by bus) | |
| 1 hour, 35 minutes | 50 |
| 2 hours | 100 |
| Non-Ambulatory Persons (by emergency vehicle) | |
| 1 hour, 50 minutes | 50 |
| 2 hours, 45 minutes | 100 |
| Total, Institutional Population | |
| 1 hour, 35 minutes | 50 |
| 2 hours, 45 minutes | 100 |

The estimated time required for the completion of the individual steps in the evacuation of the combined institutional population (both ambulatory and non-ambulatory) is summarized in Figure 18. The determining factor in the time needed to evacuate the institutional population group is the time needed to complete two round trips out of the EPZ by the special vehicle fleet, mainly ambulances.

A special vehicle (bus and ambulance) fleet large enough to evacuate the population in institutions in one and two trips, respectively, is critical to achieve the total evacuation time of 2 hours and 45 minutes for this population segment. If a sufficiently large bus and ambulance fleet could not be mobilized and additional trips out of the EPZ were needed (even by only a few of the vehicles), the total evacuation time for the population in institutions would increase by approximately 1 hour, to 3 hours and 45 minutes after the start of notification.

SUMMARY OF EVACUATION TIMES FOR NORMAL CONDITIONS

Table 18 summarizes the evacuation times for normal conditions. As indicated in this table the evacuation times vary according to the population segments considered. The maximum evacuation time for the entire EPZ, established by the time needed for the "Permanent Resident (Vehicle-Ownning)" segment of the population, is 4 hours.

EVACUATION TIMES UNDER SEVERE WEATHER CONDITIONS

Severe weather conditions for the Catawba Nuclear Power Station EPZ are defined as a severe winter storm, with accumulations of snow or ice on the roadways within the EPZ.

Severe weather conditions affect the evacuation process by reducing road capacities, due to slower vehicle speeds and a reduction in vehicular capacity at intersections. Typically, under adverse winter weather conditions, an intersection functions at only 60 percent of its normal capacity.¹

1. Due to increase in headway between vehicles.

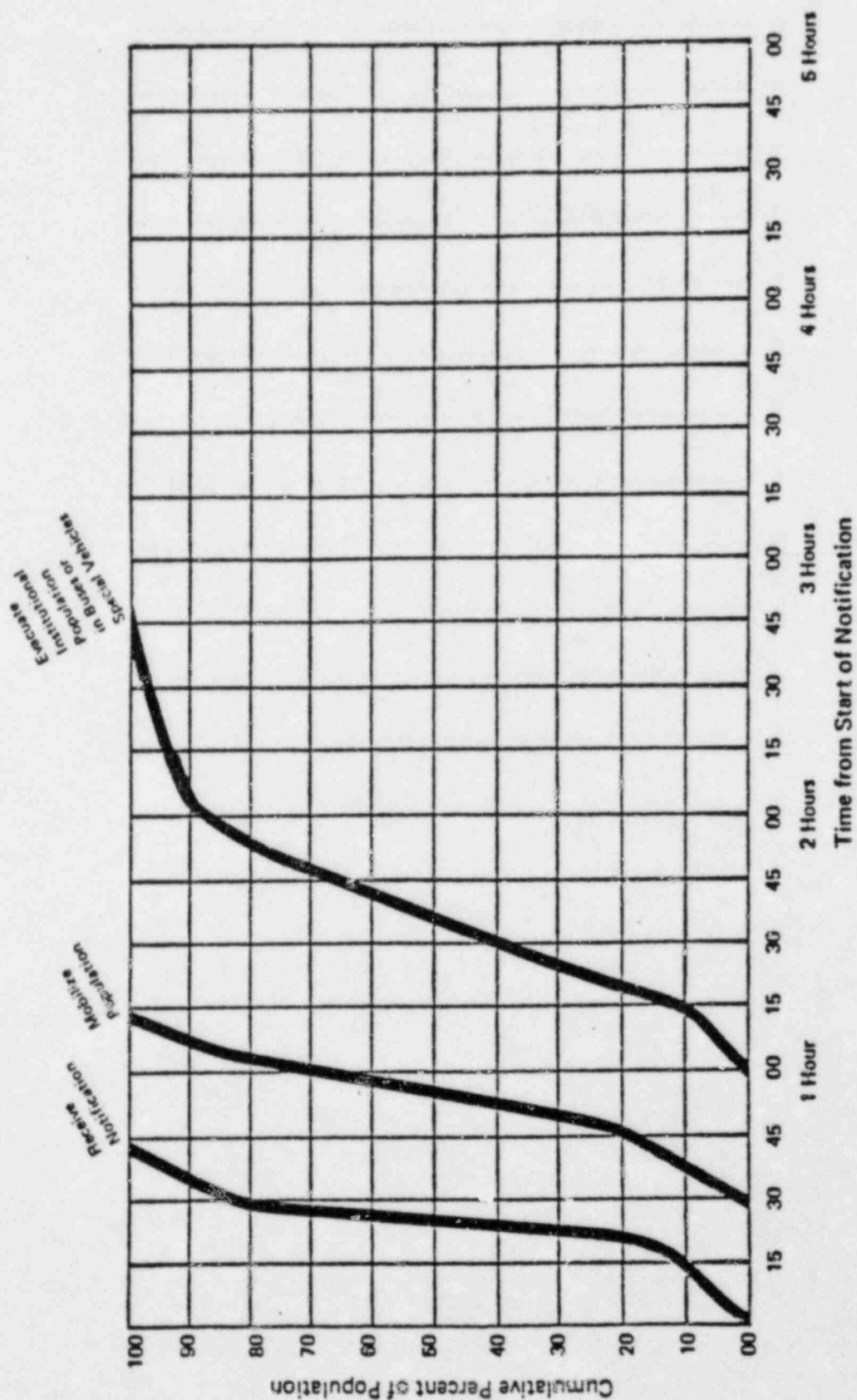


Figure 18. Evacuation Times for the Special Facility Population (Institutions)

