Evacuation Time Estimates

H. B. Robinson Steam Electric Plant, Unit 2

Prepared by

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1.0 INTRODUCTION

1.1 Applicable Regulations and Regulatory Guidance

The NRC's regulations relative to emergency planning for fixed nuclear facilities are found in 10CFR Part 50, specifically in the following sections: 10CFR50.47, 10CFR50.54, and 10CFR Appendix E. These regulations require in part that emergency plans include discussion of the protective actions that can be taken on behalf of the general population in the area surrounding a fixed nuclear facility.

Following issuance of the NRC's draft proposed rule on emergency planning in December, 1979, the NRC and FEMA issued NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," January, 1980. Item II.J.10 of this document recommended that emergency plans identify the distribution of the population around the nuclear facility (Item II.J.10.b), the projected traffic capacity of evacuation routes (Item II.J.10.i), and the time estimates for evacuation of various sectors in the plume exposure pathway emergency planning zone (EPZ) (Item II.J.10.1). Appendix 4 to this version of NUREG-0654 reiterated an earlier request by the NRC staff for evacuation times. The January, 1980, version of NUREG-0654 was issued for trial use and comment. When NUREG-0654 was reissued in November, 1980, (Revision 1), the items mentioned above remained essentially unchanged; and Appendix 4 to NUREG-0654 was supplemented to provide more definitive guidance on presenting evacuation time estimates.

1.2 Scope of Work

This report has been prepared by Carolina Power & Light Company and its consultant, NUTECH. This report presents the results of a study of the evacuation of the plume exposure pathway emergency planning zone (EPZ) for the H. B. Robinson Steam Electric Plant, Unit No. 2, using the evacuation routes identified by the South Carolina Emergency Preparedness Division. This report provides the information requested by items II.J.10.b, II.J.10.i, and II.J.10.1 of NUREG-0654. The format of this report follows the format suggested in NUREG-0654, Revision 1, Appendix 4. The following sections of this report provide:

- A general description of the H. B. Robinson plume exposure emergency planning zone (EPZ) (Section 2.0).
- Estimate of the population at risk in the EPZ and the basis for these estimates (Section 3.0).
- Estimates of the traffic capacity of the evacuation routes identified by the South Carolina Emergency Preparedness Division (Section 4.0).
- The methods used to estimate the evacuation time and the resulting evacuation times (Section 5.0).
- The estimated resources required to support the evacuation process and the time to confirm that zones have been evacuated (Section 6.0).

2.0 GENERAL SITE DESCRIPTION

The H. B. Robinson site is located in the north-central section of the state of South Carolina. It is located in the western corner of Darlington County on the southeast shore of Lake Robinson about 4.5 miles west-northwest of Hartsville, South Carolina. The North Carolina border is 28 miles north of the site, and the Atlantic Ocean is about 88 miles to the southeast.

There are four counties within a ten-mile radial distance from the reactor site: Darlington, Lee, Chesterfield, and Kershaw Counties. For the purpose of emergency planning, the plume exposure emergency planning zone (EPZ), which roughly defines a ten-mile circle around the site, has been designated by the South Carolina Emergency Preparedness Division. The EPZ includes portions of Lee, Darlington, and Chesterfield Counties only.

The South Carolina Emergency Preparedness Division has excluded Kershaw County from the EPZ because (1) Kershaw County occupies less than five percent of the area within ten miles of the Robinson facility, (2) the population in this portion of Kershaw County is low, (3) Kershaw County is due west of the facility, whereas the predominant wind directions are north and north-northeast, (4) the distance between Kershaw County and the Robinson facility is significant.

The South Carolina Emergency Preparedness Division has subdivided the EPZ into 13 subzones for planning purposes. Figure 2.0 illustrates

the locations of the facility, the subzones, and the counties within ten miles of the facility.

The general topography of the EPZ includes rolling farmland to the south of the site in Lee County and hills to the north in Chesterfield County. A large state forest, the Sandhills State Forest, is located to the north in Chesterfield County. Lake Robinson, which borders the reactor site, extends approximately eight miles in a northerly direction from the site. The width of the lake is about a mile in most sections and thins down toward the northern end.

The distribution of population within the EPZ includes a large concentration of people in the town of Hartsville and to the east of Hartsville. The other concentration of population is in the town of McBee, eight miles to the northwest of the reactor site. The total resident population within the EPZ is approximately 30,800. About 90 percent of the total resident population in the EPZ (27,720) reside in the Hartsville area. There is no significant transient population to consider for this site in evaluating alert and notification capability.

The hills to the north of the site, the population using Lake Robinson for recreational purposes, and the relatively large population density in the Hartsville area are the only site-specific features that require special attention in considering alert systems.

Figure 2.0 is located at
the end of this report

3.0 POPULATION AT RISK

The population at risk is subdivided into three general categories: resident population, transient population, and special facility population. The first category is the resident population as determined by the Census Bureau; this category is discussed in Section 3.1. The second category includes the population for the major industrial facilities and the recreational/tourist use of areas within the EPZ; this category is discussed in Section 3.2. The third category is the population that may be at schools, hospitals, and nursing homes; this category is discussed in Section 3.3. The information on the last two categories was determined by field surveys and contacts with local officials.

The method used to translate the population at risk into a demand on-the-road network is discussed in Section 3.4.

3.1 Permanent Resident Population

The information that was used to calculate the permanent resident population within the plume exposure pathway emergency planning zone (EPZ) for the Robinson facility were the preliminary 1980 census figures for Chesterfield, Darlington, and Lee Counties, the 1980 enumeration district maps for these counties and the CP&L emergency response map for the Robinson facility. This latter map was a composite of individual county highway maps which included the locations of specific residences. The preliminary 1980 census data

used was taken from Census Bureau printouts dated July, 1980, that were provided to county officials. In December, 1980, a revised set of preliminary census data was prepared by the Census Bureau. Comparison of the December and July census data for Chesterfield, Darlington, and Lee Counties is shown in Table 3.1.

The calculations for the distribution of the population and the evacuation times were performed without the consideration of this recent adjustment made by local officials.

The first step in calculating the permanent population was to determine the resident population for each of the 160 area segments within ten miles of the Robinson facility. This was performed in the following manner: for rural areas of low population density, the Census Bureau's enumeration district boundaries, as shown on the 1980 enumeration district maps, were transferred onto the emergency response map. The number of houses on the map for each enumeration district were counted and compared with the number of residences listed for each enumeration district in the preliminary census data. The numerical relationship between "houses shown" on county maps and "houses listed" in census data was determined. On average, 18 percent of the houses in an enumeration district were not shown. Next, a diagram of the area segments was superimposed on the Robinson emergency response map. The actual population for each of the area segments was determined by counting the number of houses appearing in each area segment and correcting each total for the houses "not shown."

The population in each area segment was determined by multiplying the adjusted number of houses by the average population per household (3.2 persons per household, according to the Census Bureau)* for the area within the EPZ.

In summary, the method used for calculation of population per subdivision in the ten-mile EPZ is as follows:

Houses counted x 1.18 x 3.2 = population per area segment,

where: 1.18 = factor determined to relate actual houses present to houses shown on the county highway maps and 3.2 = average population per household within the EPZ from 1980 census data.

Within incorporated towns or in areas where houses were not indicated, the population within an area segement was determined by calculating the portion of the area of each enumeration district falling within the area segment. The population within each enumeration district was assumed to be evenly distributed throughout the area unless land use maps, road maps, or visual observations provided more accurate information on population distribution. The resident population distribution within the EPZ for the Robinson facility is shown in Table 3.2. Summary totals are presented in Figure 3.1.

*The State of South Carolina uses 2.8 persons per household. Since this results in less persons which need to be evacuated, the Census Bureau value of 3.2 persons per household was used for conservatism.

Permanent population figures were also generated for each of the 13 planning zones used by the South Carolina Emergency Preparedness Division. The populations previously calculated for all area segments located within a particular planning zone were totaled. In the cases where an area segment fell into more than one planning zone, the fraction of the area of the segment was used to divide the area's population. In some instances, more accurate information was available on the population concentration within a specific area segment; in such a case, fractional population estimates were based on that information rather than on an area ratio. The permanent population distribution for each of the emergency planning zones within the Robinson EPZ is shown in Table 3.3. Zones designated are as presented in Figure 2.0.

3.2 Transient Population

3.2.1 Industrial Labor Force

The industrial labor force in the EPZ consists primarily of four components: the Hartsville area employees, West Hartsville employees, employees at the Robinson facility, and McBee area employees. The breakdown by shift of the industrial labor force in the four major employment areas is shown in Table 3.4.

Table 3.5 represents the distribution of the industrial labor force within the ten-mile EPZ. As can be seen from Tables 3.4 and 3.5, the largest segment of the industrial labor force is working during

the period of 7 a.m. to 5 p.m., in or near Hartsville. During second and third shifts, this work force diminishes to less than one-fourth of the daytime industrial labor force but is still located in the same sub-area.

The industrial labor force represents only a fraction of the total work force in the EPZ; the total work force in the EPZ is approximately 15,000 (75 percent of the population above age 18). The location and size of the industrial facilities are significant because: (1) industrial facilities produce population densities that are much higher than the surrounding area, (2) industrial facilities bring additional population from outside the EPZ into the EPZ, and (3) the number of occupants per vehicle leaving an industrial facility may be much less than the number of occupants per vehicle for the general population, namely, 1.5 per vehicle as opposed to three per vehicle.

3.2.2 Seasonal Population Variations

Within the EPZ, there are no major seasonal population variations. Table 3.6 summarizes lake and state forest recreational usage during summer months.

During the summer months (June through September), the Lake Robinson area is used by the general population for boating, picnicking, and other recreational activities. Based upon our field investigation and interviews with a local official, the summer weekend peak transient population is approximately 300-500 people. This figure would

include people who are boating on Lake Robinson, as well as those using shore facilities. Also during the summer months, Prestwood Lake, located on the north side of Hartsville, is utilized by local residents for boating and recreation. Prestwood Lake is a comparatively small body of water, and it is estimated that 25-50 people would be using the area during a peak summer weekend day.

The major tourist attractions and activities in the general surrounding area are Southern 500 Race at Darlington Raceway and the Cotton Festival in Bishopville. These are activities which occur only once per year and do not significantly affect the population within the EPZ.

Portions of the Sandhill State Forest and the Sandhill Wildlife Refuge fall within the EPZ. In both cases, about ten percent of the land areas are within the EPZ.

The primary users of the Sandhill State Forest are hunters, fishermen, hikers, and picnickers. Discussions with State Forest personnel disclosed that the use of Sandhill State Forest is normally very low. The peak during summer weekends is about 150 people; most of these people are at Sugarloaf Mountain, which is 14 miles from the Robinson facility. The population from this source is estimated to be 15 based upon a conservative assumption of uniform distribution (.10 x 150).

