SURRY NUCLEAR POWER STATION

ESTIMATION OF EVACUATION TIMES

Prepared for

VIRGINIA ELECTRIC AND POWER COMPANY

Prepared by

PRC VOORHEES
7798 Old Springhouse Road
McLean, Virginia 22102

March 1981

PERSONAL PRIVACY INFORMATION
DELETED IN ACCORDANCE WITH THE
FREEDOM OF INFORMATION ACT

TABLE OF CONTENTS

Table of Contents, Continued

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

STUDY OBJECTIVES

This report describes the estimates of time required to evacuate the population from about a 10-mile radius of the Surry Nuclear Power Station.

Two objectives are served by this analysis:

- An assessment of evacuation times to serve the state and local emergency civil preparedness agencies in selecting appropriate public protective action during an emergency.
- To indicate potential problem areas in the event a mass evacuation is necessary and thus provide a focus for review of manpower and other resources required to effect an effective area evacuation.

LOCATION OF THE SURRY STATION

The Surry Nuclear Power Station is located on the James River in the northeastern portion of Surry County, Virginia, approximately 46 miles from Richmond and 25 miles from the urban concentrations of the Tidewater area. (See Figure 1.)

LOCAL PREPAREDNESS AND EVACUATION PLANNING

An evacuation time estimate assumes that an effective local preparedness plan is in operation. Among the elements of such a local preparedness plan, some of the more critical elements are identified:

- Detailed evacuation plans, addressing notification, routing, manpower and resource requirements, confirmation of evacuation, and transportation of non-vehicle-owning population (schools, non-auto-owning households and persons in institutions)
- Local notification procedures and hardware, including sirens, public address and telephone notification, and procedures for broadcasting radio and television information

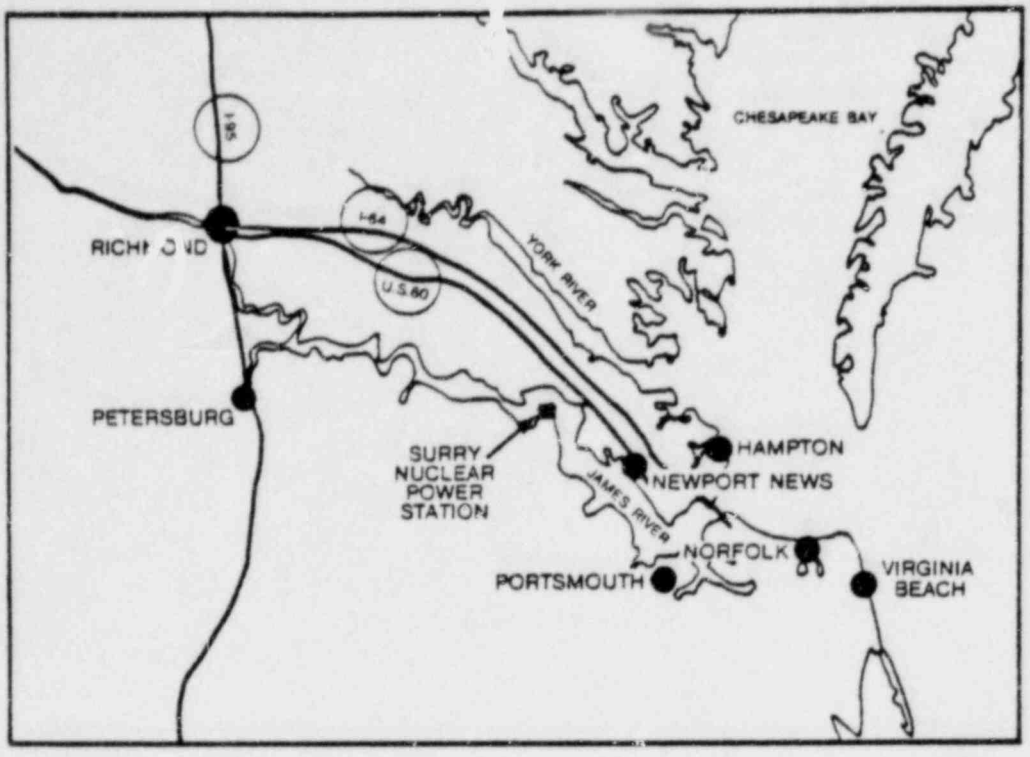

Figure 1. Location of the Surry Nuclear Power Station

- Communication within the EPZ, and between the Surry Station, State Emergency Preparedness Agency and communities, and within the communities themselves
- Local mobilization and decisionmaking
- Detailed traffic control plan
- Securing buses for transporting the school population
- Securing buses and other vehicles for transporting non-auto-owning households and persons in institutions
- Securing ambulances for non-ambulatory populations
- Reception centers and procedures for clearing evacuated population through them
- Manpower (traffic control, supervisory, security emergency services) for conducting the evacuation

The existing local Radiological Emergency Response Plans (December 1980) address most of the critical elements outlined above.

THE EMERGENCY PLANNING ZONE (EPZ) BOUNDARY

The Surry Station EPZ boundary is defined almost entirely along major roadways or arterial streets in the area. The geographic extent of local jurisdictions precluded the effective use of municipal boundaries in defining the EPZ.

SUMMARY OF ESTIMATING TECHNIQUE

The method used in developing evacuation time estimates is based on separating the population into segments, according to how they evacuate the area. For each population segment, a series of discrete action steps is defined, and the completion times for each step determined.

These times for completing each step are then linked together statistically to yield the total evacuation time for that population segment.

Two cases of evacuation time estimates are made:

1. For evacuation during a summer Sunday when temporary (tourist) population is greatest
2. For evacuation on a winter weekday when schools are in session

SUMMARY OF EVACUATION TIMES

On a summer Sunday all evacuation routes on the north side of the James River will be congested during a general area evacuation. The total evacuation time of 5:15 hours will be determined by the capacities of the individual routes out of the area. On the south side of the James River, with little or transient travel, the evacuation time is determined by the expected rate at which local residents receive the emergency notification information and the rate at which they can prepare to leave home. The estimated evacuation time for the area south of the James River is 2:15 hours.

During the wintertime, when there are few or no transients in the area, the evacuation on most routes is determined by the rate at which the population can be prepared to leave home. Notable exceptions to this are the evacuation of the concentrated populations in Newport News and Williamsburg. In these areas, roadway congestion will develop on the local roads leading to the major evacuation routes. With more road capacity available for fewer cars (i.e., no transient traffic) the estimated evacuation time is 3:45 hours on a winter weekday.

II. CHARACTERISTICS OF THE SURRY STATION VICINITY

HIGHWAY SYSTEM IN THE SURRY STATION VICINITY

Some important features of the highway system and highway travel in the 10-mile area of the Surry Station (Figure 2) are noted.

- The James River traverses the emergency planning zone from northwest to southeast. There are no bridges crossing the river within the EPZ. The areas north and south of the river are thus separate and distinct areas.

- An intercity major trunk highway, I-64, runs along the north side of the river. This facility is of major significance in both local and interregional travel.

- Two other primary highways, U.S. 60 and State Route 143, run generally parallel to the interstate route. These highways serve a predominantly local travel function.

- Other travel facilities in the area north of the river are essentially routes that feed into the major arterials noted above. One major local traffic distribution facility is the Colonial Parkway. This is a freeway-type facility that provides access to the historic centers in the area.

- On the south side of the river, the road facilities are typically local land access facilities without any major trunk facility alignments.

EXSITING TRAFFIC VOLUMES

The existing traffic volumes suggest some distinct patterns:

- Major traffic flows exist on I-64--20,000 average daily traffic (ADT) in the Williamsburg area, and 35,000 ADT in Newport News.

- On U.S. 60 and State Route 143, maximum traffic flows occur within the urban portions of Newport News. In the Williamsburg area, those facilities have an average daily volume of 10,000 to 12,000. Outside the urban areas the ADT's on these routes is about 5,000.

- On the south side of the river, the traffic volumes are typical of rural access roads in sparsely populated areas with volumes generally about 2,000 to 3,000 or less.