TABLE 18. SUMMARY OF EVACUATION TIMES

| Permanent Population | Permanent Population Vehicles | Transient Population | Transient Population Vehicles | Evacuation Capacity per Hour (Major Routes) | Notification Time | Preparation Time | Permanent Population Response Normal Conditions | Permanent Population Response Adverse Conditions | Transient Population Response Normal Conditions | Transient Population Response Adverse Conditions | General Population Evacuation Time -- Normal Conditions | General Population Evacuation Time -- Adverse Conditions | Confirmation Time | Special Population Evacuation Time -- Normal Conditions | Special Population Evacuation Time -- Adverse Conditions |
|----------------------|-------------------------------|----------------------|-------------------------------|---|-------------------|------------------|---|--|---|--|---|--|-------------------|---|--|
|----------------------|-------------------------------|----------------------|-------------------------------|---|-------------------|------------------|---|--|---|--|---|--|-------------------|---|--|

| Zones | | Within Two Miles | | | | | | | | | | | | | |
|----------------|-----|------------------|-------|-------|-------|-----|-----|-----|-----|-----|-----|------|------|------|-----|
| North Carolina | 357 | 154 | 654 | 233 | 1,200 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| South Carolina | 363 | 156 | 5,552 | 1,982 | 2,400 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| All Zones | 720 | 310 | 6,206 | 2,215 | | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |

| Zones | | Within Five Miles | | | | | | | | | | | | | |
|-----------|--------|-------------------|--------|--------|-------|-----|-----|-----|-----|-----|-----|------|------|------|------|
| A-1 | 529 | 227 | 10,187 | 3,637 | 1,200 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| B-1 | 2,631 | 1,131 | 2,588 | 924 | 1,200 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 2:30 |
| C-1 | 6,161 | 2,649 | 16,827 | 6,007 | 1,200 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 2:30 |
| D-1 | 1,414 | 608 | 109 | 39 | 2,400 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| E-1 | 429 | 184 | 0 | 0 | 3,600 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| F-1 | 2,573 | 1,106 | 1,582 | 365 | 3,600 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 2:30 |
| All Zones | 13,737 | 5,905 | 31,293 | 11,172 | | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 2:30 |

| Zones | | Within Ten Miles | | | | | | | | | | | | | |
|-----------|--------|------------------|--------|--------|--------|-----|-----|-----|-----|-----|-----|------|------|------|------|
| A-2 | 4,838 | 2,080 | 4,073 | 1,454 | 4,800 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 4:15 |
| B-2 | 9,771 | 4,201 | 46,826 | 16,717 | 4,200 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 4:00 | 1:40 | 4:15 |
| C-2 | 44,964 | 19,335 | 0 | 0 | 11,400 | (1) | (2) | (3) | (3) | (4) | (4) | 4:00 | 6:15 | 1:40 | 4:15 |
| D-2 | 9,169 | 3,943 | 0 | 0 | 4,800 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 4:15 |
| E-2 | 4,957 | 2,132 | 0 | 0 | 4,800 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 4:15 |
| F-2 | 2,655 | 1,142 | 650 | 232 | 6,000 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | (5) |
| F-3 | 2,672 | 1,149 | 651 | 232 | 2,400 | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 2:30 |
| All Zones | 79,026 | 33,982 | 52,220 | 18,635 | | (1) | (2) | (3) | (3) | (4) | (4) | 3:25 | 3:25 | 1:40 | 4:15 |

1. See distribution in Table 7.
2. See distributions in Tables 8 and 9.
3. See distributions in Tables 10 and 11.
4. See distribution in Table 13.
5. No special facilities in these zones.

Reflecting this reduction in capacity in the EPZ road system results in the adverse condition time estimates as indicated in Table 18. As indicated in this table, the time for the evacuation of the entire EPZ becomes 6 hours and 15 minutes under adverse conditions.

SUMMARY OF TIMES FOR SELECTIVE EVACUATIONS

Table 18 shows the times needed for the selective evacuation of the subareas within the EPZ. In the evacuation of most of the subareas, traffic congestion is not a factor, and the evacuation time depends only on the rate at which the resident population prepares to leave home. Thus, for most of the subareas, the selective evacuation time is 3 hours and 25 minutes under normal conditions.

For some of the subareas, the evacuation time is determined by the extent of the traffic congestion present. The maximum evacuation time under normal conditions for any subarea is 4 hours for any group of subareas containing Zone C2.

VIII. CONFIRMATION OF EVACUATION

INTRODUCTION

"Confirmation" of evacuation measures the extent of compliance with the evacuation order. Confirmation is conducted by local preparedness agencies, beginning at about the time that evacuation is estimated to be substantially completed.

PLANNED APPROACH TO CONFIRMATION

Local plans for the confirmation process call for public safety agencies (fire and police departments), working at the direction of the Emergency Operations Centers (EOC's) of all counties within the EPZ, to assess the level of effectiveness of the evacuation.

In the initial stages of evacuation, the confirmation process is intended to establish if the public is comprehending the notification and is, therefore, beginning to react. Initial confirmation assessments will consist of reports from emergency workers, traffic control officers, observations of patrolling officers and aerial observations of traffic flows.

At later stages in the evacuation, the confirmation process will establish the rate at which the public is complying with evacuation orders. The results of the confirmation process at this stage will guide the EOC's in directing remedial measures, such as intensified notification, additional EBS bulletins or door-to-door patrolling. At later stages in the evacuation, EOC's may request that local response agencies perform some of the following specific confirmation activities.

- Observe outbound traffic flows and report on traffic volumes
- Count arrivals at reception centers and report on the results
- Secure detailed reports from traffic control officers and perimeter control officers

- Conduct limited door-to-door canvasses to determine extent of evacuation

TIME REQUIRED FOR CONFIRMATION

The time required for confirmation depends on the degree of assurance desired. For example, a survey of 100 percent of the EPZ population would assure a completely accurate measure of the success of the evacuation. On the other hand, such a survey would be lengthy and costly in terms of resources that would be needed for other resource activities occurring at that time. Partial surveys of the EPZ population (samples) can offer a sufficiently high degree of reliability without incurring the cost of a full survey of EPZ population.