Estimates of the number of deer hunters in the three counties were made during an average number of kills per hunting trip. The average was 0.03 kills per trip. This average was provided by the North Carolina Department of Fisheries and Wildlife; the equivalent department in South Carolina did not have a similar statistic. The number of hunters in Table 3.6 was calculated by combining the following considerations:

- The average kills per trip
- The number of kills for a county
- The fractional area of a county in the EPZ
- An uncertainty factor of 2 and dividing by the number of weeks in the hunting season and the number of days per week hunters would be out (2).

The total number of hunters was distributed across the planning zones with the exception of the center zone and B1.

3.3 Special Population

Special populations include schools, hospitals, and nursing homes.

3.3.1 Schools

It is estimated that within the EPZ during the school year, there are 7,890 students in attendance at the various public schools,

private schools, church-affiliated kindergartens, Coker College, and schools for the handicapped. The location of the school population is presented in Table 3.7. The school population for each school is presented in Table 3.8.

3.3.2 Hospitals and Nursing Homes

Within the EPZ, there is one hospital, one nursing home, and one center for handicapped children (See Table 3.9). Byerly Hospital has 116 beds and is located in the sector that is four to five miles east-southeast of the Robinson Plant. A study prepared by the Research Triangle Institute concluded that an average ten percent of a hospital's patients cannot be moved. For this purpose of estimating evacuation times, it was assumed that the balance of the hospital population is evenly divided between ambulatory and nonambulatory individuals.

The Saleeby Center houses approximately 45 incapacitated children. It is located in the same sub-area as Byerly Hospital.

The Morrell Convalescent Home houses approximately 132 senior citizens. It is located in the east sector approximately seven to eight miles from the Robinson facility.

3.4 Demand on Road Networks

The demand on the road system was estimated in terms of the total number of vehicles for each planning zone. The demand estimates were based on the assumptions delineated below.

Resident and Industrial Population:

- The number of occupants per vehicle for the resident population was chosen to be three. This is based on the average size of a household in the EPZ, which was 3.2.

- The school population is not subtracted from the resident population prior to estimating the number of vehicles.

- The resident population was assumed to be moved entirely by private automobiles. A separate population of individuals not owning automobiles was not defined. The basis for this is ratio of registered vehicles to the resident population in the EPZ: This ratio was estimated to be .51 vehicles per person. The data used in this ratio were: (1) 100 percent of the cars and 50 percent of the trucks registered in the three counties in the EPZ and (2) the population for the three counties. This ratio indicates that on average, there are 1.5 vehicles per household. For individuals or households that do not own a vehicle, there should not be a problem obtaining a ride from a neighboring household.

- The number of occupants per vehicle for the industrial labor force was chosen to be 1.5. This is the largest value suggested in Appendix 4 to NUREG-0654. The total industrial work force is conservatively assumed to be individuals from outside the EPZ.

- Vehicle demand for industrial population was determined by dividing the largest shift population (i.e., first shift) by 1.5.

- The other elements of the transient population are assumed to have three occupants per vehicle. This number is chosen because the population would normally be families or some other group.

Special Population:

- For the school population, the number of school buses required was based on the capacity of a single bus, 54.

- For the groups to be evacuated by ambulance, the capacity was assumed to be two.

- For the nursing home and the children's home, it was assumed that 20 percent of the population required ambulance transportation; and 80 percent would be transported by school buses.

- For the hospital patients, it was assumed that 10 percent was not moved; 45 percent was moved in school buses and 45 percent in ambulances.

The particular cases for which evacuation times were estimated were:

Case 1: Weekday - average weather

Case 2: Weekday - adverse weather

Case 3: Weekend day - average weather

Based on the assumptions above, the demand for each zone was determined. The totals for each zone are given in Table 3.10, Table 3.11, and Table 3.12 for Chesterfield County, Darlington County, and Lee County, respectively.

Vehicle demand for Case 1 includes all population types; Case 2 includes all but transients; and Case 3 includes only resident, transient, hospital and nursing home populations (i.e., industry and schools are not considered during a weekend).

TABLE 3.1

CHANGE IN CENSUS DATA, JULY, 1980 vs DECEMBER, 1980 FIGURES

	July, 1980	December, 1980	Percent Change
Chesterfield	36,764	38,292	+4%
Darlington	60,365	62,743	+4%
Lee	18,106	18,862	+4%

TABLE 3.2

1980 RESIDENT POPULATION

ZONE[1]	SECTOR															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	4	15	4	0	0	24	81	63	99	99	99	0	0
2	0	79	42	34	67	142	26	11	0	169	188	121	11	11	30	11
3	8	151	56	172	258	251	202	269	60	30	130	250	15	4	53	57
4	0	177	42	186	500	294	655	436	42	15	34	64	26	0	34	8
5	76	72	49	167	1181	1688	1249	402	42	72	94	38	19	30	34	0
6	38	38	94	238	1667	5048	1519	190	98	143	38	79	42	49	42	0
7	30	38	53	182	727	1423	460	279	177	83	8	30	72	19	174	4
8	30	57	53	196	483	658	249	132	117	106	38	8	11	8	784	0
9	79	79	53	196	405	385	227	257	76	79	102	19	23	38	38	11
10	38	83	162	189	321	211	113	232	83	140	128	72	53	11	4	0

[1]Zone 1 is between 0-1 miles; Zone 2 is between 1-2 miles, etc.

TABLE 3.3

Resident Population in Zones

Zone	County			Total
	Darlington	Chesterfield	Lee	
Center	1554			1554
A1	452	299		751
A2	257	650		907
B1	12271			12271
B2	7707			7707
C1	1174		69	1243
C2	2834		608	3442
D1	314		48	362
D2			523	523
E1	295	83		378
E2		292		292
F1		249		249
F2		1128		1128
Total	26858	2618	1331	30807

TABLE 3.4

DISTRIBUTION OF INDUSTRIAL EMPLOYMENT, BY SHIFT

		SHIFT	
	1st	2nd	3rd
(A) Hartsville Planning Zones (Partial B1, Total B2, Total C2)	2363	635	470
(B) West Hartsville Planning Zone (Partial B1)	400	50	0
(C) Robinson Power Plant Planning Zone (Center)	300	50	50
(D) McBee Planning Zone (F2)	200	0	0
TOTAL	3263	735	520

TABLE 3.5

LOCATION OF INDUSTRIAL WORK FORCE WITHIN THE EPZ

22½ Degree Sector	RANGE - MILLES										
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTAL
N/A	400[1]										400
E					100[3]						100
ESE						3225[4]					3225
SE				450[6]							450
SSE								143[5]			143
NW								200[2]			200
TOTAL	400			450	100	3225		343			4518

NOTES: [1]Estimated labor force at Robinson Nuclear Power Plant: estimated peak labor for both Robinson, Unit 1 (fossil fired) during outage and Robinson, Unit 2 during normal operation. Planning Zone - Center.

[2]A.O. Smith Company: current work force of 100 (single shift 8 a.m.-5 p.m.); estimated work force of 200 in 6 to 12 months (possible two shifts); projected work force of 400 to 500 in two years. Planning Zone - F2.

[3]International Mineral & Chemical Corporation. Planning Zone - B1.

[4]Cokers Pedigreed Seed Company (300 maximum); Hartsville Manufacturing (390); Hartsville Oil Mill (125); Hartsville Mill, Div. Milliken (175); Red Fox Apparel (173); Sonoco Products (2062); total shift man loading for this sector is: 1st shift (2163), 2nd shift (612), 3rd shift (450) Planning Zone - B2.

[5]Roller Bearing Corporation of South Carolina (143), estimated shift man loading: 1st shift (100), 2nd shift (23), 3rd shift (20). Planning Zone - C2.

[6]L'Eggs Products; total shift man loading for this sector is: 1st shift (400), 2nd shift (50), 3rd shift (0). Planning Zone - B1.

TABLE 3.6

SEASONAL POPULATION VARIATIONS

Recreational Area	Usage (No. of Persons)
Lake Robinson (Darlington County)	500
Lake Prestwood (Darlington County)	50
Sandhill State Forest (Chesterfield County)	15
Hunting Areas In:	
Darlington County	132
Chesterfield County	129
Lee County	48

TABLE 3.7

LOCATION OF SCHOOL POPULATION WITHIN THE EPZ

22½ Degree Sector	RANGE - MILES 3-4	4-5	5-6	6-7	7-8	8-9	9-10	TOTALS
ENE							184[1]	184
E		604[2]	132[3]					736
ESE		2642[4]	2484[5]					5126
SE			219[6]			190[7]		409
SSE	598[8]							598
S							55[9]	55
NW					782[10]			782
TOTALS	598	3246	2835		782	190	239	7890

NOTES:
[1] Antioch Elementary, Byrd Town Academy (Planning Zone - B2)
[2] North Hartsville Elementary (Planning Zone - B1)
[3] Sonavista Elementary (Planning Zone - B1)
[4] Hartsville Jr. High School, Hartsville Sr. High School, Carolina Elementary (Planning Zone - B1)
[5] Butler High School, Washington St. Elementary, First Baptist, Thornwell Elementary, Emanuel Baptist, Coker College, First Presbyterian, St. Mary's, Head Start Preschool (Planning Zones - B1 and B2)
[6] Southside Elementary (Planning Zone - B1)
[7] Thomas Hart Academy (Planning Zone - C2)
[8] Kelleytown Baptist Church, West Hartsville Elementary (Planning Zone - C1)
[9] Ebenezer School (Planning Zone - C2)
[10] McBee Elementary, McBee High School (Planning Zone - F2)

TABLE 3.8

ENROLLMENT FOR SCHOOLS IN EPZ

School	Enrollment
Butler High	439
Hartsville Jr. High	791
Hartsville Sr. High	1426
Antioch Elementary	134
Thornwell Elementary	464
North Hartsville Elementary	604
Southside Elementary	219
West Hartsville Elementary	546
Sonavista Elementary	132
Carolina Elementary	425
Washington St. Elementary	523
Hartsville Area Vocational	(Included in Sr. High School numbers)
Emanuel Baptist	296
Thomas Hart Academy	190
Byrd Town Academy	50
Kelleytown Baptist Church	52
Saleeby Center	45
Coker College	305
First Baptist	296
First Presbyterian	66
St. Mary's	12
Head Start Preschool	83
McBee Elementary	364
McBee High	418
Ebenezer	55

TABLE 3.9

LOCATION OF HOSPITAL AND NURSING HOMES WITHIN THE EPZ

Range - Miles

Sector	4-5	5-6	6-7	7-8	Total
E				132[1]	132
ESE	161[2]				161
Total	161			132	293

[1] Morrel Convalescent Home (Planning Zone - B2)

[2] Byerly Hospital (116 patients), Saleeby Center (45 children) (Planning Zone - B1)

TABLE 3.10

SUMMARY OF VEHICLE DEMAND - CHESTERFIELD COUNTY

Planning Zone	Resident	Industrial	Other Transient	Schools	Hospital/ Nursing Home	Totals Case 1	Case 2	Case 3
A1	100	-	3	-	-	103	100	103
A2	217	-	8	-	-	225	217	225
E1	28	-	1	-	-	29	28	29
E2	98	-	15	-	-	113	98	113
F1	83	-	6	-	-	89	83	89
F2	376	134	15	15	-	540	525	391
Totals	902	134	48	15	-	1099	1051	950