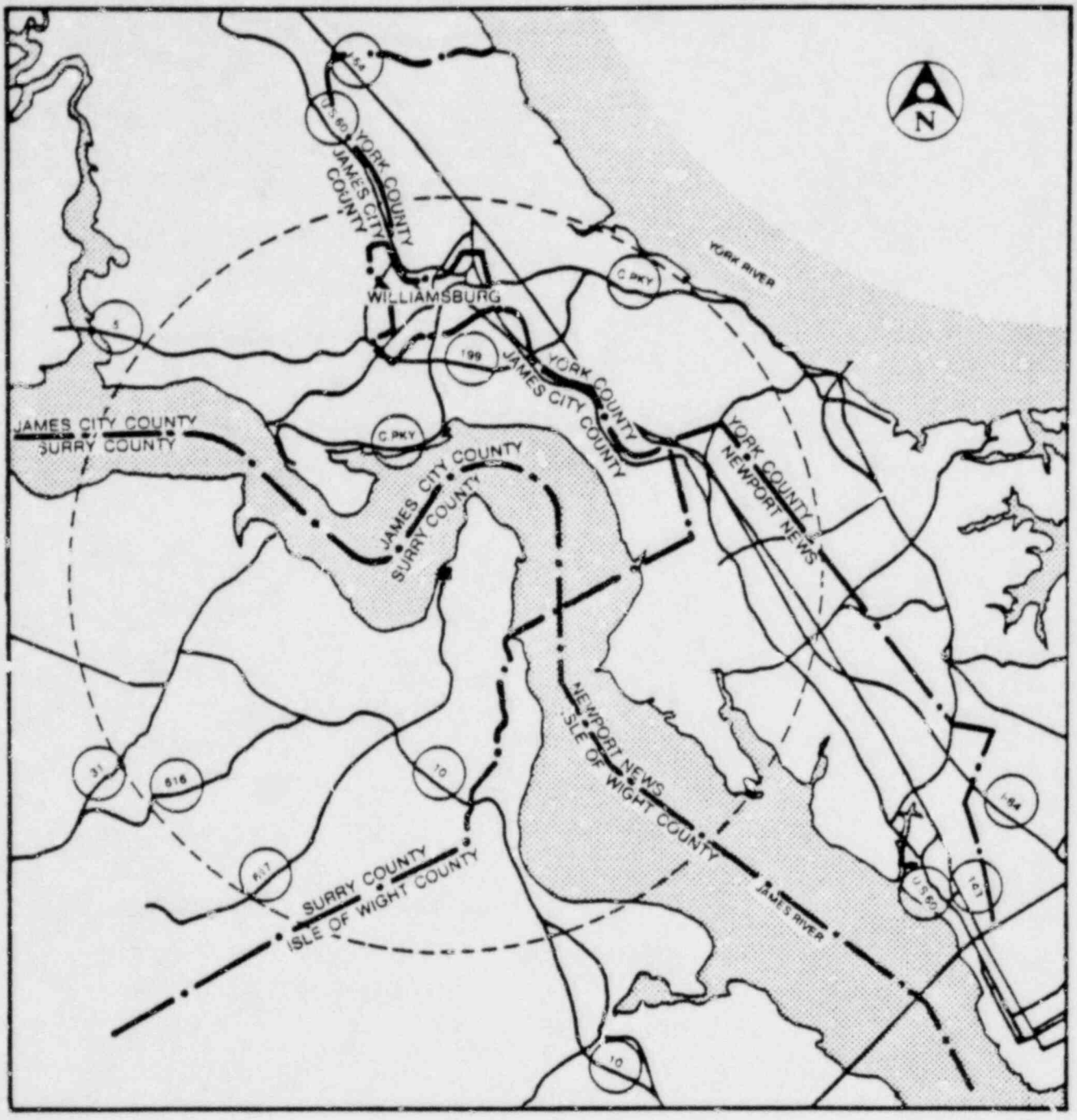

Figure 2. Highway System in the Vicinity of the Surry Power Station

SPECIAL FACILITIES IN THE SURRY STATION EPZ

Special facilities in the EPZ include hospitals, large recreational attractions, educational institutions, and military establishments.

Two hospitals, Williamsburg Community Hospital and Eastern State Hospital, are located in the Williamsburg area.

The College of William and Mary is the only major educational institution in the Surry EPZ which contains a significant population of resident students.

Three military establishments, Fort Eustis, Naval Weapons Station and the Naval Supply Depot, are located within the EPZ. The combined daytime population of these military establishments is about 7,000 persons.

Major recreational facilities in the EPZ are Busch Gardens, Colonial Williamsburg, and historical parks in Jamestown and York County. The summer peak transient population within the EPZ is estimated to be about 55,000 persons.

III. POPULATION OF THE SURRY STATION EPZ

TOTAL POPULATION CHARACTERISTICS

The total permanent resident population of the Surry Station EPZ,[1] is 86,617 persons (Table 1). This population is distributed to 23,400 households.

TABLE 1. TOTAL RESIDENT POPULATION OF THE SURRY STATION EPZ (1980 PRELIMINARY CENSUS DATA)

Government Unit	Population within the EPZ	Households within the EPZ*
James City County	16,502	4,583
York County	8,584	2,384
Williamsburg	11,644	3,234
Newport News	45,300	12,583
Isle of Wight	900	250
Surry	3,687	1,024
TOTAL	86,617	24,058

* Estimated on the basis of U.S. Census Household Size Data.

The distribution of the population over the EPZ is quite varied. Major population concentrations exist in the Williamsburg and Newport News sectors of the EPZ. The balance of the area is rather sparsely populated. Only about five percent of the area resident population is located on the south side of the river in Surry County and Isle of Wight County.

1. As defined in: Commonwealth of Virginia, Emergency Response Plan -- Radiological Emergency Response Plan, June 1980.

On the north side of the river, about one-half of the EPZ population resides in the City of Newport News.

Seasonal and Transient Population

During the summer months, the population of the EPZ is greatly increased by transient persons visiting the area for short periods of time (overnight or day trips). Under peak conditions on a summer weekend, 55,000 seasonal and transient persons are added to the permanent population of 86,600. This additional population is concentrated at Busch Gardens, Colonial Williamsburg, and the historical parks.

The greatest concentration of transients occurs at Busch Gardens where peak attendance may amount to 35,000 persons. The transient population at Busch Gardens varies by time of year. During the winter period from late October to April, the park facilities are closed to the public.

Other key visitor attractions in the area are Colonial Williamsburg and the Colonial Historical Parks. Peak attendance at the Historical Parks is estimated at 1,500 persons. At Colonial Williamsburg, the peak attendance is estimated at 15,000 persons.

AUTOMOBILE OWNERSHIP

Table 2 shows the distribution of auto-owning and non-auto-owning households in the Surry Station EPZ. Some patterns of auto ownership of interest in estimating evacuation times are noted:

- Sixteen percent of the households in the EPZ do not own an auto.
- Nearly three-quarters of the non-auto-owning households are in Newport News and Williamsburg. These two areas also have two-thirds of the EPZ area population.
- Relatively few non-auto-owning households are in the rural areas.

TABLE 2. AUTO OWNERSHIP IN THE SURRY STATION EPZ

Government Unit	Households With Auto Available				Population Without Auto Available
	0	1	2	3+	
James City County	628	2,502	1,319	133	1,256
York County	150	1,135	970	128	300
Williamsburg	495	1,901	727	110	990
Newport News	2,315	6,077	3,674	516	4,630
Isle of Wight	54	133	57	6	104
Surry	205	568	225	26	410
Total	3,847	12,316	6,972	919	7,690

The transient population is, for purposes of evacuation time estimation, assumed to be 100 percent auto-owning. Those transients that visit the area by bus travel virtually exclusively by charter bus and thus have "private" transportation.

The seasonal population (for example, the student body at the College of William and Mary) has a large public transport-dependent component. With an estimated private auto fleet on campus of about 800 and a total staff and student body of 8,500, the non-car-owning individuals are in excess of 7,500 persons.

POPULATION SEGMENTS AS DEFINED FOR EVACUATION ANALYSIS

In estimating evacuation times, four population segments are identified on the basis of how persons are evacuated from the EPZ:

- Auto-owning population. This population segment consists of all members of car-owning families, except children at school at the time of a general emergency.
- School population. All children at school at the time of a general emergency, regardless of automobile ownership status of their families.

- Non-auto-owning households. All persons (except school children) in households where a car is not reasonably available for evacuation.

- Population in institutions such as hospitals and nursing homes, etc. and not having access to a private vehicle for evacuation.

Rearranging the EPZ population into these categories (Table 3) reveals that:

- Most of the population (76 percent) is in the auto-owning segment.

- The next largest segment is the school population, accounting for 13 percent of the population.

- The non-auto-owning population accounts for 9 percent of the Surry Station EPZ inhabitants.

- The institutionalized population comprises 2 percent of the total population.

TABLE 3. SURRY STATION EPZ POPULATION BY SEGMENTS

Population Segment	Population[1]	Percent of Total Population
Auto-owning Population[2]	65,747	76
School Population[3]	11,820	13
Non-Auto-Owning Population	7,690	9
Population in Institutions[4]	1,360	2

1. Permanent population. Seasonal and transient population of 55,000 persons not included.

2. Auto-owning population excludes school children.

3. All school children regardless of car-owning status of their households.

4. Does not include nursing homes.

IV. THE EVACUATION SEQUENCE FOR SURRY STATION

GENERAL CONCEPT OF EVACUATION

The overall purpose of the evacuation is simply to remove the population of the EPZ as rapidly as possible. The evacuated population is directed to reception centers, where it is temporarily lodged or reassigned to other mass care facilities.

Wherever possible, the evacuating population will leave the EPZ by means of private automobiles. Persons without automobile transportation will be transported by transit vehicles, ambulances and other available vehicles.

In general, motorists will leave the EPZ by the most direct route; that is, the shortest route out of the EPZ. Traffic direction at key locations will help balance the traffic volumes on the evacuation routes. Normal traffic flow will generally be observed, with most or all streets open to all vehicles and functioning in their usual manner.

In estimating evacuation times, the EPZ population is grouped according to how it evacuates: (1) auto-owning population; (2) school population; (3) non-auto-owning population; and (4) persons in institutions.

Each of these groups follows a different sequence in evacuating:

- The auto-owning population, after receiving the notice to evacuate, assembles the family (except for children at school) at home, prepares for evacuating the home and drives out of the EPZ. Non-residents (for example, Park visitors) simply assemble the group with which they are traveling, and leave the area.

- The school population is transported out of the EPZ directly from the schools. School buses are used to evacuate this population.

- Non-auto-owning households prepare for leaving their home, assemble at collection locations, and are then transported out of the EPZ in buses or other vehicles.

- Persons in institutions (hospitals, etc.) are prepared for evacuation, then transported out of the EPZ in buses and ambulances.

POSSIBLE EVACUATION TIME PERIODS

The length of time needed for evacuation of the Surry Station EPZ will vary, depending on the time of day, day of week and season of year in which the evacuation occurs. Four possible time periods are identified:

- Nighttime
- Daytime on a summer weekend ("Summer Sunday" case)
- Daytime on a winter weekend
- Daytime on a "winter weekday" case

In estimating evacuation times, the "worst cases" of these four time periods should be adopted; that is, evacuation time estimates should reflect conditions likely to cause the longest evacuation times.

Nighttime Evacuation

In a night evacuation, the notification process would be slowed by people having to wake up and comprehend the evacuation information being broadcast. Additional time would be required to prepare vehicles for evacuation in the dark. On the other hand, for most segments 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.

Daytime on a Summer Weekend ("Summer Sunday" Case)

In any daytime evacuation, the notification time is at a minimum, since most people are awake, and many are already listening to radio and television broadcasts. Families are more likely to be at the same location on weekends, since schools are not in session and relatively few persons are at work. Outdoor recreation is at a peak during this season, and many non-residents are at the recreational areas.