At the 95-percent confidence level, an accuracy of ± 2 percent can be obtained with a survey of 900 households. This indicates that in a survey of 900 households, there is a 95 percent assurance that the estimated fraction of population evacuated is within 2 percent of the "true" fraction evacuated (as would be established with a 100 percent survey of all EPZ households).

The time required for a "door-to-door" canvass yielding the accuracy described above is 1 hour, 40 minutes. The time is based on participation by 30 public safety personnel (fire or police) canvassing 30 households over a period of 1 hour, 40 minute. It is assumed that, in most instances, this canvassing would be performed in conjunction with other planned emergency response activities (for example, security patrolling of evacuated areas, patrolling for persons without transportation, etc.).

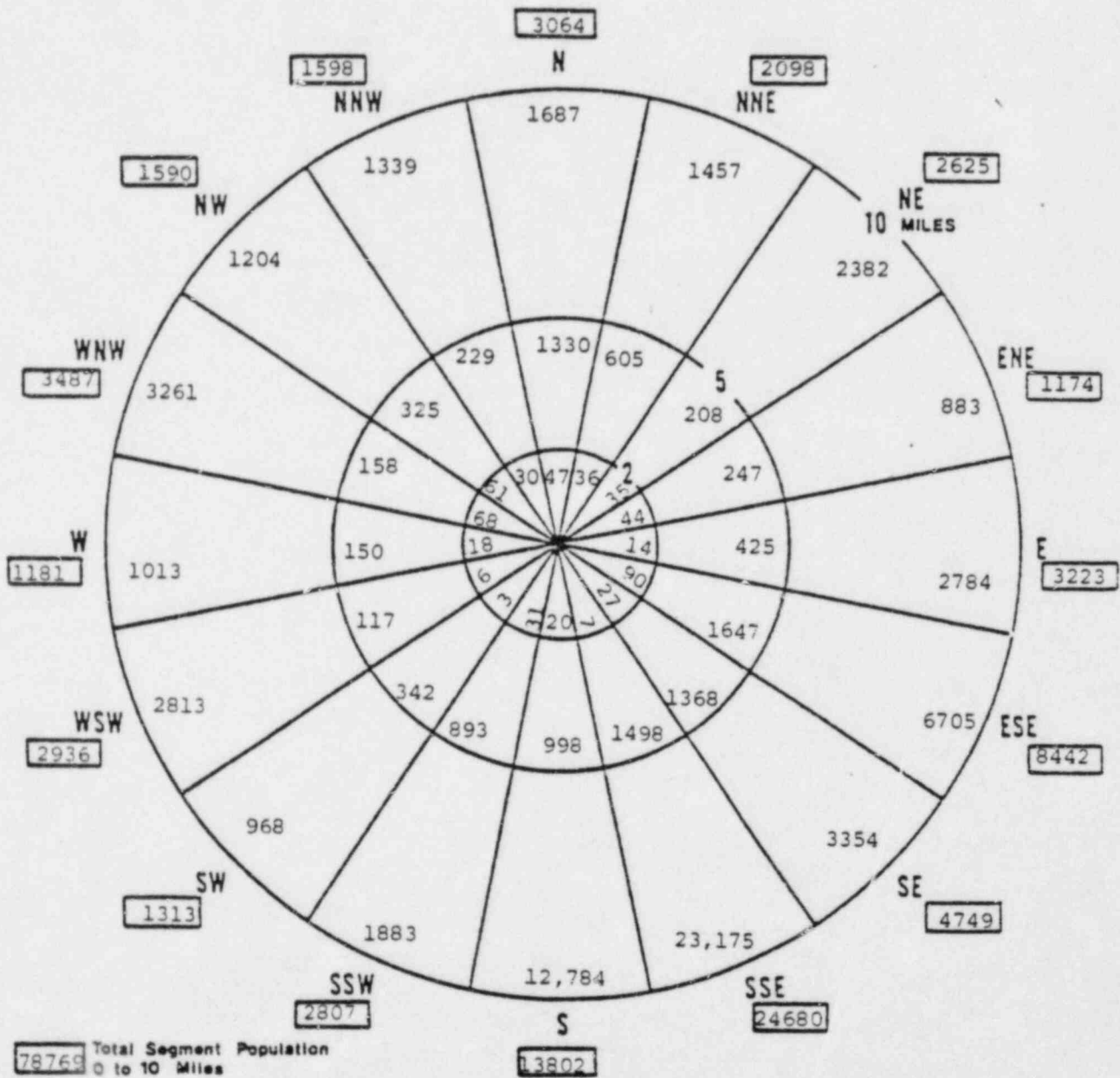
APPENDIX A
POPULATION BY 22.5 DEGREE SECTORS

INTRODUCTION

This appendix includes the following distributions, arranged into 22.5 degree sectors and within 2, 5 and 10 miles of the Catawba Nuclear Station:

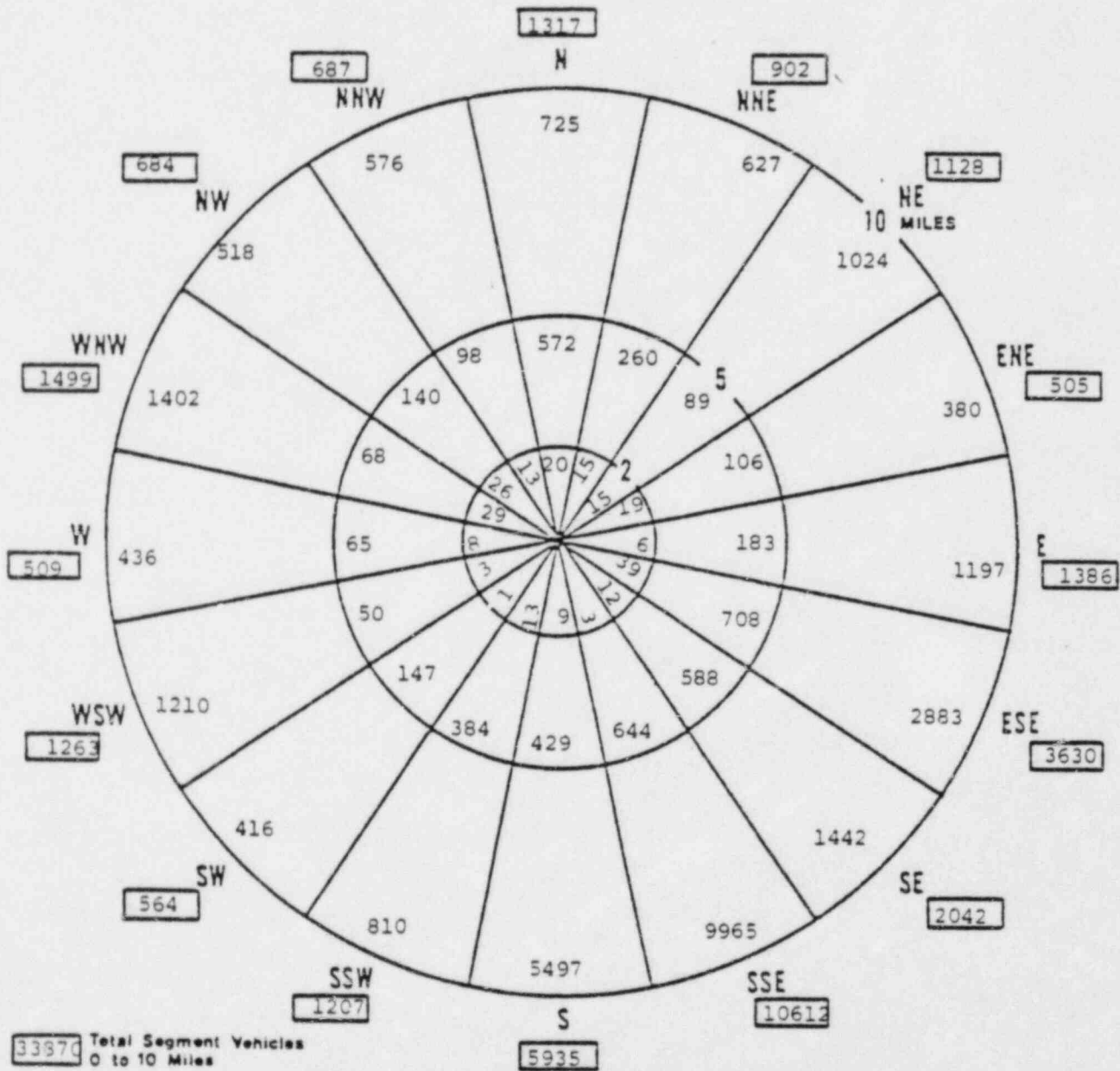
1. Permanent population
2. Estimated evacuation vehicles of the permanent population
3. Estimated transient population
4. Estimated evacuation vehicles of the transient population

Exhibit A-1. Permanent Population by Sector



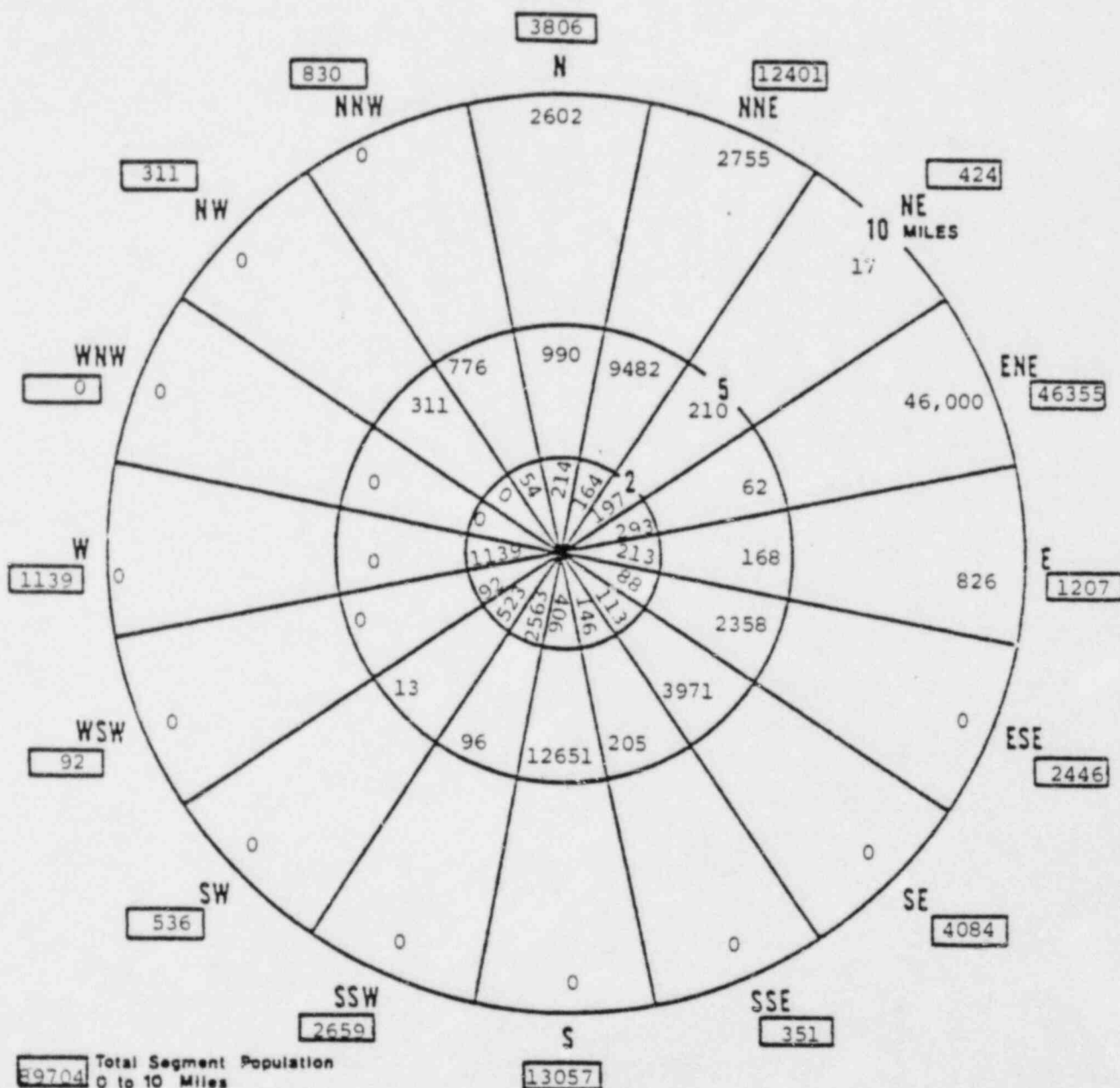
| POPULATION TOTALS | | | |
|-------------------|--------------------|-------------|--------------------------|
| RING, MILES | RING POPULATION | TOTAL MILES | CUMULATIVE POPULATION |
| 0-2 | 537 | 0-2 | 537 |
| 2-5 | 10,540 | 0-5 | 11,077 |
| 5-10 | 67,692 | 0-10 | 78,769 |