TABLE 3.11

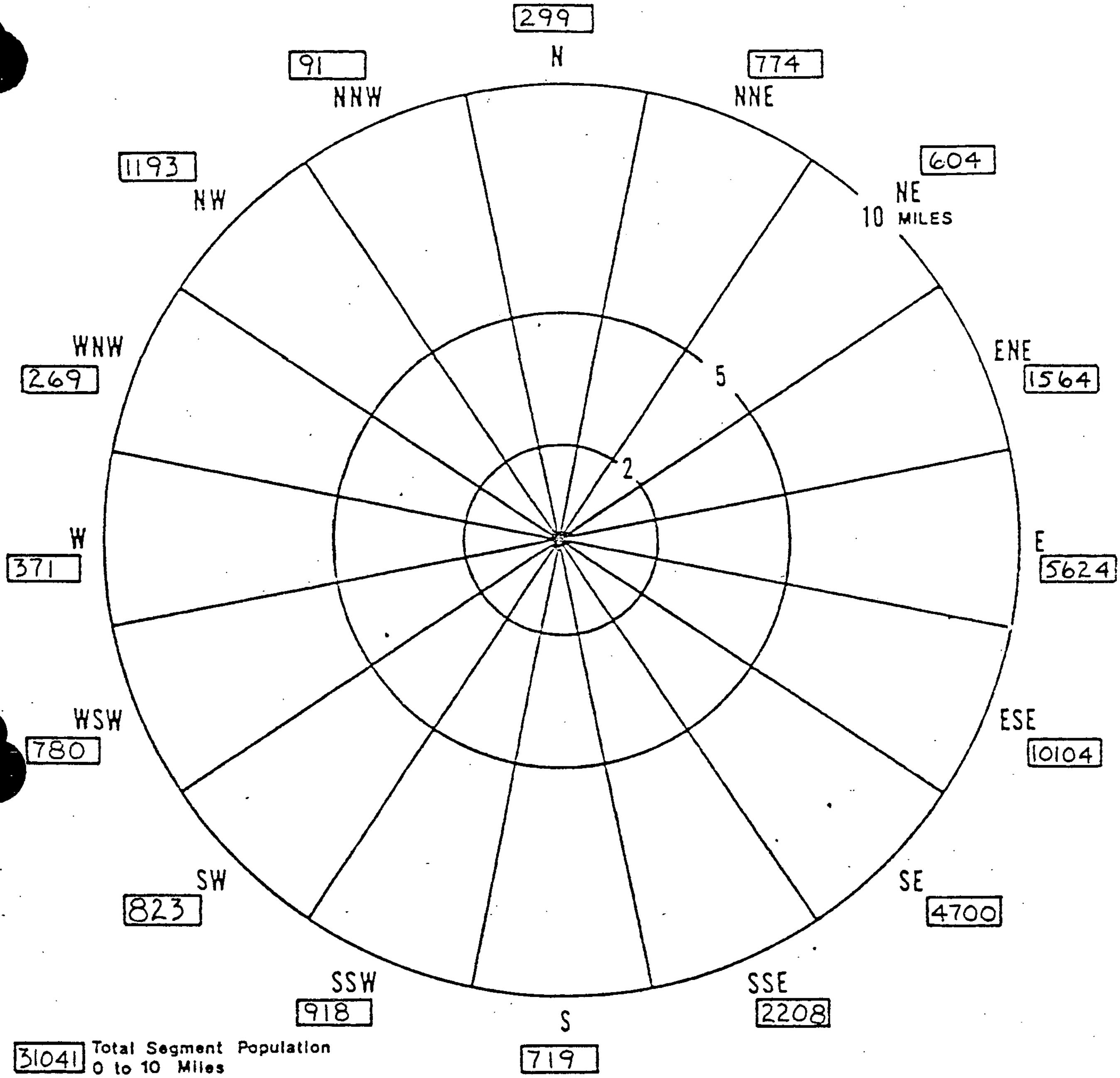
SUMMARY OF VEHICLE DEMAND - DARLINGTON COUNTY

Planning Zone	Resident	Industrial	Other Transient	Schools	Hospital/ Nursing Home	Totals Case 1	Case 2	Case 3
Center	518	200	166	-	-	884	718	684
A1	151	-	3	-	-	154	153	154
A2	86	-	4	-	-	90	86	90
B1	4091	1842	16	104	33	6086	6070	4140
B2	2569	-	12	17	15	2613	2601	2596
C1	392	-	6	11	-	409	403	398
C2	945	-	8	4	-	957	949	953
D1	105	-	6	-	-	111	105	111
D2	-	-	-	-	-	-	-	-
E1	99	-	5	-	-	104	99	104
Totals	8956	2066	226	134	55	11,408	11,182	9,230

TABLE 3.12

SUMMARY OF VEHICLE DEMAND - LEE COUNTY

Planning Zone	Resident	Industrial	Other Transient	Schools	Hospital/ Nursing Home	Totals Case 1	Case 2	Case 3
C1	23	-	-	-	-	23	23	23
C2	203	-	4	1	-	208	204	207
D1	16	-	-	-	-	16	16	16
D2	175	-	12	-	-	187	175	187
Totals	417	-	16	1	-	434	418	433



POPULATION TOTALS			
RING, MILES	RING POPULATION	TOTAL MILES	CUMULATIVE POPULATION
0 - 2	1430	0 - 2	1430
2 - 5	9692	0 - 5	11122
5 - 10	19919	0 - 10	31041

FIGURE 3.1
ROBINSON SITE
SECTOR PERMANENT POPULATION TOTALS

4.0 Evacuation Route

The evacuation routes that have been identified by the South Carolina Emergency Preparedness Division resulted in ten (10) exits from the 10-mile EPZ. These ten exits lead from the EPZ to relocation centers in Chesterfield, South Carolina, and Darlington, South Carolina. The following sections discuss the location, characteristics, and capacities of the evacuation routes.

4.1 Evacuation Roadway Network

Figure 2.0 illustrates the location of the planning zones and the evacuation routes from the EPZ. Table 4.1 lists the evacuation routes for each individual planning zone.

4.2 Roadway Segment Characteristics

Table 4.2 lists the characteristics of the major roads illustrated in Figure 2.0. With the exception of SC 151 southeast of Hartsville, the roads are two-lane roads with at-grade crossings. SC 151 southeast of Hartsville (after Business SC 151 joins SC 151) is a four-lane road with at-grade crossings.

The values for road system capacity were chosen based on guidance contained in "Guide for Crisis Relocation Contingency Planning," January, 1979 (CPG2-8-C). That document was prepared by the U.S.

Department of Defense - Defense Civil Preparedness Agency. That document identifies the theoretical maximum capacity for a multi-lane, limited access road as being 2,000 vehicles per hour per lane. The document suggests the road capacities tabulated in Table 4.3.

As shown in Table 4.3, a value of 850 vechicles per hour (vph) was used for all routes except for a portion of SC 151. SC 151 southeast of Hartsville was assigned a capacity of 1000vph per lane instead of 1200vph because the approaches to the four lane section of SC 151 are two-lane roads. A value of 1000vph per lane is used instead of 850 because northbound traffic (toward Hartsville) on SC 151 is presumed to be blocked at the EPZ boundary. The value of 1000vph for Business SC 151 presumes unimpeded access to SC 151; normally this traffic yields to traffic northbound on SC 151.

The capacity used for adverse weather was 80 percent of the capacities discussed above and listed in Table 4.3. The reduction to 80 percent was based on discussion in CPG2-8-C which suggested that if an evacuation would require more than 24 hours, the road capacities should be reduced to 80 percent. The resulting capacity for a two-lane road is 850 x .80 = 680vph. The resulting capacity for Business SC 151 is 1000 x .80 = 800vph. Conditions which produce capacities lower than this are not considered credible conditions for an evacuation; such conditions would typically be an ice storm or a snow storm.

TABLE 4.1
Evacuation Routes For The 10 Mile EPZ

Sector	County	Roads
Center	Darlington	SC 151 to Darlington
A-1	Darlington	S-39; S-20; S-889; S-51; S-23; S-13; US-15; S-41: US-401; Darlington
	Chesterfield	S-763; S-29; SC 145; Chesterfield
A-2	Darlington	S-51; S-23; S-13; US-15; S-41; US-401; Darlington
	Chesterfield	S-491; S-29; SC145; Chesterfield
		S-149; SC-102; SC145; Chesterfield
B-1	Darlington	SC-151 to Darlington
		S-135; S-24; S-13; SC-151; Darlington
		US-15; S-41; US-401; Darlington
B-2	Darlington	S-13; US-15; S-41; US-401; Darlington
		S-13; SC-151; Darlington
		S-135; S-24; S-13; SC-151; Darlington
C-1	Darlington	S-52; S-769; US-15; SC-151; Darlington
	Lee	S-105; S-13; US-15; S-22; I-20; US-401; Darlington
C-2	Darlington	S-52; S-769; US-15; SC-151; Darlington
		S-65; S-769; US-15; SC-151; Darlington
	Lee	S-100; S-26; S-39; S-22; I-20; US-401; Darlington
D-1	Darlington	S-85; S-23; S-53; S-200; SC-151; Darlington
		SC-151; Darlington
	Lee	S-105; S-13; US-15; S-22; I-20; US-401; Darlington
D-2	Lee	SC-341; US-15; S-22; I-20; US 401; Darlington
E-1	Darlington	S-23; SC-151; Darlington
	Chesterfield	S-150; S-711; SC-151; US-1; SC 145; Chesterfield
E-2	Chesterfield	S-296; US-1; SC-145; Chesterfield
F-1	Chesterfield	S-46; S-346; SC-151; US-1: SC-145; Chesterfield
		SC-151; US-1: SC-145; Chesterfield
F-2	Chesterfield	US-1; SC-145; Chesterfield

TABLE 4.2

ROAD CHARACTERISTICS FOR ROADS IN FIGURE 2.0

Route	Number of Lanes[2]	Type[1]	Assigned Capacity (vph)[3]
SC 145	2	P	850
SC 151	2	P	850
S13-346	2	R	850
S13-150	2	R	850
US 1	2	P	850
S13-29	2	R	850
SC-102	2	P	850
S13-149	2	R	850
SC-341	2	P	850
SC-102	2	P	850
US 15	2	P	850
S31-22	2	R	850
S16-12	2	R	850
S16-65	2	R	850
SC 151 Bus.	2	P	1000
SC 151	4	P	2000
S16-23	2	R	850

TABLE 4.2 (Cont'd)

ROAD CHARACTERISTICS FOR ROADS IN FIGURE 2.0

Route	Number of Lanes[2]	Type[1]	Assigned Capacity (vph)
S16-53	2	R	850
S16-200	2	R	850
S16-52	2	R	850
S16-769	2	R	850
S16-135	2	R	850
S16-24	2	R	850
S16-13	2	R	850
S16-39	2	R	850
S16-889	2	R	850
SC-34	2	P	850

[1]R indicates rural highway; P indicates primary road.