Daytime/Weekday Evacuation ("Winter Weekday" Case)

During a daytime/weekday evacuation, a majority of the employed population would be on the job. During most of the year, schools are in session and the transportation of students becomes a large issue in any evacuation. For much of the population, a daytime/weekday evacuation creates additional action steps, since families must be assembled prior to leaving the home and evacuating the EPZ. Also, during the daytime/weekday period, the likelihood of persons being away from home without a vehicle are greatest.

Critical Time Periods

For the evacuation of the Surry Station EPZ, the critical time period--that is, the period for which evacuation is likely to require the most time--is the "Summer Sunday". During this period, the population and vehicle accumulation in the EPZ is at a maximum.

The next most critical time period is the "Winter Weekday" period. During this period, the time needed to assemble family units is likely to be at its maximum. Furthermore, the daytime/weekday periods raises issues of school population evacuation which do not exist in other time periods.

Separate evacuation time estimates are prepared for both of these time periods, i.e., for "Summer Sunday" and "Winter Weekday".

POPULATION SEGMENTS TO BE EVACUATED

As a first step in estimating the evacuation times for the Surry EPZ, its population is divided into segments by HOW that segment leaves the EPZ (see Section IV).

Family Units

Families (excluding children in school) are evacuated as units. On weekdays, assembly of the family units involves members returning 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, Park 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 action steps. These are clearly defined actions, performed in a predictable sequence (see Figure 3).

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 process permits the estimation of time for each individual step, for most of which data are readily available.

Public Agency and Private Steps

Some of the evacuation steps identified in Figure 7 are performed by public agencies. For all population groups, the "Evacuation Notice" 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 evacuation step; for example, "Evacuate School Population in Buses", "Evacuate Non-Auto-Owning Households in Buses", etc. For the population 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 auto-owning population, all steps after the initial "Receive Broadcast Information" are private actions; that is, they are initiated by the individuals being evacuated. Similarly, two of the steps in the evacuation of non-auto-owning households are private steps.

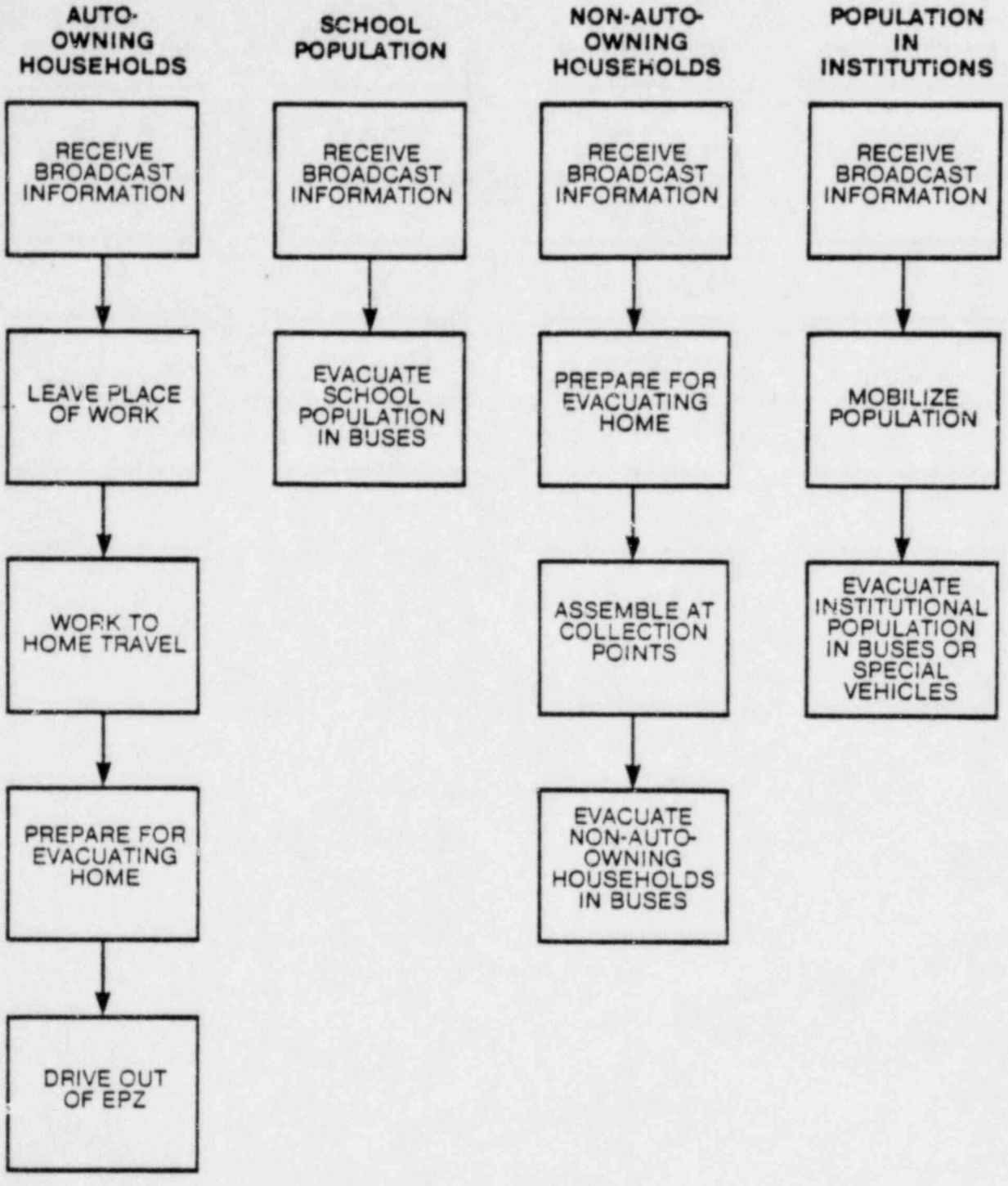

Figure 3. Population Segments and Evacuation Sequences

EVACUATION OF AUTO-OWNING POPULATION

The action steps described in the following sections describe the sequence of evacuation for resident auto-owning households, evacuating the area during the daytime/weekday period. For some other components of the auto-owning population, the sequence is shortened and certain action steps are omitted. For example, the transient population does not need to return home from work, nor to prepare for leaving a household. In the calculation of evacuation times, only those action steps appropriate to the population component are included.

Receive Broadcast Information

Following the decision to evacuate, the first activity is the notification of the public that an emergency exists. This is accomplished either by the sounding of sirens, or activation of other alert systems (such as NOAA), or through the use of mobile PA units. This notification alerts the public that an emergency exists, and that they should tune in to radio and television broadcasts for further information.

The next activity is the broadcast of radio and television information, with specific instructions for evacuating.

Leave Place of Work

The rate at which 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 machinery, 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 essentially a normal journey-to-work travel time distribution. The maximum trip length for work trips in the EPZ is not likely to exceed 20 miles, and the average trip is less than three miles. An average travel speed of 20-30 miles per hour is typical for the travel home for area workers.

This movement of workers, because of the short time over which it occurs, can be expected to cause some traffic congestion. This level of congestion should be similar to that occurring during the twice-daily work travel peak. It is expected that the road system will 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 the conditions imposing an evacuation need on the area population are likely to generate great differences in the amount of time that people will spend in preparing to leave their home. Three factors in particular affect the amount of time needed to prepare for evacating 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 at 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, for example, in apartments, can be prepared for evacuation in minutes.

Travel Out of the EPZ

After households are secure, auto-owning households will drive out of the EPZ by the most direct routes available.

The auto-owning population will drive either to reception centers established outside the EPZ, or to other destinations (primarily homes of friends and relatives) of their own choosing.

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. Police officers will also channel flows of traffic out of the EPZ.

During the evacuation, normal traffic operations will generally prevail. Specifically, two-way streets will continue in two-way operation, traffic signals will continue to function, and so forth. Some modifications might be made; for example, some three-lane roads may be operated in an "imbalanced" manner, with two lanes flowing out of the EPZ and only one lane used for inbound traffic.

During much of the evacuation, traffic will be only moderately congested. However, at several locations and during certain periods, significant traffic congestion and delays are expected.

EVACUATION OF SCHOOL POPULATION

Receive Broadcast Information

Following the decision to evacuate, the local preparedness agencies notify schools directly of the need for evacuation. This is done through radio warning systems and telephone calls directly to the schools.

Evacuate School Population in Buses

The school population is transported directly by bus from school to mass care centers. Generally, 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 families is discouraged.

School bus fleets from all districts within the Surry EPZ and from neighboring districts within about a 20-mile distance of the EPZ will be used for evacuation. All school buses used in these districts, whether publicly or privately owned, will be used to evacuate students from the EPZ.

NON-AUTO-OWNING HOUSEHOLDS

Receive Broadcast Information

The procedure for receiving broadcast information is the same as for the auto-owning population (above). This may include the sounding of sirens or mobile public address and possibly some direct notification by telephone calls.

Prepare for Evacuating Home

This step is the same as for the auto-owning population (above). As in the case of the auto-owning population, primary factors in the time required for this action are 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.

Assemble at Collection Points

A significant fraction of the non-auto-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-auto-owning population could then be considered, in effect, as part of the auto-owning population.

Persons from non-auto-owning households who do not evacuate as passengers in private vehicles will assemble at locations (for example, churches and public buildings) designated as collection points. From the collection points, buses will transport them to the reception centers.

Most of the population in settled areas lives within one mile of a collection point, and the majority of this population will walk there. Persons unable to walk to the

collection point will, by telephone, request transit service from their homes to the collection point. The rural non-auto-owning population will be taken to collection points in transit vehicles and in some cases, automobiles.

Evacuate Non-Auto-Owning Households in Buses

Transit buses will pick up evacuees who have assembled at the collection points, and take them to the reception centers outside the EPZ.

Potential sources of buses include private common carrier fleets, public transit systems from within the EPZ, and public transit systems from outside the EPZ, particularly from the Tidewater urban area.

POPULATION IN INSTITUTIONS

Receive Broadcast Information

Following the decision to evacuate, the local preparedness agencies will notify institutions directly about the need to evacuate. This is done by radio warning system or telephone calls.