Exhibit A-2. Estimated Evacuation Vehicles
of Permanent Population



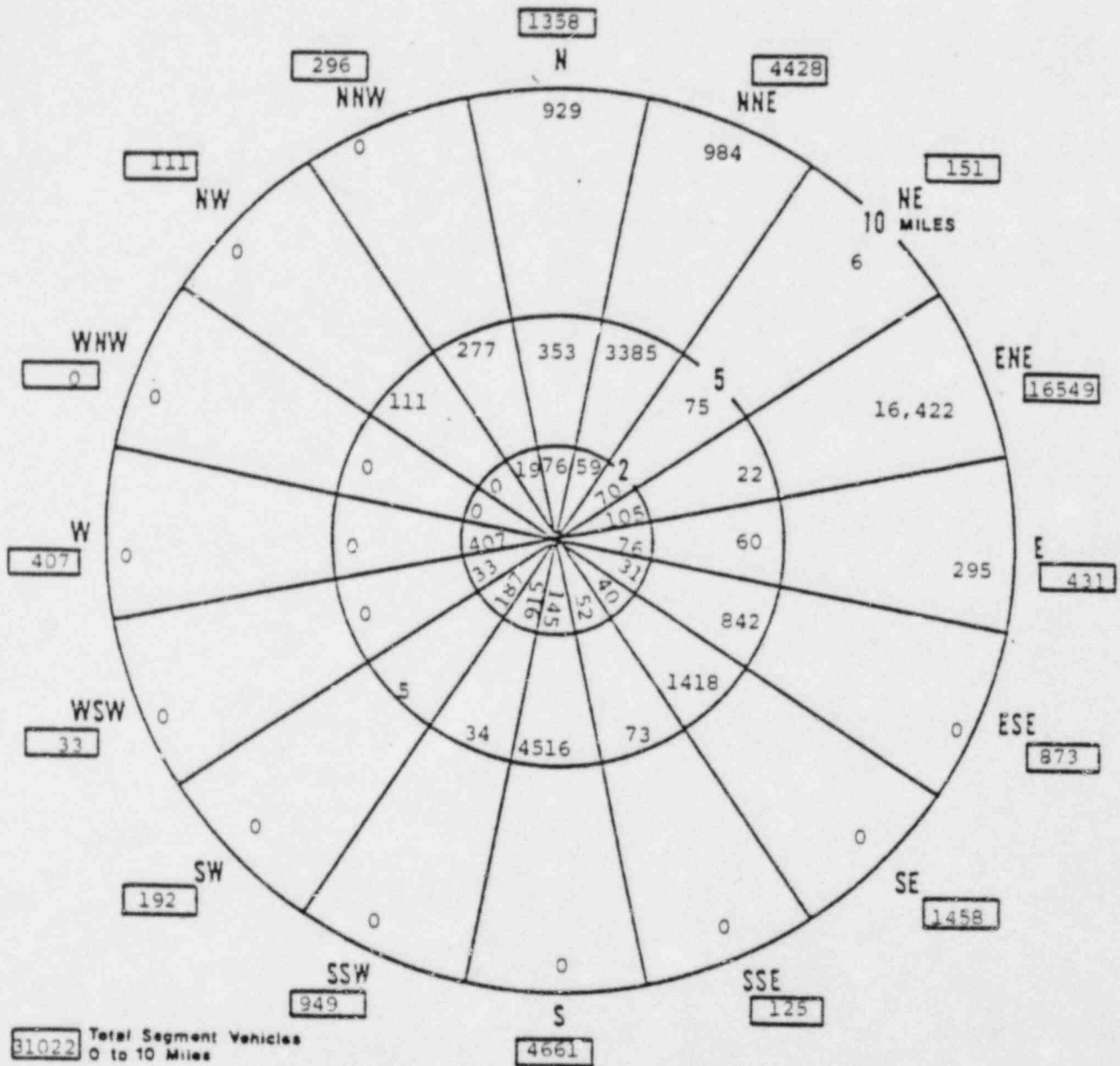
| VEHICLES TOTALS | | | |
|-----------------|---------------|-------------|---------------------|
| RING MILES | RING VEHICLES | TOTAL MILES | CUMULATIVE VEHICLES |
| 0-2 | 231 | 0-2 | 231 |
| 2-5 | 4,531 | 0-5 | 4,762 |
| 5-10 | 29,108 | 0-10 | 33,870 |

Exhibit A-3. Estimated Maximum Transient Population



| POPULATION TOTALS | | | |
|-------------------|-----------------|-------------|-----------------------|
| RING, MILES | RING POPULATION | TOTAL MILES | CUMULATIVE POPULATION |
| 0-2 | 6,206 | 0-2 | 6,206 |
| 2-5 | 31,298 | 0-5 | 37,504 |
| 5-10 | 52,200 | 0-10 | 89,704 |

Exhibit A-4. Estimated Evacuation Vehicles
of the Maximum Transient Population



| VEHICLES TOTALS | | | |
|-----------------|---------------|-------------|---------------------|
| RING MILES | RING VEHICLES | TOTAL MILES | CUMULATIVE VEHICLES |
| 0-2 | 2,215 | 0-2 | 2,215 |
| 2-5 | 11,171 | 0-5 | 12,386 |
| 5-10 | 18,636 | 0-10 | 31,022 |

APPENDIX B
DERIVATION OF NON-VEHICLE-OWNING POPULATION AND
NUMBER OF CARS USED FOR EVACUATION

The number of non-vehicle-owning households in the Catawba EPZ is derived on the basis of the three-county vehicle ownership pattern as obtained from the 1980 census.