[2]Total in both directions.

[3]Eighty percent of these capacities were used for adverse weather conditions.

TABLE 4.3
ROAD CAPACITIES

Highway Type	Capacity Per Lane (Vehicles Per Hour)
Multi-lane, limited access	1500
Multi-lane, without access control	1200
Two-lane highway	850

Note: Adverse weather conditions will result in road capabilities of 80% of those listed above.

5.0 ANALYSIS OF EVACUATION TIMES

This section presents the methodology used to estimate the evacuation times for the population at risk (Section 5.1), and the resulting evacuation time estimates for the different subgroups within the population at risk (Section 5.2).

Evacuation time estimates were developed for three different cases. The three cases are:

- Case 1: Weekday - Average Weather
- Case 2: Weekday - Adverse Weather
- Case 3: Weekend - Average Weatehr

The vehicle demand in the respective zones has already been discussed in Section 3.4. Other cases such as nighttime-average weather or nighttime-adverse weather were not investigated because the location of the population at risk, and the road capacities would be enveloped by the cases investigated.

5.1 Methodology

The analysis of the evacuation time proceeded with the following steps:

- Estimation of the delay time: the time between notification of evacuation and actual movement of individuals

- Identification of critical locations in the evacuation network, and the time required to overload or saturate an evacuation route

- Determination of sensitivity of evacuation times to the delay times.

5.1.1 Delay Time

The delay time encompasses various activities to be performed by the resident and transient populations between the time of evacuation notification and the time that individuals arrive at the road network. These steps for the resident population are:

- Receipt of the evacuation notice
- Formation of family groups
- Packing belongings identified in the evacuation notice
- Securing the household
- Loading the vehicle

For the industrial labor force, the second largest group in terms of vehicle demand, the steps would be:

- Receipt of evacuation notice
- Shutdown of facility
- Evacuation of facility
- Formation of carpools

In general, precise data are not available on any of these steps; even if this information were available, it would vary from household to household and from facility to facility.

To encompass the uncertainties associated with these steps, a statistical distribution was chosen. For the resident population and the industrial labor force, the delay time was assumed to be normally distributed with a mean of 30 minutes and a standard deviation of 11.7 minutes. The normal distribution was chosen because it has been found to be a reasonable approximation of many different types of processes involving measurements of some quantity. The 30-minute mean presumes that 50 percent of the population will be delayed less than 30 minutes and 50 percent will be delayed longer than 30 minutes. The standard deviation presumes that only 4 percent of the demand will be delayed longer than 54 minutes (the mean time plus two standard deviations). These assumptions were based primarily on judgment, the sensitivity of the resulting evacuation time estimates to these assumptions is discussed in Section 5.1.3. Figure 5.1 is the integral of a standard normal distribution with a mean of 30 minutes and a standard deviation of 11.7 minutes. The Figure illustrates the number of vehicles (demand) which are in transit at a certain time. For example, if the total number of vehicles is 1500, the total number of vehicles moving at fifteen minutes is 1500 x 0.105 = 157.

Figure 5.2 is a graph of the differential with respect to time of Figure 5.1. The curve is used to estimate the arrival rate of

vehicles at a given time. For example, if the total demand is 1500, at 15 minutes after notification the rate at which vehicles are leaving homes is .0135 x 1500 = 20 vehicles per minute. The later curve is important in identifying the time when demand on the road network is equal to the capacity of the road network.

5.1.2 Identification of Critical Locations

As discussed in Section 4.0 of this report, the South Carolina Emergency Preparedness Division has identified evacuation routes which lead to ten evacuation exits from the 10-mile EPZ. The capacity of four of these exits (Exits 1, 3, 4, and 5) are the critical features of the evacuation analysis because the vehicle demand on the routes leading to Exits, 1, 3, 4, and 5 exceeds their capacity. The evacuation routes and the ten exits are shown in Figure 2.0. One-line diagrams illustrating evacuation routes from Darlington, Chesterfield, and Lee counties are presented in Figure 5.3, Figures 5.4, and Figure 5.5, respectively.

The residential and industrial vehicles demands by exit and planning zone have been calculated and presented in Table 5.1 for Cases 1 or 2, and in Table 5.2 for Case 3.

A rough approximation of the evacuation time through each exit can be determined by:

$$\frac{\text{Number of vehicles}}{\text{Capacity (vehicles/hour)}} = \text{evacuation time (hrs.)}$$

The resulting evacuation times are rough approximations of the total evacuation time through an exit. Significant additions to the evacuation time may result from the travel time to critical locations and the time to reach the maximum capacity at those critical locations. The analysis of these two times is discussed below.

The travel time to the critical locations and the time required to buildup to the maximum capacity of the critical locations can be determined by two methods. The first involves detailed modeling of individual road segments. The model employs a time varying demand on a road segment as determined from Figure 5.2, length of the road segment, the maximum speed along the road segment, and the connections between roads.

The model also uses a finite difference equation to approximate the flow out of one road segment into another road segment. Use of a finite difference scheme assumes that the flow rate out of a road is constant over some short time interval Δt. The road segments are linked by assuming that the output from an inner segment, i, (0_i) is the input to the next road segment, i+1. The output of a segment (0_i) is determined by assuming that the vehicles on road segment i are uniformly distributed along the segment of length m miles and are traveling at a speed of s miles/hour. The fraction that leave in a time interval Δt is:

- fraction that leave segment i = $\frac{\Delta ts}{m}$

If the number of vehicles in segment i at time t is designated as $C_i(t)$, the output of segment i at time t is then:

- $$O_i(t) = \frac{\Delta ts}{m} Ci(t)$$

D_i $(t-\Delta t)$ is used to designate vehicles that enter segment i from sources other than the previous road segment. These sources would be driveways or side streets that connect along road segments. This source is determined from the geographic distribution of vehicle demand and the distribution of delay times.

Figure 5.6 presents an illustration of the model flow. From the Figure the combination of inputs to and outputs from any segment i can be described as well as the number of vehicles within the segment determined. The number of vehicles in any segment at time interval t is as indicated in Figure 5.6.

$$C_i(t) = C_i(t-\Delta t) + D_i(t-\Delta t) + O_{i-1}(t-\Delta t) - O_i(t-\Delta t)$$

For each road segment, an equation such as the above can be developed and combined with all other equations for the entire EPZ and solved by a large computer. However, examination of the problem in a practical and straightforward manner indicates a simple method of solution is possible. The key parameter of interest is the flow rate of any road segment which has defined limits. If the road system saturates due to a limited flow capacity when compared to the

flow demand, the term $0_i(t)$ becomes a constant and no complicated calculations are necessary. If the last intersection on an evacuation route within the EPZ is examined and an unrestricted flow to that intersection is assured by its supplying routes, the maximum time to saturation of any road segment can be determined. This can be accomplished by calculating the average travel time to that intersection by the evacuating population and determining the distribution of their starting times. If this time to saturation when compared to total time is short, then the effect upon the evacuation time estimates will be insignificant.

The time to saturation is a function of the number of vehicles which load the road system over any interval of time. That number is the total vehicle population, N, times the normalized demand rate as presented in Figure 5.2. Therefore, (dQ/dt) N must be less than the flow rate limit of the road, R, from Table 4.3 or

$$(dQ/dt)\,N < R \;\rightarrow\; dQ/dt < R/N$$

A sample calculation of an evacuation time is presented in Table 5.3, which illustrates the individual steps in calculating the time at which an exit will overload and the time to completely evacuate the resident population and the industrial labor force. The evacuation time calculation results for each exit are presented for Cases I, II, and III in Tables 5.4, 5.5, and 5.6, respectively.

5.1.3 Sensitivity of Evacuation Time to Delay Time

The total evacuation times listed in Tables 5.4, 5.5, and 5.6, line 8 were calculated assuming a delay time that was normally distributed. For the cases listed the average amount of time that is attributed to this delay varies from two percent to six percent of the total evacuation time. Since these percentages are so low the distribution of the delay time could increase by a factor of two (in the worst case) or more before there would be a significant change in the total evacuation time. A decrease in the delay time would be bounded by the times given earlier in Section 5.1.2.

An increase in the mean delay time to 60 minutes with a doubling of the standard deviation to 22 minutes would produce the curves illustrated in Figures 5.7 and 5.8. For comparison, curves used in Section 5.1.2 are also displayed.

A mean of 60 minutes is a generous amount of time to perform the steps required by the resident population or the industrial labor force and yet the change in the total evacuation time is six percent or less. The conclusion that can be drawn is that for the cases evaluated the limiting characteristics of the evacuation routes overshadow the delay times associated with the evacuation.

5.2 Estimates of Evacuation Times

5.2.1 Resident Population

Estimates of the total time required to evacuate the resident population and the industrial labor force are presented in Table 5.7. The vehicle demand presented by other transient and special (schools, hospitals, nursing homes) populations is small, about six percent, compared to the resident and industrial populations. The increase for Case 1, Exit 1 is 264 vehicles or 16 minutes of evacuation time (264 vehicles ÷ 1,000 vehicles/hour).

The evacuation times expected for the other transient and special populations will not vary from the times presented in Table 5.7 unless the respective delay times exceed the evacuation time for their respective zones or special evacuation routes or priorities are assigned to vehicles for the special population. The delay times for the balance of the population at risk are discussed below.

5.2.2 Other Transient Populations

This group results from recreational use of Lake Robinson, Lake Prestwood, and Sand Hill State Forest and deer hunters in the EPZ. The total number of vehicles is 280. This population is assumed to exist only during average weather cases (Cases I and III). A delay time of about one to two hours is assumed to be reasonable for this population and therefore the evacuation of the majority of this group would be limited by the capacity of the respective exits.

5.2.3 Schools

The mode of evacuation for the schools in the EPZ will be the school buses operated by the respective counties' school systems. The capacities of buses available in each county are listed in Table 5.8 along with the school population.

It is assumed that a particular county's school buses remain in that county and the time required to activate and load the local bus capacity is 20 minutes. The delay time for the Lee County school is then 20 minutes.

For Darlington and Chesterfield Counties additional bus capacity would have to be brought into the local area from other parts of the county. The delay time for this capacity is assumed to be 20 minutes plus the travel time from Darlington to Hartsville or the transit time from Chesterfield to McBee. In both cases this delay time is approximately 55 minutes. Therefore the delay times for Darlington and Chesterfield County schools range from 20 to 55 minutes and the evacuation is limited in most cases by the capacity of the road system.

5.2.4 Hospitals and Nursing Homes

The mode of evacuation for the hospital and nursing home patients is a mixture of ambulances and school buses. The breakdown of vehicles would be as shown in Table 5.9.

The Darlington County ambulances are assumed to be available within 30 minutes and the balance within 45 minutes. The time to load each ambulance is assumed to be one person per minute.