Mobilize Population

The institutional population is instructed about evacuation procedures 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

Transit buses will pick up ambulatory hospital patients, nursing home residents and other persons not requiring ambulance transportation. These passengers will be transported directly to specially designated reception centers. Generally, all residents of a given institution will be evacuated to the same reception center. Potential sources of buses include private common carrier fleets, public transit systems

within the EPZ and public transit systems from outside the EPZ, particularly from the Tidewater urban area.

Non-ambulatory persons will be transported directly from institutions by ambulance. These vehicles will be drawn from the fleets normally based within the EPZ, supplemented by ambulances from neighboring communities.

SUMMARY OF THE EVACUATION PROCESS

In order to examine the "worst case" for which evacuation times are not a maximum, the evacuation is assumed to occur during the daytime on a summer weekend. The next most critical period, daytime on a winter weekday, is also examined.

Four population groups, having distinctly different evacuation methods, are recognized.

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	ACTIONS STEPS AND DESCRIPTION
Auto-Owning Population (All members of households, except school children, having a private vehicle available for evacuation)	1. RECEIVE BROADCAST INFORMATION, 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. DRIVE OUT OF THE EPZ in private vehicles, using most direct routes
School Population (All persons in schools, whether public or private)	1. RECEIVE BROADCAST INFORMATION, including instructions for evacuating 2. EVACUATE SCHOOL POPULATION IN BUSES from districts in EPZ and other sources
Non-Auto-Owning Population (Persons not having a private vehicle available for evacuation)	1. RECEIVE BROADCAST INFORMATION, including instructions for evacuating 2. PREPARE FOR EVACUATING HOME (close house, secure property) 3. ASSEMBLE AT COLLECTION POINTS such as churches or public buildings 4. EVACUATE NON-AUTO-OWNING POPULATION IN BUSES from EPZ and other sources
Persons in Institutions (Hospitals, nursing homes, Naval Base, etc.)	1. RECEIVE BROADCAST INFORMATION, including instructions for evacuating 2. MOBILIZE POPULATION, prepare population for evacuation 3. EVACUATE INSTITUTIONAL POPULATION IN BUSES OR SPECIAL VEHICLES

* These steps omitted by non-residents; for example, Park visitors.

V. EVACUATION ROUTES

GENERAL STRATEGY OF EVACUATION ROUTING

This chapter considers the evacuation of the largest population segment of the EPZ -- those using private automobiles. The basic objective of evacuation routing for automobile traffic is to permit vehicles to exit as rapidly as possible from the EPZ. The overall evacuation strategy is derived from key geographic features of the EPZ such as the location of the Surry Nuclear Power Station and the constraint on north-south movement presented by the James River, as well as from the characteristics and configuration of the road network. The basis of the strategy is the evacuation of principal year-round population centers by the most direct movement possible. The major components of this strategy are illustratred in Figure 4 and summarized below:

- Newport News, the largest population concentration of the EPZ, should be evacuated directly to the southeast.
- Williamsburg, the second ranking population center, should be evacuated directly to the northwest.
- The southern half of the EPZ should be evacuated both to the west and to the southwest.
- The major population concentration at Busch Gardens is to be distributed onto three major travel arteries, I-64, Route 60 and Route 143.

These major movements define the corridors for evacuation of the population of the EPZ. Clearly, this strategy provides for the separation of the major flows which is important to the minimization of traffic conflict.

ROAD NETWORK FOR VEHICLE EVACUATION

The characteristics of the road system within the EPZ were presented in Chapter II. A capsule description of the facilities available for evacuation traffic would note that the EPZ is served by a full range of facility types that includes one interstate highway, Federal primary system routes as well as primary and secon-

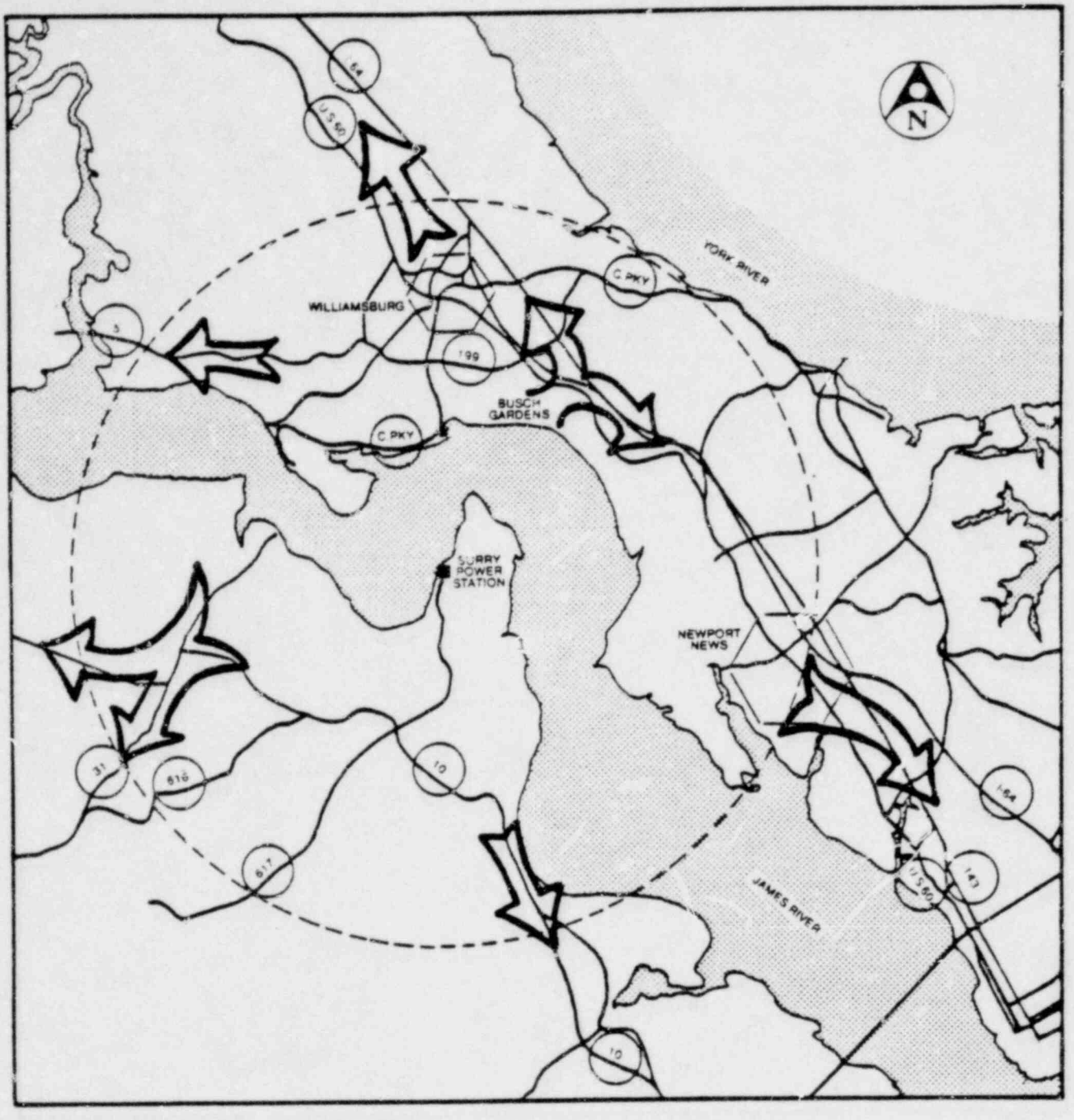

Figure 4. Evacuation Routing Stategy

ary state roads. The major facilities, I-64 and Route 60, are continuous and offer high capacity for traffic exiting the area to the northeast and southwest.

Figure 5 identifies the "gateway" points where roads cross the boundary of the EPZ. This set of fifteen gateway points represents the total roadway capacity for evacuation. In general, the capacity of a roadway is determined by the capacities of its intersections, rather than by its cross sections at the non-intersection locations. In the case of evacuation routes, capacity is likely to be determined by a "critical intersection". These are intersections that represent the "bottlenecks" on the evacuation routes. In general, they are locations at which (1) the evacuation route has a high traffic volume, after having collected traffic from various tributary roads, and (2) cross-street traffic at the intersection is significant, reducing the amount of time available for evacuation traffic to move through the intersection.

The capacity of an intersection is based on a maximum flow of 1,500 vehicles per lane hourly, with full assignment of the right-of-way (or, in other words, 1,500 vehicles hourly if there is no cross-street traffic). This capacity is then adjusted downward to reflect the demands of the cross traffic. At the critical intersections, which are establishing the capacity on the evacuation routes, the total capacity is adjusted downward to 80 percent of the maximum to reflect this cross-street traffic. The resulting capacity is 1,200 vehicles per lane per hour.

On freeways where there is no interference to traffic from side streets and driveways, capacity is 1,800 vehicles per hour, and on ramps to the freeways the capacity is 1,500 vehicles per hour.

The total capacity of the Surry EPZ gateway points is approximately 27,600 vehicles per hour. This estimate of total capacity is based upon the use of hard-surface highways and primary and secondary roads as evacuation routes, and does not include local urban streets and unpaved roads.