VEHICLE OWNERSHIP IN 1980

The vehicle ownership pattern for Gaston, Mecklenburg, and York Counties, as derived from the 1980 census, is shown below:

| Vehicles Owned by Households | Percentage of Households | | | Weighted Average for EPZ |
|------------------------------------|--------------------------|-----------------------|-------------|--------------------------------|
| | Gaston County | Mecklenburg County | York County | |
| 0 | 10 | 10 | 10 | 10 |
| 1 | 32 | 34 | 30 | 30 |
| 2 | 38 | 38 | 40 | 40 |
| 3 or more | 20 | 18 | 20 | 20 |

As indicated in the above table, 10 percent of the households in the three-county area do not own a vehicle.

On the basis of the postulated household vehicle usage, the average number of vehicles per household used for evacuation is 1.30. On average, this represents a vehicle occupancy of 2.33 persons per vehicle.

APPENDIX C
DESCRIPTION OF EVACPLAN MODELS USED
IN THE ANALYSIS OF EVACUATION TIMES

The PRC EVACPLAN package used for the analysis of evacuation times consists of two modules:

1. EVACURVE module, which establishes the rate at which the population of the risk area completes preparations to evacuate and enters (or attempts to enter) the relocation road network.
2. QUEUE module, which simulates the flow of traffic out of the EPZ, portrays the impact of traffic control measures employed, and identifies the location, extent and severity of any traffic congestion that occurs during the relocation process. The QUEUE module computes the total time needed for evacuation, on a route-by-route basis.

These modules incorporate features particularly important in the analysis of evacuation times:

1. Dynamic — The EVACPLAN program recognizes that the entire process changes continuously as evacuation proceeds. For example, the rate of discharge of vehicles onto the roadway is neither a single event nor a steady rate, but rather is a distribution that varies with the elapsed time after the start of evacuation.

In a similar manner, traffic congestion does not occur in a regular manner throughout the area and throughout the entire evacuation process, but rather it appears at different locations and for different durations at these locations. Also, the severity of traffic congestion varies sharply from location to location, even within a single evacuation route.

2. Behavior-based — The EVACPLAN program recognizes that the population of the risk area will not evacuate as a single body, with the entire population completing one step of the process (for example, the population will proceed at its own pace, with different portions of the population at various stages of the evacuation sequence at any given time.
3. Probabilistic — The EVACPLAN program recognizes that the time distributions for completing each of the various relocation steps are, in the statistical sense, conditional probability distributions, contingent on completion of the previous steps. Total departure times—that is, the times needed for the entire preparation process—are

derived by computing the joint probability distribution from the individual time distributions for each step.

4. Sensitive to control measures — The EVACPLAN model can reflect the full range of measures that might be employed to improve the evacuation traffic flow. This range includes actions to regulate the flow of traffic onto the road system (demand measures), actions to increase the available road capacity for relocation flows (supply measures), and actions to improve the capacity of the available roads (traffic control measures).

THE EVACURVE MODULE

The EVACURVE module calculates the "departure curve" for the EPZ population; that is, the distribution of time needed for the EPZ population to complete preparations to evacuate. The departure curve, therefore, also defines the rate at which the EPZ population enters (or attempts to enter) the evacuation route system.

The EVACURVE module calculates the departure curve from a series of time distributions needed to complete each step of the evacuation sequence. Statistically, the time distribution for each individual step is conditional probability distribution; the final departure curve is calculated by computing the joint probability distribution of all the component steps.

Inputs to the EVACURVE Module

The series of action steps which comprise the evacuation sequence is identified. The time distribution required to complete each individual step of the evacuation sequence will be established. Methods for establishing these distributions will be based on local preparedness plans, projections of shut-down times by employers and institutions (such as schools), driving time to return home and distribution of time needed for securing households as derived from evacuation studies for nuclear power plants and natural disasters.

The time distributions for each step are characteristically in the "S-curve" form. This reflects the behavioral realities of the risk area population; that is, some of the population will complete a particular step rapidly (the low "tail" of the curve),

most of the population will complete the step in times which cluster around the center of the distribution (the steep central portion of the curve), and a small part of the population will require a very long time for the step (the "tail" at the high end of the distribution).

Computation Procedure for the EVACURVE Module

The EVACURVE module summarizes the input time distributions for the individual action steps of the evacuation sequence (Exhibit C-1).

The final departure curve is displayed in graphical and tabular form (Exhibits C-2 and C-3).

THE QUEUE MODULE

The QUEUE module begins with the evacuation road network (that is, the system of roads available for evacuation) the distribution of population onto this network. The QUEUE module then simulates the traffic flow through the evacuation road network. This simulation is iterative; that is, it is repeated for small increments of time. Consequently, the status of traffic congestion is calculated at each time interval, and the dynamic aspects of traffic flow and congestion can be traced.

Inputs to the QUEUE Module

Inputs to the QUEUE program are:

1. Road network used for evacuation. This includes the major evacuation routes, branches to these routes (evacuation subroutes), and points at which the population enters the evacuation route system (loading points).
2. Departure curve for the risk area population, which gives the rate at which the population enters the road system. The departure curve is the direct output of the EVACURVE module as described above.
3. Traffic flow parameters to reflect the capacity of the roads in the relocation network.