School buses are available from Chesterfield County or Lee County to assist the evacuation of ambulatory individuals from the special facilities within the time delay for the road system. The delay time for the persons accommodated by the first wave of ambulances is 56 minutes (30 minutes + 26 minutes).

Byerly Hospital and Saleeby Center are assumed to be evacuated first because they are closer to Robinson facility than the Morrel Convalescent Home. The delay time for the non-ambulatory patients at the Morrel Convelescent Home would depend on whether the ambulances would use the same evacuation route as the resident population. If this were the case, the delay time for Morrel Convalescent Home would be the time required for the ambulances to evacuate the EPZ (0.5 hours). The ambulances returning to complete evacuation of non-ambulatory patients would then be evacuated with the resident population. The resulting evacuation time would be 5.3 hours. The time for additional assistance from outside the three counties to travel to the EPZ is less than five hours. For ambulances coming from Florence, South Carolina, the travel time would be approximately one hour. Therefore, the evacuation is again limited in most cases by the capacity of the road system.

5.3 Summary of Evacuation Times

Table 5.10 provides a summary of the 10-mile EPZ evacuation times by Case and exit. These times were determined by the maximum time required to clear the last exit used by the zone. For example, Zone B1 (as shown by Table 5.1) is evacuated through Exits 1, 3, and 4. Of these three exits, Exit 1 will be the last to clear for Case I. Therefore, 268 minutes (4.5 hour) was used for the Case I, Zone B1 evacuation time.

The method of summary used to determine Table 5.10 is probably overly conservative for zones such as C1, D1, and E1 where the evacuation times were limited by Exit 1 times although only a small number of vehicles from those zones (compared with total exit vehicle demand) actually passed through the exit.

TABLE 5.1
CASES I & II
RESIDENT & INDUSTRIAL VEHICLE DEMAND

	EXIT										
ZONE	1	2	3	4	5	6	7	8	9	10	TOTAL
Center	718										718
A1			151						100		251
A2			86						128	89	303
B1	1978		1978	1977							5933
B2			1284	1285							2569
C1	392					23					415
C2	630	315						208			1153
D1	105					16					121
D2							175				175
E1	99				28						127
E2					98						98
F1					83						83
F2					510						510
TOTAL	3922	315	3499	3262	719	39	175	208	228	89	12456

TABLE 5.2
CASE III
RESIDENT VEHICLE DEMAND

	EXIT										
ZONE	1	2	3	4	5	6	7	8	9	10	TOTAL
Center	518										518
A1			151						100		251
A2			86						128	89	303
B1	1364		1364	1363							4091
B2			1284	1285							2569
C1	392					23					415
C2	630	315						203			1148
D1	105					16					121
D2							175				175
E1	99				28						127
E2					98						98
F1					83						83
F2					376						376
TOTAL	3108	315	2885	2648	585	39	175	203	228	89	10275

TABLE 5.3

CALCULATING FOR EXIT 1 FOR CASE 1

1. Average travel time from planning zone to Exit 1's last intersection:

$$\frac{6 \text{ miles}}{35 \text{ mph}} = .16 \text{ hours or } 10 \text{ minutes}$$

2. Fraction of demand that will overload Exit 1 (dQ/dt = R/N):

$$\frac{1000 \text{ vph}}{3{,}922 \text{ vehicles}} \times \frac{\text{hour}}{60 \text{ min}} = \frac{.0042}{\text{min.}}$$

3. Time that fraction of demand from Step 2 occurs (from Figure 5.2).

dQ/dt = .0042/minute at 7 minutes

4. The maximum time to overload Exit 1 is time to reach maximum road flow rate plus travel time to the exit:

7 + 10 = 17 minutes

5. Fraction of total demand that has left EPZ via Exit 1 at 17 min. (from Figure 5.1 at 7 minutes):

.03 or .03 x 3922 = 118 vehicles, which is 7 minutes of full flow

6. Time required to process balance of demand:

$$\frac{(1 - .03) \times 3922}{1{,}000 \text{ vehicles per hour}} = 3.8 \text{ hours or } 228 \text{ minutes}$$

7. Time required for last vehicle to reach EPZ boundary from last critical location at Exit 1's last intersection:

$$\frac{4 \text{ mile}}{35 \text{ mph}} = .12 \text{ hours or } 7 \text{ minutes}$$

8. Total evacuation time:

17 minutes + 228 minutes + 7 minutes = 252

TABLE 5.4

EVACUATION TIME CALCULATIONS

CASE I

Mean = 30 minutes 850 VPH

Step	Exit	1[1]	2[2]	3	4	5	6[2]	7[2]	8[2]	9[2]	10[2]
1	Min	10	7	10	7	12	3	3	3	10	10
2	Min^{-1}	.0042	.045	.004	.0043	.020	.3632	.0810	.068	.062	.159
3	Min	7	NA	7	7	18	NA	NA	NA	NA	NA
4	Min	17	NA	17	14	30	NA	NA	NA	NA	NA
5		.03	NA	.03	.03	.18	NA	NA	NA	NA	NA
6	Min	228	22	240	223	42	5	12	15	16	6
7	Min	7	3	-	3	3	7	3	3	4	4
8	Min Hour	252 4.2	55 0.9	257 4.3	240 4	75 1	42 0.7	45 0.8	48 0.8	50 0.8	40 0.7

NOTE 1: Evacuation time based on 1,000 VPH (See Section 4.0).
NOTE 2: These exits are delay time limited and 30 minutes is added to the time required to process demand through final exit (Steps 6 and 7).

TABLE 5.5

EVACUATION TIME CALCULATIONS

CASE II

Mean = 30 minutes   680 VPH

Step	Exit	1[1]	2[2]	3	4	5	6[2]	7[2]	8[2]	9[2]	10[2]
1	Min	10	7	10	7	12	3	3	3	10	10
2	Min^{-1}	.0034	.036	.003	.003	.016	.29	.064	.054	.049	.13
3	Min	5	NA	5	5	16	NA	NA	NA	NA	NA
4	Min	15	NA	15	12	28	NA	NA	NA	NA	NA
5		.03	NA	.03	.03	.12	NA	NA	NA	NA	NA
6	Min	285	27	299	279	56	3	15	18	20	8
7	Min	7	3	-	3	3	7	3	3	4	4
8	Min Hour	307 5.1	60 1	314 4.9	294 4.9	87 1	40 0.7	48 0.8	51 0.9	54 0.9	42 0.7

NOTE 1: Evacuation time based on 80% x 1,000 VPH = 800 VPH (See Section 4.0).
NOTE 2: See Table 5.4, Note 2.

TABLE 5.6

EVACUATION TIME CALCULATIONS

CASE III

Mean = 30 minutes   850 VPH

Step	Exit	1[1]	2[2]	3	4	5	6[2]	7[2]	8[2]	9[2]	10[2]
1	Min	10	7	10	7	12	3	3	3	10	10
2	Min^{-1}	.005	.045	.005	.005	.024	.36	.081	.070	.062	.159
3	Min	8	NA	8	8	21	NA	NA	NA	NA	NA
4	Min	18	NA	18	15	33	NA	NA	NA	NA	NA
5		.03	NA	.03	.03	.25	NA	NA	NA	NA	NA
6	Min	186	22	198	182	31	3	12	14	16	6
7	Min	7	3	-	3	3	7	3	3	4	4
8	Min Hour	211 3.5	55 1	216 3.6	200 3.3	67 1.4	40 0.7	45 0.7	47 0.7	50 0.8	40 0.7

NOTE 1: Evacuation time based on 1,000 VPH (See Section 4.0).
NOTE 2: See Table 5.4, Note 2.

TABLE 5.7

COMPOSITE EVACUATION TIMES (MINUTES)

Exit #1

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	252	12	4	268
Case 2	307	0	4	311
Case 3	211	12	1	224

Exit #2

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	55	1	1	57
Case 2	60	0	1	61
Case 3	55	1	0	55

Exit #3

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	257	2	5	264
Case 2	314	0	5	319
Case 3	216	2	1	219

TABLE 5.7 (Cont'd)

COMPOSITE EVACUATION TIMES (MINUTES)

Exit #4

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	240	1	4	245
Case 2	294	0	4	298
Case 3	200	1	1	202

Exit #5

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	75	3	1	79
Case 2	87	0	1	88
Case 3	87	3	0	70

Exit #6

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	42	0	0	42
Case 2	40	0	0	40
Case 3	40	0	0	40

TABLE 5.7 (Cont'd)

COMPOSITE EVACUATION TIMES (MINUTES)

Exit #7

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	45	1	0	46
Case 2	48	0	0	48
Case 3	45	1	0	46

Exit #8

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	48	1	0	49
Case 2	51	0	0	51
Case 3	47	1	0	48

Exit #9

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	50	1	0	51
Case 2	54	0	0	54
Case 3	50	1	0	51

TABLE 5.7 (Cont'd)

COMPOSITE EVACUATION TIMES (MINUTES)

Exit #10

	Residential and Industrial	Transient	Special	Total (Min)
Case 1	40	1	0	41
Case 2	42	0	0	42
Case 3	40	1	0	41

TABLE 5.8

SCHOOL BUS CAPACITY

	Bus Capacity		
County	In EPZ	Out of EPZ	School Population
Darlington	2200-Hartsville Area	5153-Darlington Area	7,053
Chesterfield	600-McBee	6,042	782
Lee	0	1653-Bishopville	55

TABLE 5.9

SCHOOL BUS/AMBULANCE DISTRIBUTION, BY COUNTY

County	Ambulance
Darlington County	13
Chesterfield County	12
Lee County	6
TOTAL	31

REQUIRED VEHICLES

	Ambulance	Bus
Byerly Hospital	26	1
Saleeby Center	5	1
Morrel Convalescent Home	13	2

TABLE 5.10

EVACUATION TIME SUMMARY

10 Mile EPZ

Zone		Case 1	Case 2	Case 3
Center	(min)	268	311	224
	(hr.)	4.5	5.2	3.8
A1	(min)	264	319	219
	(hr.)	4.4	5.3	3.7
A2	(min)	264	319	219
	(hr.)	4.4	5.3	3.7
B1	(min)	268	319	224
	(hr.)	4.5	5.3	3.8
B2	(min)	264	319	219
	(hr.)	4.4	5.3	3.7
C1	(min)	264	319	219
	(hr.)	4.4	5.3	3.7
C2	(min)	268	311	224
	(hr.)	4.5	5.2	3.8
D1	(min)	268	311	224
	(hr.)	4.5	5.2	3.8
D2	(min)	46	48	46
	(hr.)	0.8	0.8	0.8
E1	(min)	268	311	224
	(hr.)	4.5	5.2	3.8
E2	(min)	79	88	70
	(hr.)	1.3	1.5	1.2
F1	(min)	79	88	70
	(hr.)	1.3	1.5	1.2
F2	(min)	79	88	70
	(hr.)	1.3	1.5	1.2