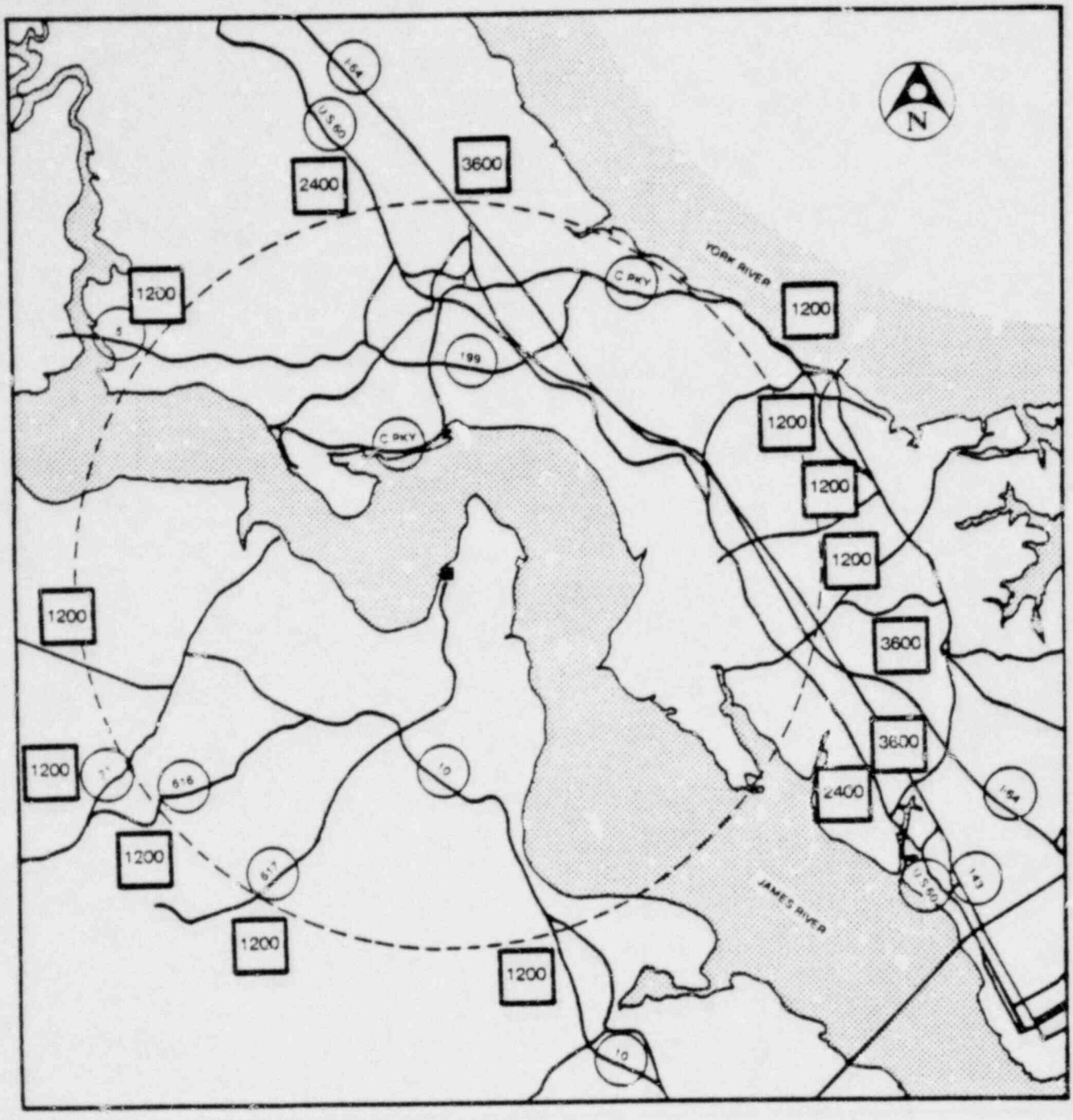

Figure 5. Evacuation Gateways and Capacities

FORECASTING EVACUATION TRAFFIC

The review of data on the characteristics of the population of the EPZ included an assessment of auto ownership patterns in the area. At this point in the analysis, we consider the generation of automobile vehicle trips for the evacuation of those households with an auto available. It is important to recognize that automobile evacuation trips and total automobiles within the EPZ are not necessarily the same.

The trip generation step is a calculation based upon the auto ownership patterns of the year-round residents and the vehicles associated with recreational visitors and seasonal residents. The patterns of auto ownership and the median household size (number of persons per household) indicate that there are households with fewer vehicles than licensed drivers and households with more vehicles than licensed drivers. Recreational vehicles, for example, are often "excess" vehicles that are used only for special purposes. The trip generation step is built up from the segments of the auto-owning population and recognizes that households with only one or two vehicles will utilize a greater proportion of their cars than households with three or more vehicles. Table 5 presents the total vehicle trips forecast for the EPZ under the two different evacuation scenarios.

TABLE 5. EVACUATION TRAFFIC ESTIMATE

	Case A: Summer Sunday		Case B: Winter Weekday	
Government Unit	Total	Peak Hour	Total	Peak Hour
James City County	17,706	16,820	5,610	4,768
York County	3,724	3,538	2,918	2,480
Williamsburg	8,925	8,479	3,958	3,364
Newport News	15,402	14,632	15,402	13,092
Isle of Wight	306	291	306	260
Surry	1,254	1,192	1,254	1,065
Total	47,317	44,951	29,448	25,029

This forecast level of auto vehicle trips averages approximately 85 percent of the estimated total number of vehicles in the EPZ. This level of vehicle utilization appears reasonable when allowances are made for vehicles being outside the EPZ at the time of evacuation, vehicles being out of service for mechanical problems, and the number of "excess vehicles" in households where there are not as many licensed drivers as vehicles.

INDIVIDUAL EVACUATION ROUTES

In order to assess the time required to evacuate the Surry EPZ, individual exit routes were developed for "watershed area" relative to the major evacuation routes. This enables a relatively "fine-grained" analysis that can be related to actual concentrations of population and the evacuation route options available to each subarea.

Individual evacuation routes are determined following these guidelines:

- The route must lead fairly directly out of the EPZ, and should not have a circuity of greater than 150 percent. (Circuity is the amount by which the actual road distance exceeds the straight-line distance).
- The routes must be at least collector streets in the urban areas, or at least paved secondary roads in the rural areas. Local urban streets and unpaved rural roads are not designated as evacuation routes.

The system of evacuation routes is shown in Figure 6. For each of the evacuation scenarios carried through the analysis, the forecast traffic volumes were assigned to the system of evacuation routes. For the purposes of this analysis, it was assumed that overall, traffic facilities would be operated in a relatively normal fashion. That is to say that few instances of special traffic management capability were assumed. Noteworthy exceptions include assumed 3-lane outbound traffic on Route 143. In addition to these operating characteristics, a relatively low-level of traffic control intervention and direction was assumed for a limited number of intersections.

Beyond this, little effort was made to balance or optimize traffic flows. It is important to recognize that individual motorists will have a very imperfect knowl-

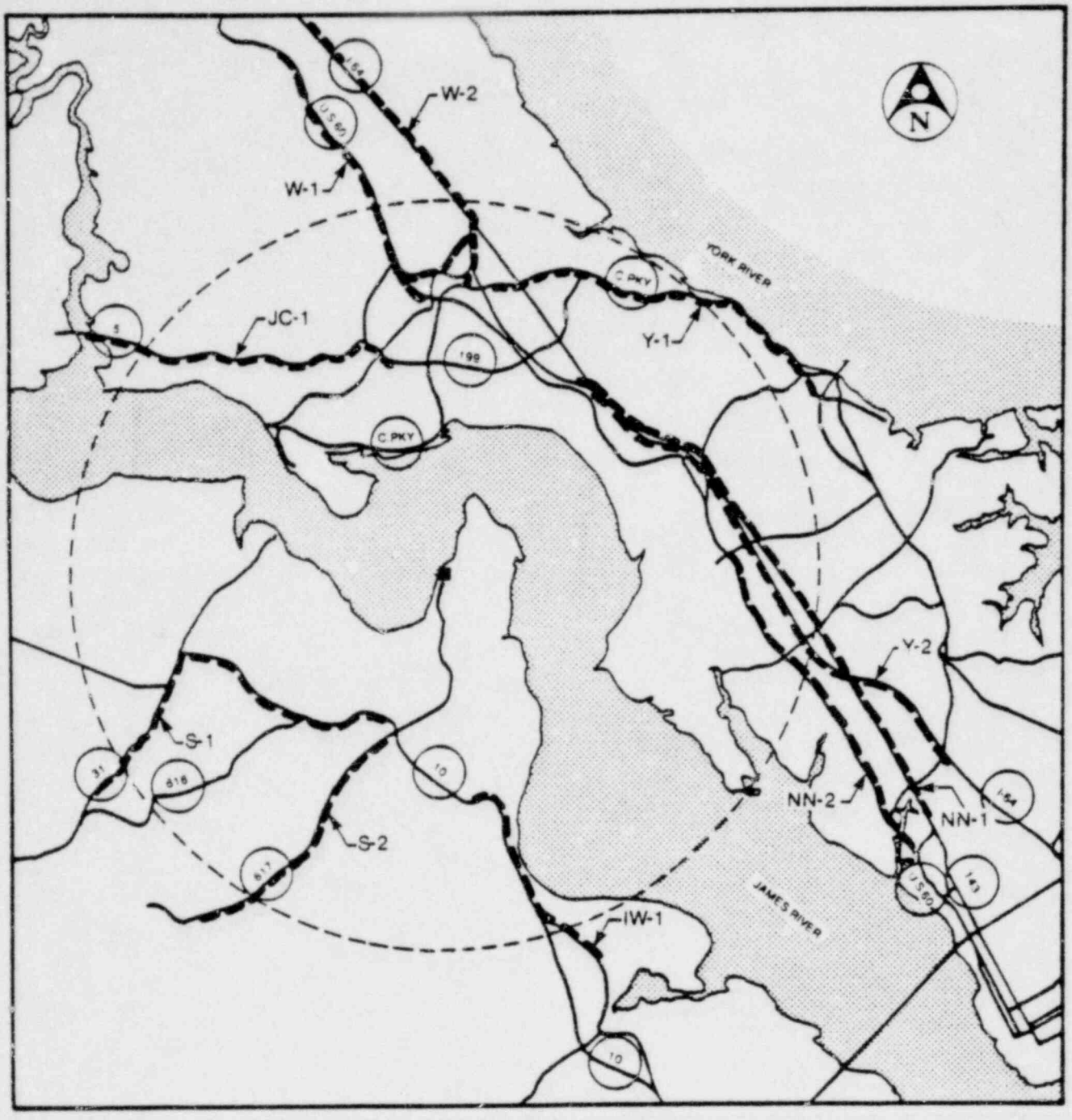

Figure 6. Evacuation Routes

edge of traffic conditions elsewhere in the region and will only have a limited set of route options for evacuation. Thus, significant imbalances and congestion are inevitable because severe peaking characteristics foreclose chances of a situation where available roadway capacity would be utilized most efficeintly. Still, it is worth noting that even under an ideal assumption of optimal traffic balance with full utilization of gateway capacity, there would be 1.7 hours of traffic flow through the gateways in the summer-Sunday case and 1.1 hours in the winter-weekday case. Of course, actual evacuation times will be much longer, reflecting the effects of "bottlenecks" and traffic congestion.