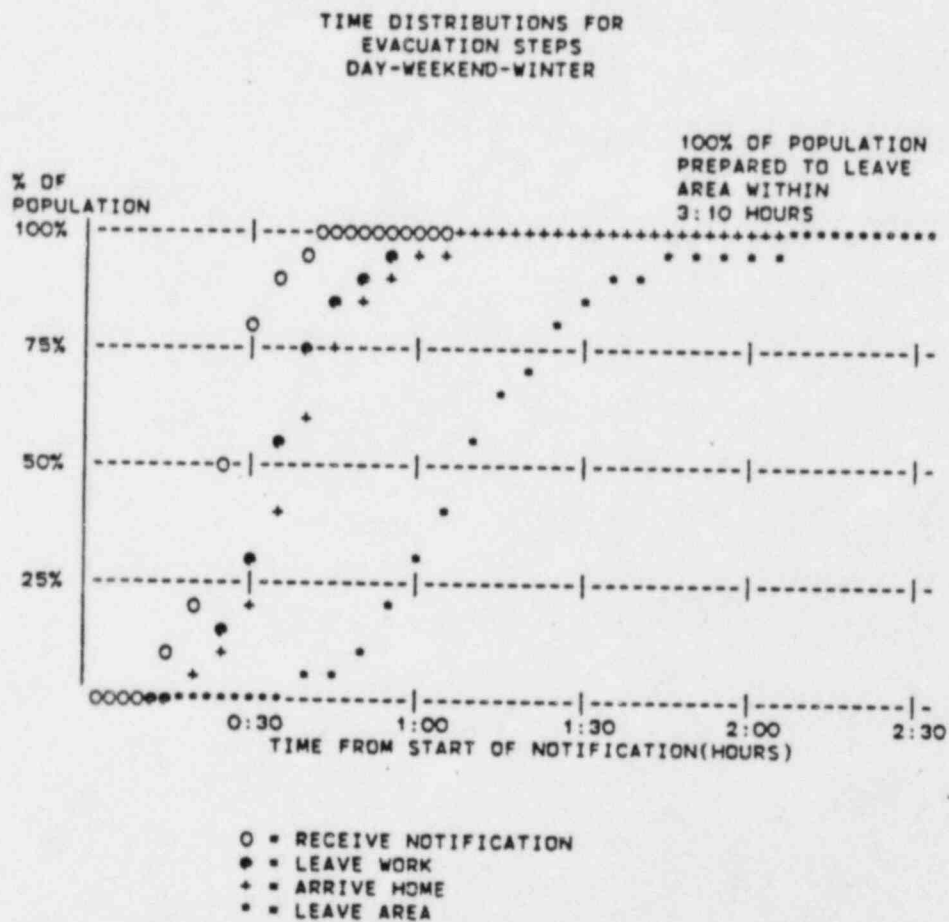
Exhibit C-1. Example of Input Time Distributions for Evacurve
Module of PRC Evacplan Program

----- INPUT DISTRIBUTIONS -----
DAY-WEEKEND-WINTER
(VALUES IN PERCENT POPULATION)

| TIME FROM START OF NOTIFICATION | RECEIVE MESSAGE | TIME FROM RECEIPT OF INFORMATION | LEAVE WORK |
|------------------------------------|--------------------|-------------------------------------|---------------------|
| 0: 5 | 0.0 | 0: 5 | 0.0 |
| 0:10 | 0.0 | 0:10 | 50.00 |
| 0:15 | 10.00 | 0:15 | 30.00 |
| 0:20 | 10.00 | 0:20 | 10.00 |
| 0:25 | 30.00 | 0:25 | 0.0 |
| 0:30 | 30.00 | 0:30 | 5.00 |
| 0:35 | 10.00 | 0:35 | 0.0 |
| 0:40 | 5.00 | 0:40 | 0.0 |
| 0:45 | 5.00 | 0:45 | 5.00 |
| 0:50 | 0.0 | 0:50 | 0.0 |
| 0:55 | 0.0 | 0:55 | 0.0 |
| 1: 0 | 0.0 | 1: 0 | 0.0 |
| 1: 5 | 0.0 | 1: 5 | 0.0 |
| 1:10 | 0.0 | 1:10 | 0.0 |
| 1:15 | 0.0 | 1:15 | 0.0 |
| 1:20 | 0.0 | 1:20 | 0.0 |
| 1:25 | 0.0 | 1:25 | 0.0 |
| 1:30 | 0.0 | 1:30 | 0.0 |
| 1:35 | 0.0 | 1:35 | 0.0 |
| 1:40 | 0.0 | 1:40 | 0.0 |
| 1:45 | 0.0 | 1:45 | 0.0 |
| 1:50 | 0.0 | 1:50 | 0.0 |
| TIME AFTER LEAVING WORK | TRAVEL HOME | TIME AFTER ARRIVAL HOME | PREPARE EVACUATE |
| 0: 5 | 50.00 | 0: 5 | 0.0 |
| 0:10 | 30.00 | 0:10 | 0.0 |
| 0:15 | 10.00 | 0:15 | 10.00 |
| 0:20 | 10.00 | 0:20 | 5.00 |
| 0:25 | 0.0 | 0:25 | 10.00 |
| 0:30 | 0.0 | 0:30 | 15.00 |
| 0:35 | 0.0 | 0:35 | 15.00 |
| 0:40 | 0.0 | 0:40 | 25.00 |
| 0:45 | 0.0 | 0:45 | 0.0 |
| 0:50 | 0.0 | 0:50 | 10.00 |
| 0:55 | 0.0 | 0:55 | 0.0 |
| 1: 0 | 0.0 | 1: 0 | 5.00 |
| 1: 5 | 0.0 | 1: 5 | 0.0 |
| 1:10 | 0.0 | 1:10 | 0.0 |
| 1:15 | 0.0 | 1:15 | 0.0 |
| 1:20 | 0.0 | 1:20 | 0.0 |
| 1:25 | 0.0 | 1:25 | 0.0 |
| 1:30 | 0.0 | 1:30 | 0.0 |
| 1:35 | 0.0 | 1:35 | 5.00 |
| 1:40 | 0.0 | 1:40 | 0.0 |
| 1:45 | 0.0 | 1:45 | 0.0 |
| 1:50 | 0.0 | 1:50 | 0.0 |