FIGURE 5.1
DELAY TIME DISTRIBUTION, MEAN= 30 MINUTES

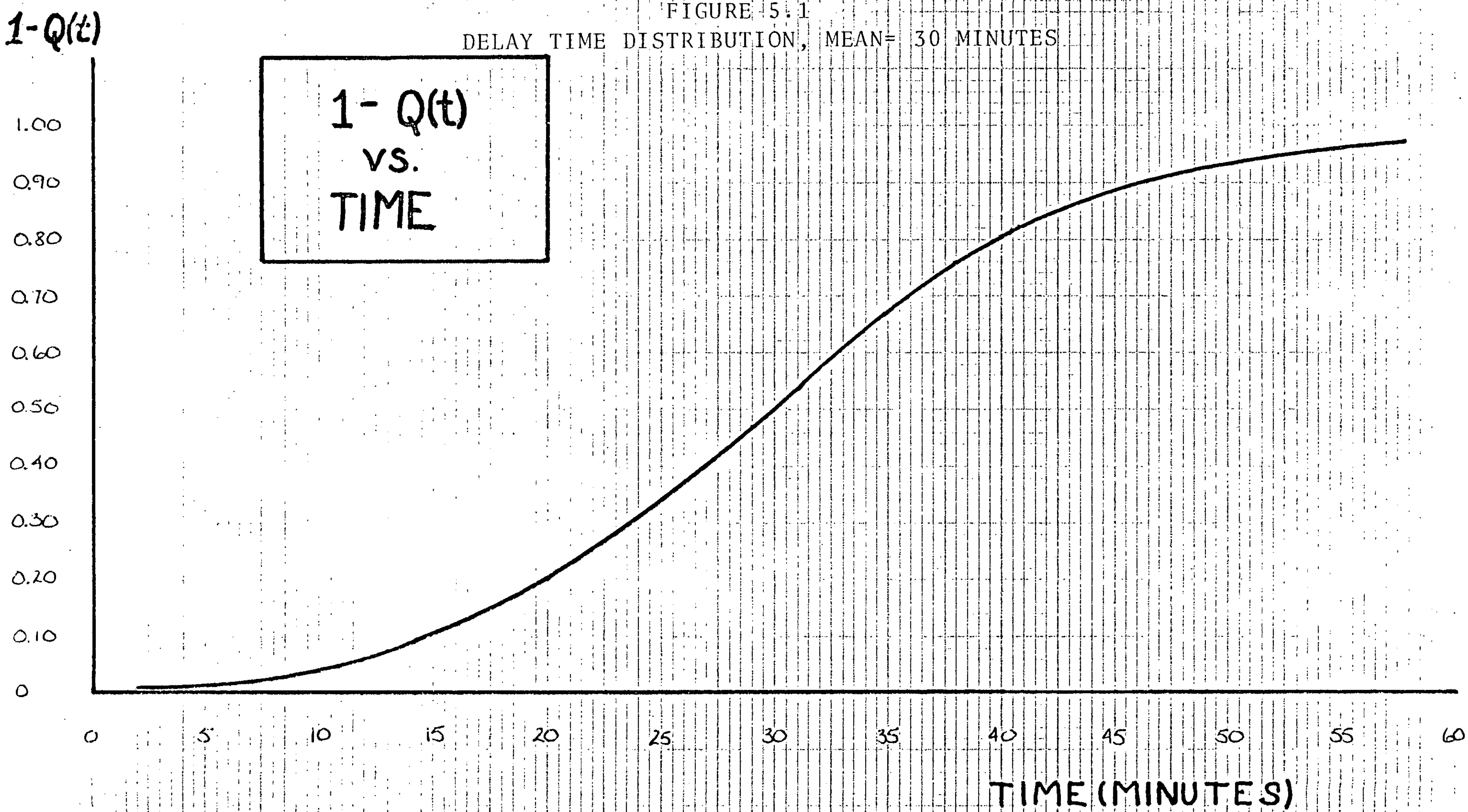


FIGURE 5.2
DEMAND RATE: MEAN= 30 MINUTES

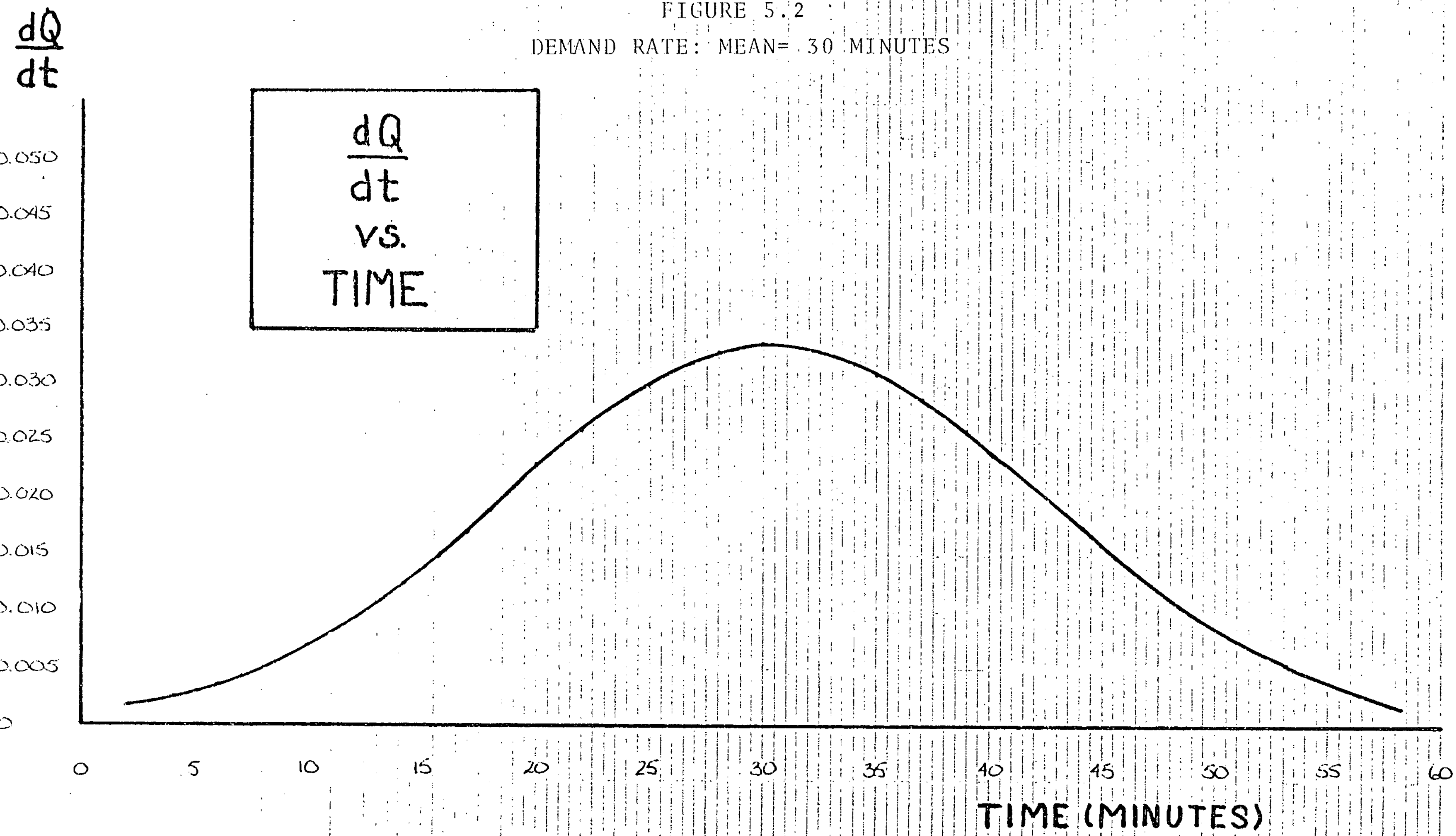


FIGURE 5.3

DARLINGTON COUNTY

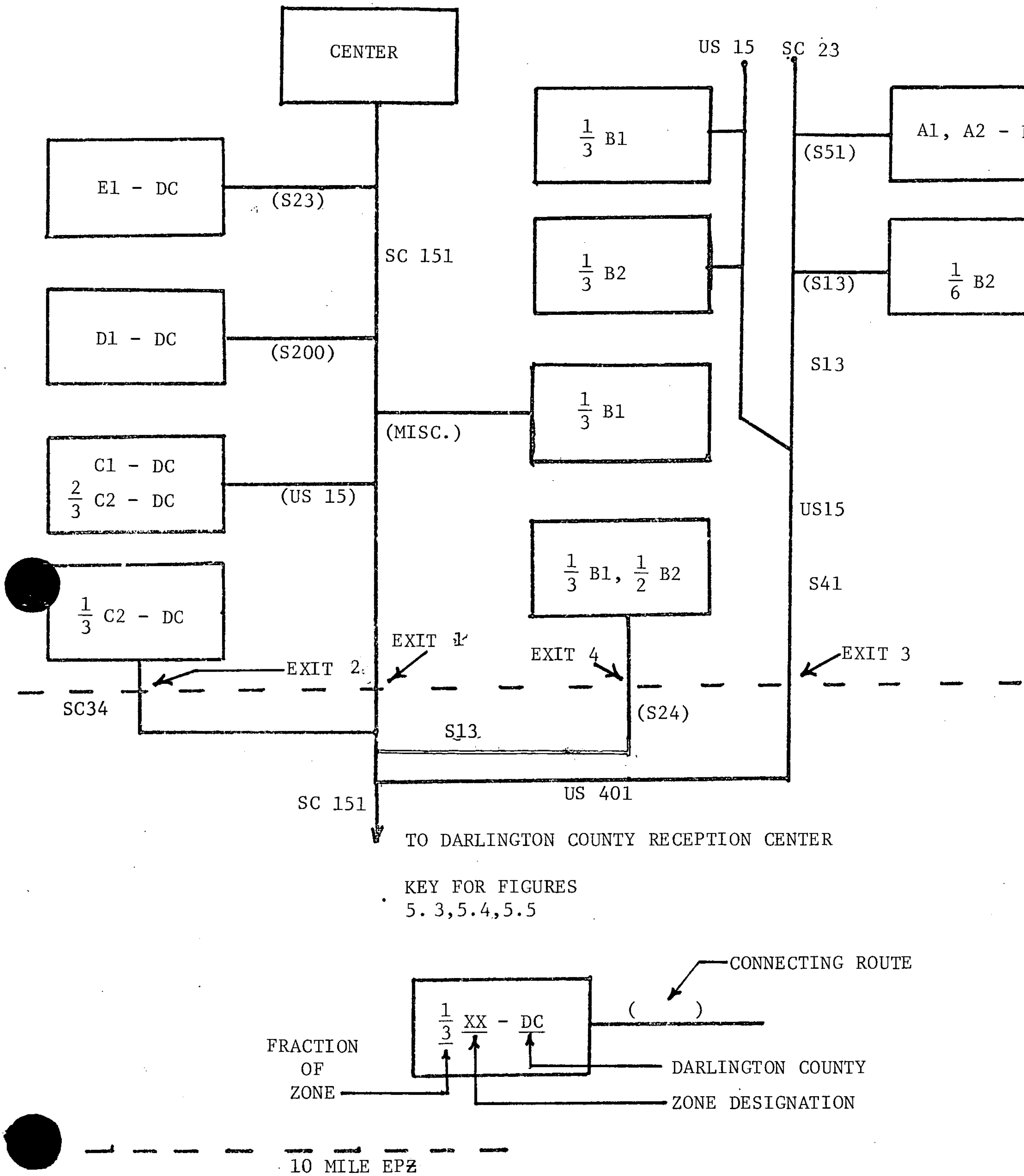
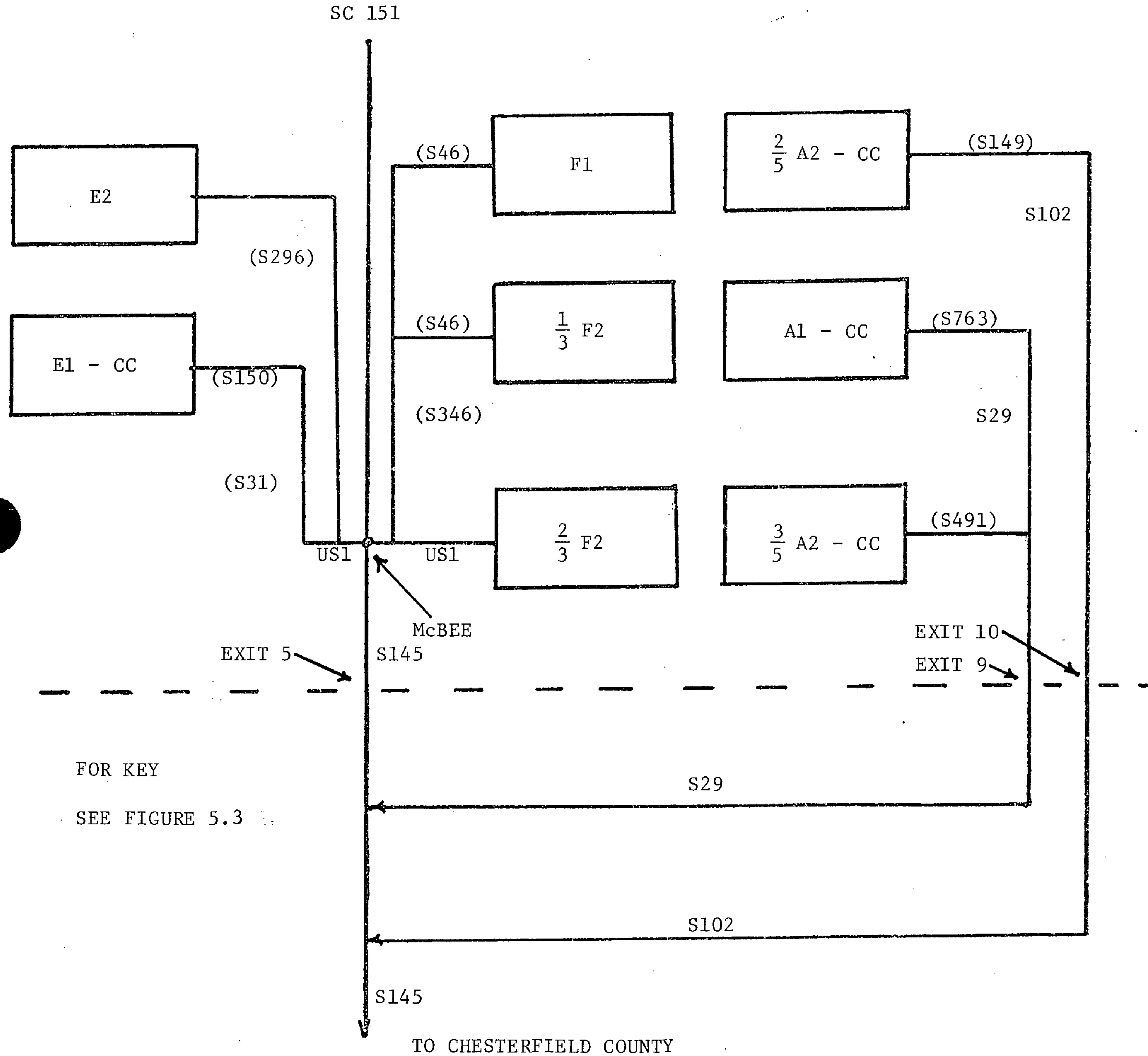