PERFORMANCE OF THE EVACUATION TRAFFIC SYSTEM

The traffic volumes forecast for the evacuation routes indicate that there will be a broad range of traffic system operating conditions under both of the evacuation scenarios. The leading characteristics of the evacuation traffic system are described generally below. A more detailed analysis of the traffic congestion and delay is provided in a subsequent chapter. An overall assessment of evacuation traffic conditions indicates that:

- The largest problems in the winter-weekday case are related to Newport New traffic. A few areas and roadways emerge as critical areas for estimation of evacuation times and traffic delays.

- The largest problem in the summer-Sunday case is in Busch Gardens traffic access to I-64. The limited nature of the transportation network leading to I-64 means that the few available evacuation routes will be swamped with traffic.

- Movement on the south side of the James River is relatively unconstrained. Analysis indicates that backups will occur but that these should be relatively limited in scope and duration because the capacity exists to accommodate anticipated peak-hour flows.

VI. SUMMARY OF EVACUATION TIME ESTIMATES

METHOD FOR ESTIMATING EVACUATION TIMES

Population Segments

Evacuation times are estimated separately for each of the four population groups discussed earlier:

1. Auto-Owning Population
2. School Population
3. Non-Auto-Owning Population
4. Population in Institutions

Time Periods

Evacuation times are estimated for two different time periods (cases) as discussed previously in Chapter V:

1. Daytime on a "Summer Sunday", and
2. Daytime on a "Winter Weekday"

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 times needed to complete each of these steps is then estimated. For the auto-owning households, for example, estimates are made for the time required for (1) receiving broadcast information, (2) leaving place of work, and so forth.

The times needed to complete each step are not expressed as a single value of time, such as an average or a median value. Rather, the times required for each step are stated as the distribution of times, relating the fraction of the population completing a particular step to the elapsed time after notice to evacuate.

Time Required for a Series of Action Steps

The total evacuation time is calculated by linking together the times required to complete the individual steps. The resulting total times for evacuations are stated, as are the times for the individual steps, as a distribution of times, showing the fraction of the population which completes the total evacuation process within a given amount of elapsed time.

Assignment of the Traffic to the Evacuation Routes

The traffic due to the evacuation of the auto-owning households is "assigned" (that is, distributed) to the available roads out of the EPZ, as shown in the previous chapter. Delays due to this traffic are calculated, and the evacuation times are adjusted to relect these delays.

EVACUATION TIMES FOR CASE A: SUMMER SUNDAY

Figure 7 shows the time needed to evacuate the population of the entire Surry Station EPZ under a summer weekend condition (that is, under Case A: Summer Sunday).

The critical population element is the auto-owning population; in other words, it is this element of the population that established the total evacuation time. Other elements of the population (for example, population in institutions) can be evacuated in a shorter time than the auto-owning population, provided that vehicles are available for their evacuation. Consequently, their evacuation does not add to the total evacuation time.

As indicated in Figure 7, the total time needed to evacuate both the transient and resident population of the entire Surry EPZ on a summer Sunday is 5 hours and 15 minutes.

The initial population element is this evacuation time is the auto-owning population; in other words, it is this element of the population that establishes the total

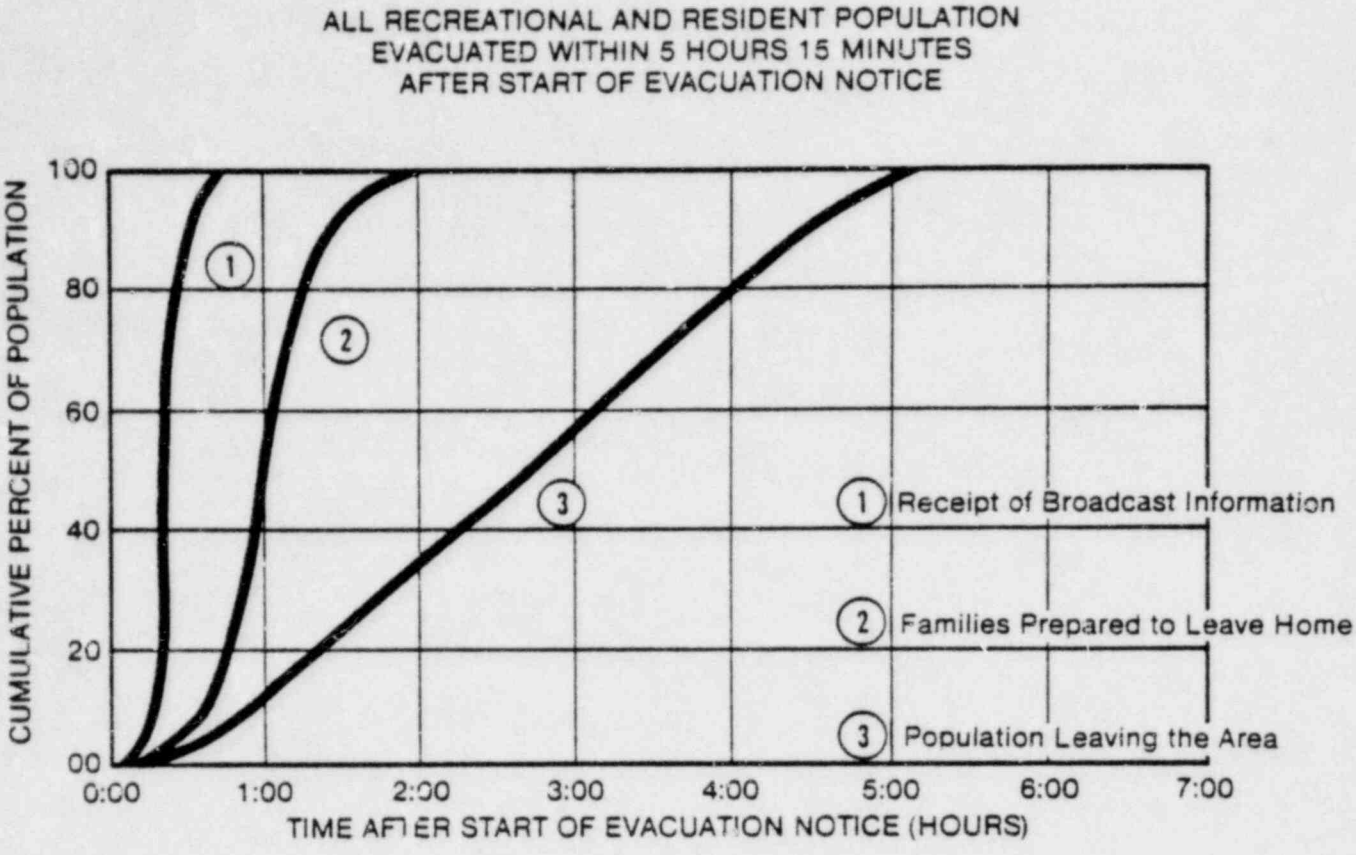

Figure 7. Evacuation Times: Case A, Summer Sunday

evacuation time. Other elements of the population (for example, population in institutions) can be evacuated in less time than the auto-owning population, provided only that vehicles are available for their transport. Consequently, their evacuation does not add to the total evacuation time.

Formation of Traffic Congestion

At numerous points within the Surry EPZ, particularly in the Williamsburg and Newport News areas, traffic backups (queues) will form during part of the evacuation process. These are caused as the auto-owning population completes the necessary preparation to leave their homes or the Parks, 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 ("bottlenecks") at which traffic demands are the greatest. Congestion then spreads rapidly from these critical intersections. Shortly after they first form, queues spread along arterial streets, blocking traffic attempting to feed in from side streets. 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 or the Parks. Motorists leaving their homes and entering the street system during such a period are simply "stored" in traffic queues in the street system. Under such conditions, increasing the speed of notification and the clearing of households and Parks does not improve the total evacuation time, but rather merely puts more vehicles into the traffic congestion.

Extent of Traffic Congrestion

The level of congestion, the length of time spent in traffic backups, and the length of these backups are quite extensive.

- Length of delays: The maximum delay for the entire Surry Station EPZ will be experienced by traffic exiting from Busch Gardens and Williamsburg. For a vehicle entering the end of the traffic congestion at its maximum, the delay will be 2 hours and 45 minutes. In other words, a vehicle entering the street system at the peak of the congestions will not move (or will scarcely move) for a period of 2 hours and 45 minutes. THis is the maximum time, which represents a worst case. Delay times for other motorists range downward from this maximum; nevertheless, the majority of the Busch Gardens and Williamsburg populations will have delay times in the order of 1 hour.

  The Newport News traffic is next in order of length of traffic delay experienced, with a maximum delay of 1 hour and 15 minutes.

- Length of Traffic Backup. In some locations, the amount of traffic that is attempting to enter the street system exceeds the space available on the road system. In other words, there is not enough space on the streeets to store the vehicles attempting to get onto the street system.

This situation is the most severe at Busch Gardens where traffic will be backed up inside the Gardens parking area.

Next in terms of length of traffic backups are Williamsburg and Newport News. However, these backups are spread over numerous local streets and are not concentrated on a single highway.

Traffic Congestion and Driver Behavior

There is considerable uncertainty as to what might happen to driver behavior in 30- to 90-minute traffic backups under circumstances such as an evacuation. The existing evidence for this type of occurrence is sketchy and uneven. In some more or less documented instances, such as evacuation after chemical spills or evacuation related to natural disasters, generally orderly traffic flow has been reported.