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Exhibit C-2. Example of Plotted Distribution of Final Departure Curve
from Evacurve Module of PRC Evacplan Program



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Exhibit C-3. Example of Final Departure Curve (Tabular Form)
from Evacurve Module of PRC Evacplan Program

FINAL EVACUATION DISTRIBUTION
DAY-WEEKEND-WINTER
(VALUES IN PERCENT)

| TIME | MINUTES | | | | | |
|------|---------|-------|-------|------|------|------|
| | 5 | 10 | 15 | 20 | 25 | 30 |
| 0: 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.25 |
| 0:30 | 0.67 | 1.76 | 3.49 | 5.31 | 7.62 | 9.78 |
| 1: 0 | 11.70 | 12.09 | 10.83 | 8.95 | 7.02 | 5.23 |
| 1:30 | 3.67 | 2.52 | 1.66 | 1.14 | 0.89 | 0.99 |
| 2: 0 | 1.18 | 1.06 | 0.76 | 0.54 | 0.34 | 0.18 |
| 2:30 | 0.12 | 0.10 | 0.05 | 0.03 | 0.02 | 0.01 |
| 3: 0 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3:30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4: 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4:30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5: 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5:30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6: 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6:30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7: 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

NOTE: TIME IS IN HOURS AND MINUTES AFTER
START OF NOTIFICATION. A POINT ON THE
DISTRIBUTION IS FOUND BY ADDING THE
COLUMN "MINUTES" TO THE ROW "TIME".

The evacuation route network within the EPZ is coded into a form needed for entry into the QUEUE program. This coding process consists of:

1. Designating the major evacuation routes. The number of such routes depends on the specific corridor being considered; typically, there are two to five major evacuation routes in any given corridor.
2. Designating the subroutes; that is, the roads that feed traffic onto the major evacuation routes. The number of subroutes also depends on the specific corridor being considered; typically, there are two to four subroutes for each major relocation route.
3. Establishing the loading points, locations at which relocation traffic is assumed to be generated and at which it enters the relocation road system. Loading points are an abstraction of the actual road system, representing concentrations of households, workplaces, etc. Typically, a total of 10 to 15 loading points is established for each of the major evacuation routes.

Computation Procedure for the QUEUE Module

The QUEUE program calculates, for each time interval, the arrival and departure of traffic at all locations throughout the evacuation road system. Arrival rates of traffic are determined by:

1. The output of the EVACURVE module, which establishes for all evacuation routes the rate at which traffic enters (or attempts to enter) the evacuation road system, and
2. The loading of traffic onto the individual evacuation routes. This loading is made on the basis of population concentrations and special activity centers.

The rate of discharge of traffic through intersections is determined by:

1. The available lanes of roadway
2. The traffic flow rate, typically 1,200 vehicles per hour on each departure lane for surface roads, and 1,800 per lane on freeways. Traffic flow rates can be adjusted to reflect adverse conditions or other obstacles to free traffic flow.

Traffic queues at any given location are discharged at a rate proportional to their magnitude; i.e., the longer a queue the greater its priority at the intersection

where the queue originates. This algorithm simulates the traffic control that would be achieved by a competent traffic control officer on duty at such locations.

The QUEUE program identifies locations at which congestion occurs and calculates the extent of such congestion. Measures which are computed include the length (time) of the period over which congestion persists at particular locations, the maximum delay experienced by a vehicle passing through any congested location, and the extent (distance) of congestion on the relocation road network.

Outputs of the QUEUE Module

A summary of all evacuation routes is prepared (Exhibit C-4).

For each evacuation route, a summary status report is prepared (Exhibit C-5).

A detailed tabular report of each congested location at which congestion occurs is prepared (Exhibit C-6).

Exhibit C-4. Example of Summary of Evacuation Times by Route,
from Queue Module of PRC Evacplan Program

EVACUATION ROUTE SUMMARY

| ROUTE | POPULATION | VEHICLES | TIME TO EVACUATE (HOURS) |
|-------------|------------|----------|--------------------------------|
| SC 183 WEST | 5174 | 2224 | 3:25 |
| SC 11 SOUTH | 6222 | 2675 | 3:30 |
| US 123 WEST | 2506 | 1077 | 3:25 |
| SEC RTE 63 | 2340 | 1006 | 3:25 |
| SC 59 | 7021 | 3019 | 3:45 |
| SEC RTE 21 | 3900 | 1676 | 3:25 |
| US 76 SOUTH | 10880 | 4678 | 3:25 |
| US 123 EAST | 7541 | 3242 | 3:25 |
| SC 93 | 4514 | 1941 | 3:25 |
| SC 183 EAST | 2663 | 1145 | 3:25 |

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Exhibit C-6. Example of Tabular Report for Specific Congested Location,
from Queue Module PRC Evacplan Program

INTERSECTION: SC 11 & SEC RTE 198
ROUTE: SC 11 SOUTH
TIME PERIOD: 6

| LEG | ARRIVALS (VEH) | DEPART (VEH) | QUEUE (VEH) | QUEUE LENGTH (MILES) |
|-------|-------------------|-----------------|----------------|-------------------------|
| 1 | 205 | | 65 | 0.3 |
| 2 | 51 | | 18 | 0.1 |
| 3 | | 300 | | |
| 4 | 0 | | 0 | 0.0 |
| TOTAL | 256. | 300 | 83 | 0.4 |

TOTAL ARRIVALS: 256. VEHICLES
TOTAL BACKLOG: 39. VEHICLES

NOTE: LEG 1=MAIN APPROACH LEG
LEGS 2,4=SIDE APPROACH LEGS
LEG 3=EXIT LEG

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