FIGURE 5.4

CHESTERFIELD COUNTY

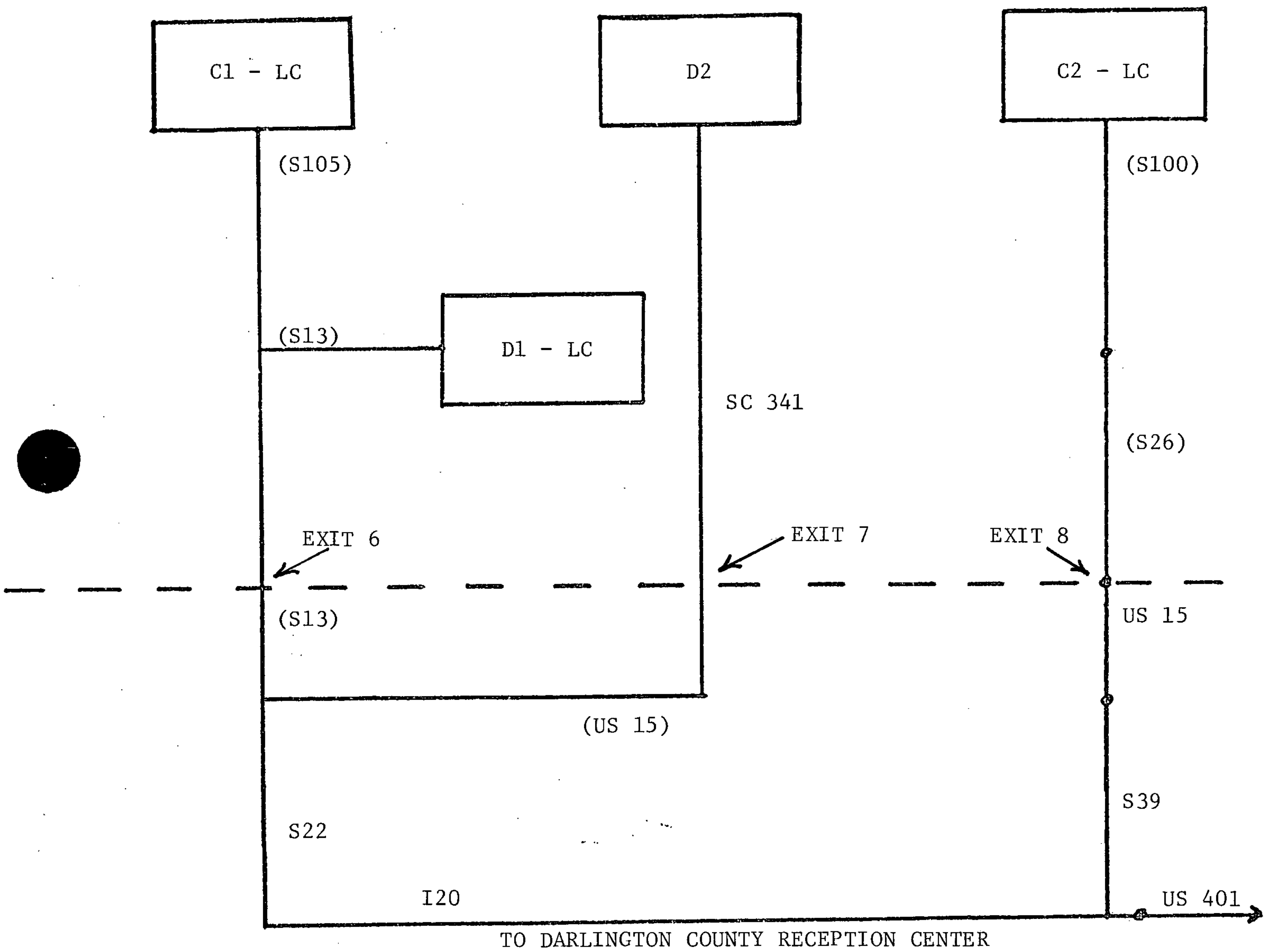


FOR KEY

SEE FIGURE 5.3

FIGURE 5.5

LEE COUNTY



FOR KEY
SEE FIGURE 5.3

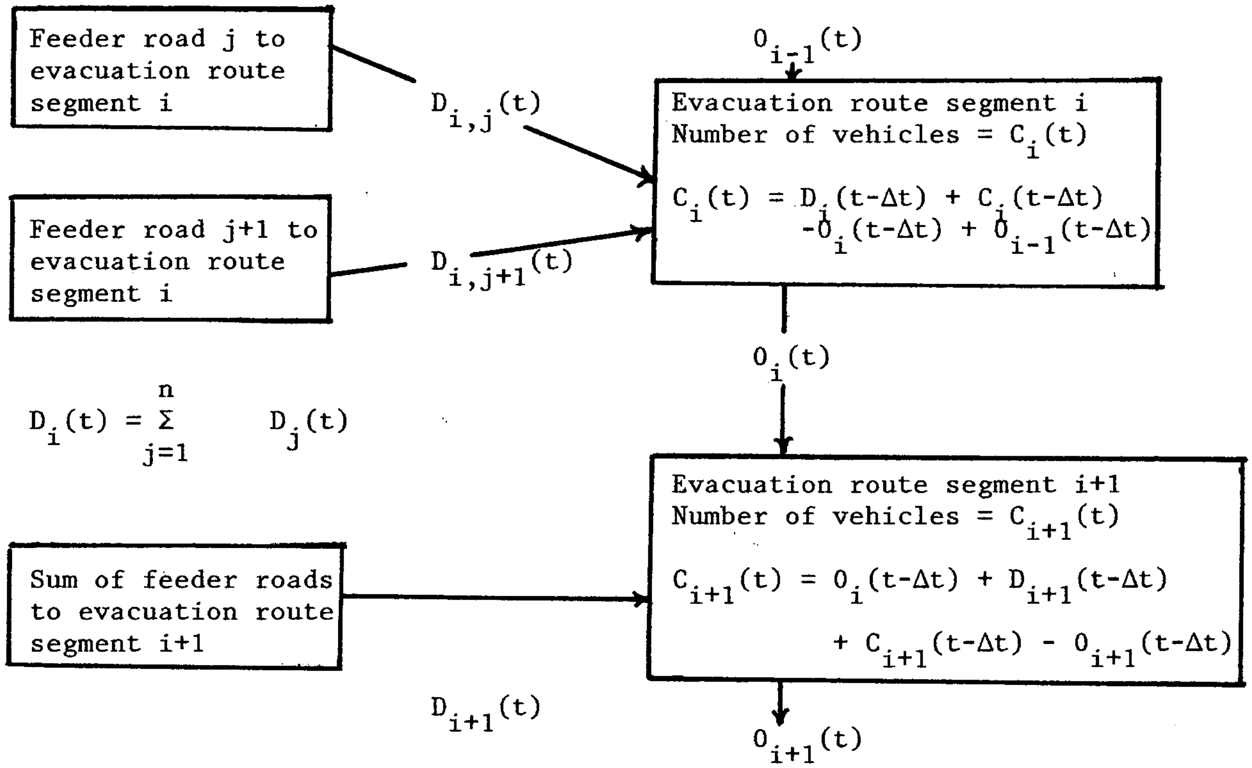


FIGURE 5.6

FLOW DIAGRAM EVACUATION MODEL

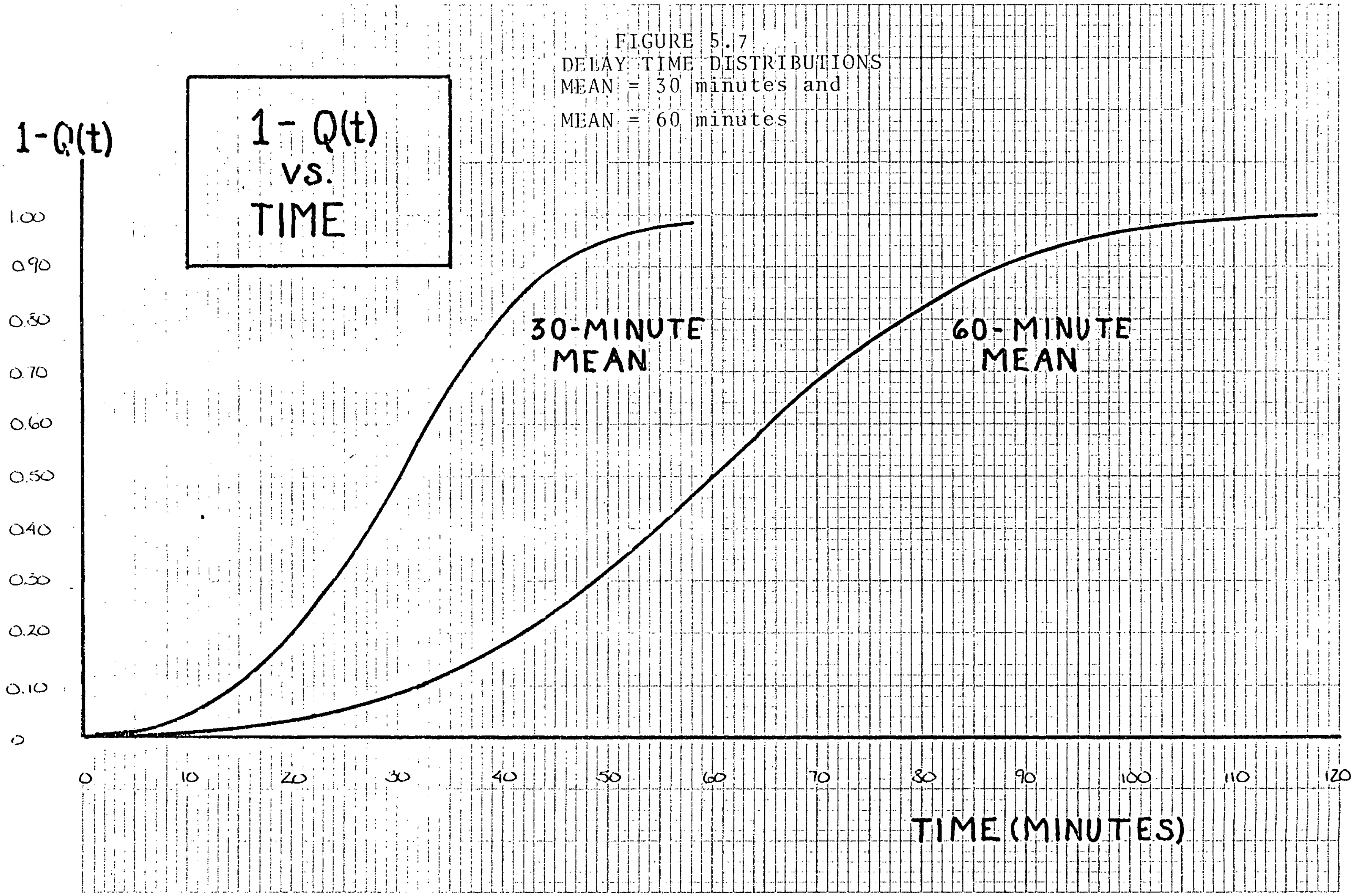


FIGURE 5.7
DELAY TIME DISTRIBUTIONS
MEAN = 30 minutes and
MEAN = 60 minutes
1-Q(t)
1- Q(t)
vs.
TIME
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
30-MINUTE
MEAN
60-MINUTE
MEAN
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (MINUTES)

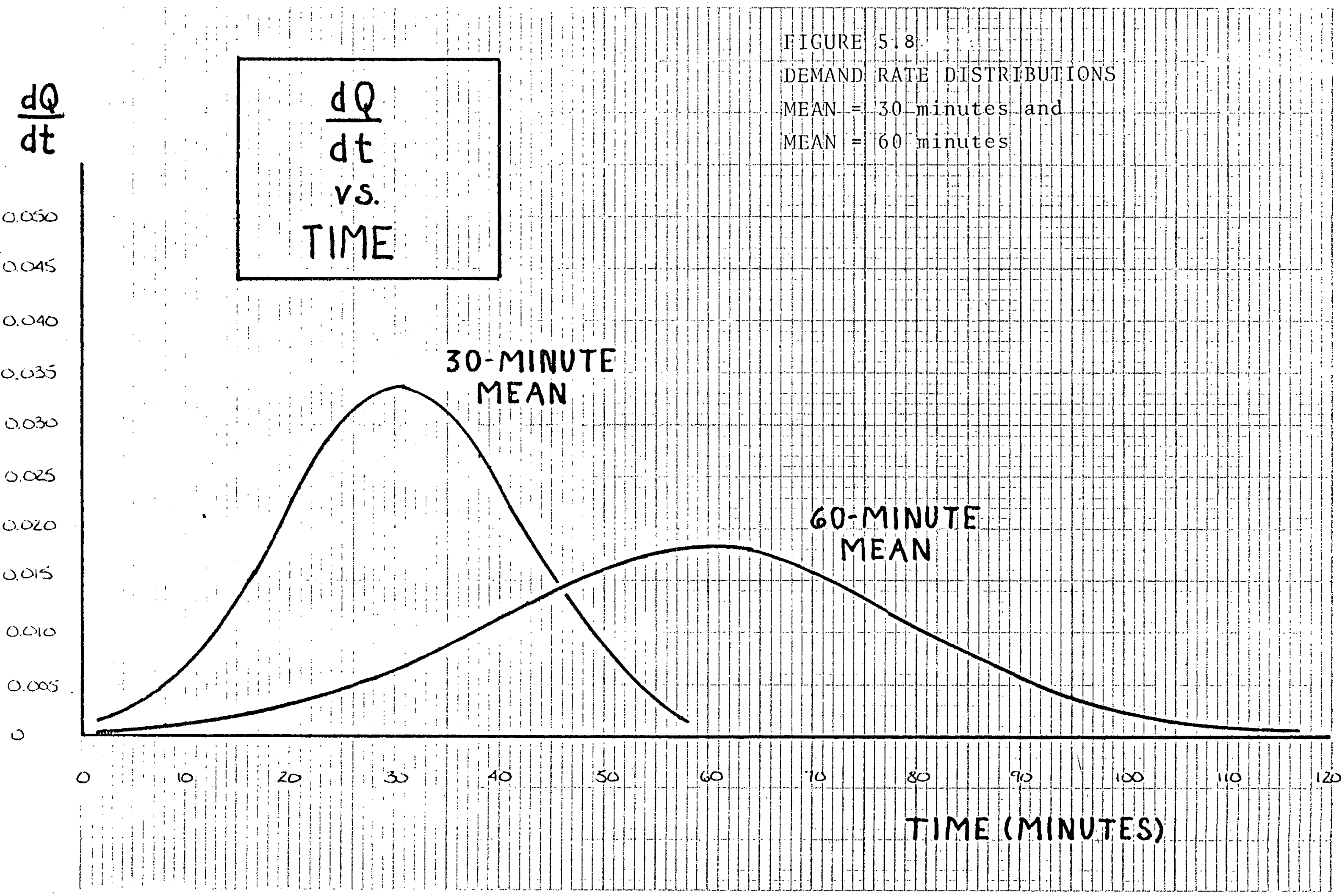


FIGURE 5.8
DEMAND RATE DISTRIBUTIONS
MEAN = 30 minutes and
MEAN = 60 minutes

6.0 RESOURCES REQUIRED TO SUPPORT AN EVACUATION AND EVACUATION CONFIRMATION

Evacuation is one of several protective actions which could be recommended by state and local officials in the event of an emergency at a nuclear facility. The use of evacuation requires specific resources which are separate from resources required to support functions that are carried out by the onsite emergency organizations. The resources required to support an evacuation of the Robinson 10-mile EPZ assuming the alerting and notification process is completed and the time required to confirm an evacuation are discussed below.

6.1 Evacuation Support

The resources required to support the evacuation fall into two categories: (1) traffic control and (2) special vehicles. Regarding control of traffic, analysis of the evacuation assumed that all of the vehicles flowed to one of ten locations. To achieve this would require, in reality, some form of traffic control at essentially each intersection in the