Some specific motorist behavior problems that could be caused by delays of the length expected in the Surry EPZ evacuation include:

- Creation of more lanes in the outbound directions; in effect, a one-way system out of the area, as motorists impatient with the length of queue simply begin using the left-hand (that is, inbound) lanes for travel out of the area. This is not necessarily a poor strategy if planned, but could be chaotic if it occurs spontaneously.

  Furthermore, if a two-lane flow must be returned to a single lane at some downstream point, then there is no advantage in the two-lane flow. To the contrary, the merging activity as the two lanes are combined into one will cause a loss in capacity relative to a single, smoothly flowing lane.

- Blocking cross streets at intersections: This is a common type of traffic disorder, even under normal traffic situations, and it can almost certainly be predicted that this will happen under evacuation circumstances, particularly since at times the length of queue will extend back through several intersections.

- Disregard of normal traffic devices (such as signals, lane markings, signs, etc.) is a frequent consequence of routine traffic congestion such as that occurring at sporting events, traffic accidents, construction locations, etc. Disregard of traffic-control devices could be assumed to be even more widespread during evacuation of the Surry EPZ. Abandoning vehicles is frequently seen in situations no worse than routine large snowfalls. If vehicles are abandoned along the roadways, or in the traffic lanes, they will seriously diminish the capacity of the roadway and cause bottleneck situations.

- Running out of fuel: It is quite likely that in any sort of traffic tie-up, some vehicles will run out of fuel, particularly since there is no time to fill cars with fuel before starting. In this situation, abandoned vehicles along the roadways seriously impair the capacities of those roads.

- Attempting to reenter area: Despite instructions to the contrary, some motorists will attempt to enter areas being evacuated, in order to gather family members, secure property, etc. Traffic caused by this activity will generate turning movements and could reduce capacity at critical intersections.

These adverse effects can be mitigated through the following actions:

- Maintain high visibility of both local and state police.

- Provide for tow truck services at critical locations where major backups are expected.

- Continuous broadcast information to the public reporting on progress in the evacuation.

EVACUATION TIMES FOR CASE B: WINTER WEEKDAY

Figure 8 shows the time needed to evacuate the population of the entire Surry EPZ under a working day during school hours (Case B: Winter Weekday).

The critical population element in this evacuation time is the auto-owning population; in other words, it is this element of the population that establishes the total evacuation time. Other elements of the population (for example, population in institutions) can be evacuated in less time than the auto-owning population, provided only that vehicles are available for their transport. Consequently, their evacuation does not add to the total evacuation time.

As indicated in Figure 8, the entire EPZ population is evacuated within 4 hours and 45 minutes after the start of notification.

Traffic Congestion in a Winter Weekday Evacuation

Traffic congestion occurs on several evacuation routes during a Winter Weekday evacuation. However, under normal weather and traffic control conditions, this

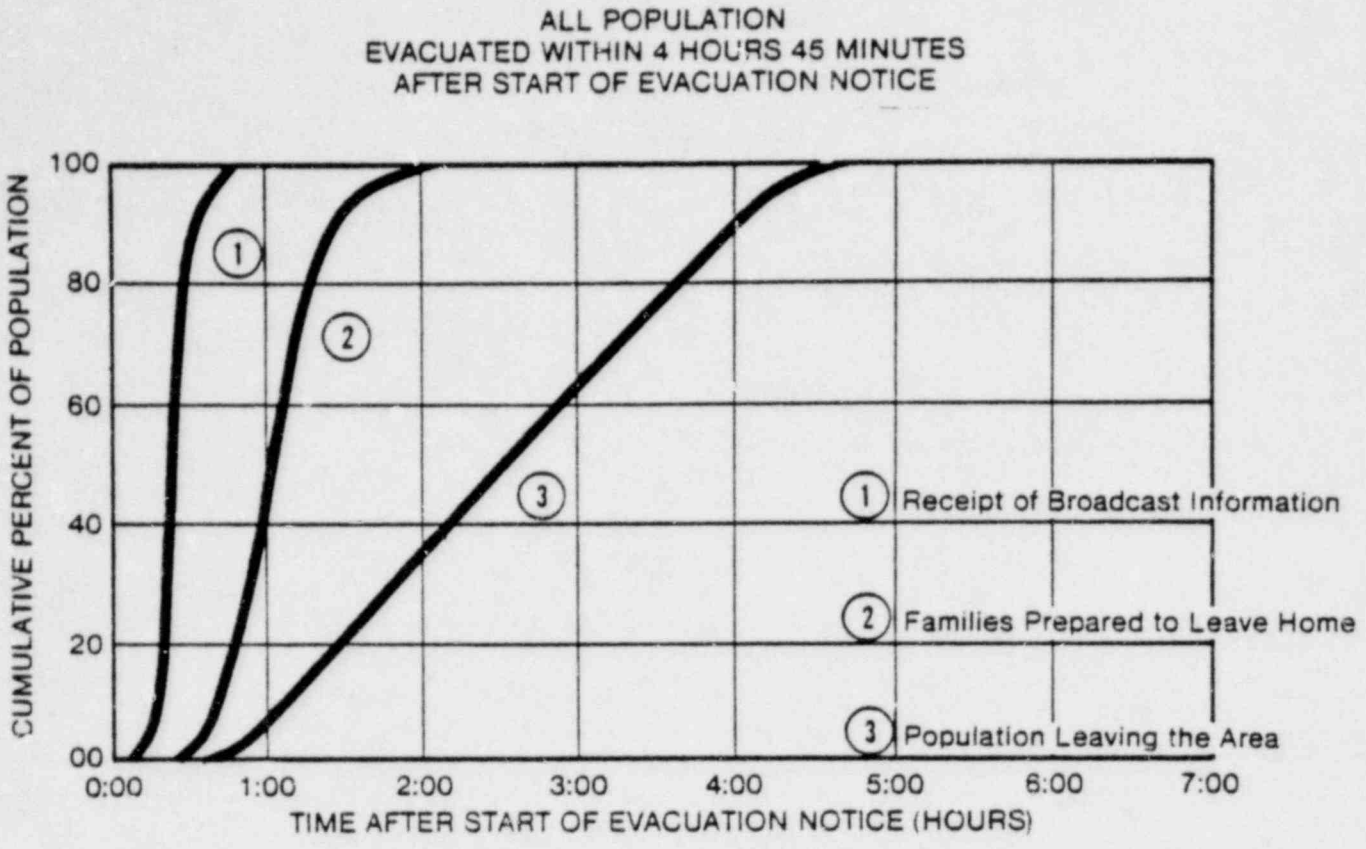

Figure 8. Evacuation Times: Case B, Winter Weekday

congestion dissipates prior to the time that all households have left home and entered the street system. Consequently, evacuation time is determined by the rate at which the population finishes preparation to leave their households, and is not determined by the capacity of the street system.

In a Winter Weekday evacuation, the road system is operating at capacity for a substantial part of the evacuation period. Any appreciable loss of capacity (for example, because of severe weather, uncontrolled traffic flow, etc.) would cause evacuation time to be extended beyond the 4 hours and 45 minutes estimated above.

EVACUATION OF THE SCHOOL POPULATION

The determining factor in the time for the evacuation of the school population is mobilizing the available school bus fleet. The school population can be notified well in advance of the arrival of school buses. After notification, preparation to leave the school premises is almost immediate (similar to a routine fire drill). Buses will be loaded immediately upon arrival at the schools and will then travel directly out of the EPZ.

A bus fleet large enough to carry the entire school population in a single trip is assumed in estimating these evacuation times. This fleet will be drawn from all districts within or partly within the EPZ. In addition, other buses will be drawn from districts not within the EPZ but in the close vicinity of it.

EVACUATION OF THE NON-AUTO-OWNING HOUSEHOLDS

The determining factor in the rate of evacuation for the non-auto-owning population is the availability of buses for transporting this segment of the population. The non-auto-owning population can be assembled at collection points well in advance of the arrival of buses for their evacuation. Buses will be loaded immediately upon arriving at the collection points, will travel directly to the reception center, and will rerun to the collection points for a second load.

A bus fleet sufficiently large to evacuate the non-auto-owning population in two trips is critical to achieving total evacuation time estimated above (5 hours-15 minutes on a Summer Sundy, and 4 hours-45 minutes on a Winter Weekday). If a sufficiently large bus fleet could not be mobilized, and a third trip out of the EPZ were needed (even if by only a few buses), the total evacuation time for the non-auto-owning population would increase and could become the critical (i.e., determining) element of the evacuation time.

Interestingly, a bus fleet larger than that needed to carry the non-auto-owning population in two trips provides only marginal savings in total evacuation time. For example, a fleet large enough to carry 75 percent of the non-auto-owning population at one time would improve total evacuation time by only 10 minutes.

EVACUATION OF THE POPULATION IN INSTITUTIONS

The determining factor in the rate of evacuation for the population in institutions is the availability of buses and ambulances for transporting this segment of the population. The population in institutions can be mobilized for evacuation well in advance of the arrival of buses for their evacuation. Buses would be loaded immediately upon arrival at the institutions, would travel directly to the reception centers, and would return to the institutions for a second load.

A bus (and ambulance) fleet large enough to evacuate the population in institutions in two and three trips, respectively, is critical to achieving the total evacuation times estimated above. If a sufficiently large bus and ambulance fleet could not be mobilized, and additional trips out of the EPZ were needed (even if only by a few vehicles), the total evacuation time for the population in institutions would increase and could become the critical (i.e., determining) factor in evacuation time.

IMPACT OF SEVERE WEATHER ON EVACUATION TIME

Severe weather, in the form of a major ice storm, would lengthen the normal weather evacuation time to 6 hours and 30 minutes after start of notification (i.e., 1 hour and 45 minutes more than evacuation time under normal weather conditions on a Winter Weekday).

This severe weather evacuation time assumes a slowdown in traffic but no loss in street capacity (i.e., no lanes or streets blocked). The impact of contingencies which cause loss of traffic capacity (i.e., blocked lanes or entire roads) cannot be estimated without specifying the exact nature of the problem. In general, any loss of capacity on any major evacuation route will cause major traffic problems throughout the evacuation period.