EPZ, which is impractical. An alternate approach is to provide traffic control at major intersections along the routes that funnel vehicles to the exits. Traffic control would also be required along Business Route SC 151 in Hartsville. The total requirements for traffic control is within the capability of the South Carolina Highway Patrol which can assign up to 25 vehicles to this function.

The special vehicles required for transportation in the event of an evacuation have been listed separately in other sections of this report. They are summed below:

- School Buses: 150
- Ambulances: 44

6.2 Evacuation Confirmation Times

Evacuation confirmation time is dictated by three parameters: (1) the number of road miles in the EPZ that must be covered, (2) the number of houses that must be checked, and (3) the number of vehicles available for this function. These numbers have been compiled for each county and for Hartsville and McBee as shown in Table 6.1. The confirmation times assume that a vehicle spends one minute at each house. The speed between homes was varied depending on the density of homes per road mile. The vehicles available column is taken from the totals of number of vehicles available to respective county sheriff departments or city police forces.

TABLE 6.1

EVACUATION CONFIRMATION TIME PARAMETERS

Location	Miles of Street on Roads	Number of Houses	Speed Between Homes (mph)	Effort in Vehicle-Hours	Vehicles Available	Confirmation Time (Hours)
Hartsville	56	2,900	5	60	11	5.5
Darlington Co.	263	5,675	10	130	31	4.2
McBee	14.4	284	5	7.6	2	3.8
Chesterfield Co.	188	700	30	17.5	16	1.1
Lee Co.	68.2	394	20	9.9	12	0.8