SUMMARY OF EVACUATION TIMES

Table 6 summarizes total evacuation times for:

- Summer Sunday and Winter Weekday cases
- Normal weather conditions
- Severe weather conditions

TRAFFIC CONTROL MEASURES

The following traffic control measures will aid the evacuation of the population from the Surry EPZ in the event of a general emergency.

Increasing Outbound Road Capacity

Routes 60 and 143 in the Newport News area are four-lane undivided facilities. With little traffic control effort, facilities can be made to operate with three outbound travel lanes and reserving onelane for inbound emergency traffic. Such action should not be initiated until about one hour following the emergency notification to allow workers to return home without undue travel constraint.

To effect such three-lane outbound operations will not require extensive barricading or signing. Police officer control at major intersections to direct drivers into three lanes will suffice.

Access to the Evacuation Routes

Key capacity constraints exist at the access points to the major evacuation routes, i.e., major intersections of collector roads with Routes 60 and 143, and access ramps to I-64. The evacuation time may be significantly impacted unless these key points are effectively controlled by police officers. High visibility of the police force at these major congestion points will aid in maintaining public confidence and in maintaining orderly traffic flow. To prevent roadway blockage by disabled vehicles (overheating, running out of gas, etc.) in these key access areas, tow trucks should be on standby at these locations to rapidly remove such vehicles. Key access locations are identified in Figure 9. In addition to these locations, all major intersections in the urban areas of Williamsburg and Newport News will require police officer control.

TABLE 6. EVACUATION TIMES FOR THE SURRY STATION

Area	Permanent Population	Permanent Population Vehicles	Transient Population	Evacuation Capacity/Hr.	Notification Time	Preparation Time	Evacuation Time Normal Condition	Evacuation Time Adverse Condition	Confirmation Time	Transient Population Vehicles
Total Area Within 2-Miles	38	13	--	--	1,200+	0:45	2:00	2:15	2:15	2:15
Within 5 Miles										
Surry Co.	686	233	--	--	2,400	0:45	2:00	2:15	2:30	2:30
Isle of Wight Co.	15	5	--	--	1,200+	0:45	2:00	2:15	2:15	2:15
James City Co.	899	305	2,500	806	1,200+	0:45	2:00	3:45	5:30*	3:45
Within 10 Miles										
Surry & Isle of Wight	3,851	1,309	--	--	6,000	0:45	2:00	2:15	2:30	2:15
James City Co.	15,603	5,305	35,000	11,290	7,200	0:45	2:00	5:15	7:15*	5:15
Williamburg	11,644	3,959	15,400	4,968		0:45	2:00	3:45	3:00	3:45
York Co.	8,584	2,918	2,500	806	3,600	0:45	2:00	3:15	2:15	3:15
Newport News	45,300	15,402	--	--	9,600	0:45	2:00	5:15	4:15	5:15

*These evacuation times can be reduced by 1 hour or more by assigning multiple evacuation routes during a winter weekday evacuation.

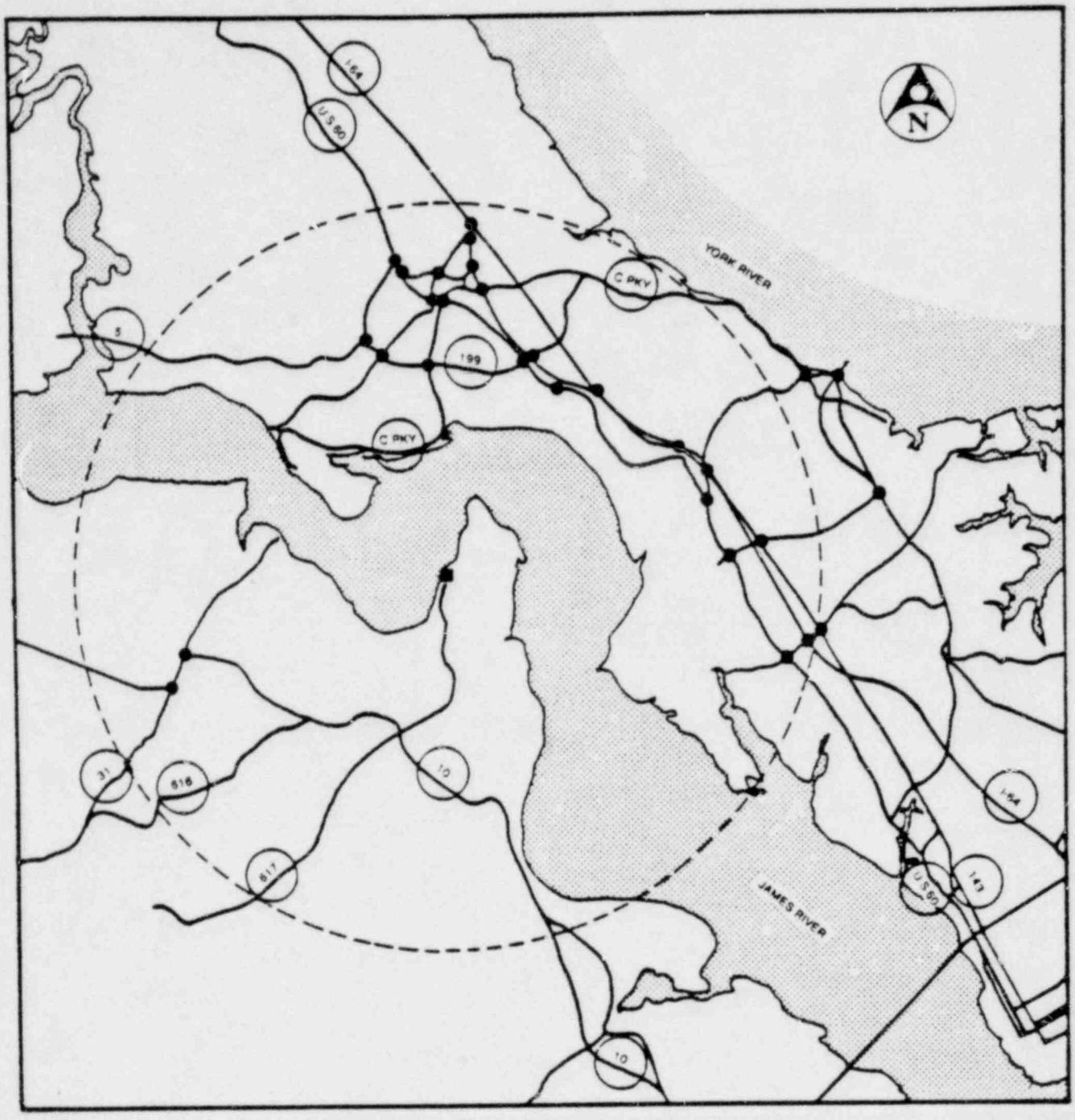

Figure 9. Key Traffic Control Points

Distribution of Busch Garden Traffic

The large transient population at Busch Gardens during a peak attendance day may represent in excess of 10,000 cars. No single travel facility in the area is able to accommodate such a magnitude within one or two hours. The proposed evacuation strategy for Busch Gardens is to direct visitors both northerly onto Route 60 and southerly onto I-64. To expedite the access to I-64, it is suggested that the railroad crossing (used only for emergency fire services) be used during an evacuation to allow Busch Gardens traffic to reach I-64 via Route 143 in addition to the access via Route 199.

VII. CONFIRMATION OF EVACUATION

CONFIRMATION PROCESS

The confirmation process measures how effectively the evacuation is being accomplished. Confirmation is conducted by the local civil defense agencies, beginning at about the time at which evacuation was estimated to be complete.

Confirmation of evacuation is essential for security reasons, to assure that all the population has left the area, and to assist those persons having difficulties in evacuating.

POSSIBLE APPROACHES TO CONFIRMING THE EVACUATION OF THE EPZ

Confirmation of evacuation may be approached in various ways:

- Active or passive -- Proof of evacuation may require some action by the evacuee, or, on the other hand, may be accomplished through other means, without any action on the part of the evacuee.

- Extent of coverage of the population -- The confirmation process may include 100 percent of the population (that is, every household) or it may be on a sampling basis, with some fraction of the total population surveyed.

- Detailed method of confirmation -- A variety of detailed methods of confirmation is possible. One such method is for the evacuating household to leave some indication (sign, flag, symbol, etc.) at their residence upon evacuating. Security personnel would patrol through the EPZ, monitoring the progress of the evacuation and the rate at which the residents are leaving.

Another method of confirmation is to have monitors call households by telephone and ascertain that they have left the area.

These methods may be supplemented by monitoring the outbound flow of traffic and recording the cumulative number of people leaving the area.

RECOMMENDED CONCEPT FOR CONFIRMING EVACUATION, IN THE SURRY STATION EPZ

Considering the population, road system and other characteristics of the Surry Station EPZ, a confirmation concept having these features is recommended:

- Passive -- The compliance problems with active methods of confirmation (that is, which require action on the part of the evacuees) are large, and substantial numbers of the evacuation population would not comply with any such plan. Furthermore, the size of the population in the Surry Station EPZ dictates major administrative effort in simply monitoring the confirmation indicators. For this reason, a passive confirmation concept (that is, one not requiring any action by the evacuee) is strongly recommended.

- Sampled -- It is not realistic to plan any confirmation system for the Surry Station EPZ that is based on 100 percent confirmation that each of the 24,000 households has evacuated. To do this would require either (a) an unreasonable number of monitors to cover all households in the EPZ or (2) a length of time required that extends far beyond the expected maximum evacuation times.

  Consequently, a confirmation concept based on sampling (rather than full counting) of the EPZ population is strongly recommended. It is stresses that the accuracy of a sampled approach is quite likely to be as good, or even better, than an active system with its attendant problems on non-compliance by the evacuating households.

- Confirmation by Telephone -- A suitable method for accomplishing a passive, sampled confirmation of evacuation is through a telephone sampling method. In such a method, monitors call a randomly selected group of households to confirm that evacuation has occurred. If continuing information on a cross section of households is desired, this sampling could be repeated at regular intervals.