

## EXECUTIVE SUMMARY

This brief summary should be viewed as a preamble of the report. The reader is encouraged to review the entire report.

This report describes the analyses undertaken and the results obtained by a study to update the existing Evacuation Time Estimates (ETE) for the Indian Point Energy Center (IPEC) located in Buchanan, New York. Evacuation time estimates provide State and local governments with site-specific information helpful for Protective Action decision-making.

In the performance of this effort, all available prior documentation relevant to Evacuation Time Estimates was reviewed. Other guidance is provided by documents published by Federal Government agencies. Most important of these are:

- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA-REP-1, Rev. 1, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR-1745, November 1980.
- State of the Art in Evacuation Time Estimate Studies for Nuclear Power Plants, NUREG/CR-4831, March 1992.

### Overview of Project Activities

This project began on May 1, 2002 and extended over a period of one year. The major activities performed are briefly described in chronological sequence:

- Attended “kick-off” meetings with Entergy Nuclear Northeast (ENN) personnel, then with emergency management personnel of the four counties within the Emergency Planning Zone (EPZ) of IPEC.
- Reviewed prior ETE reports prepared for IPEC and accessed U.S. Census Bureau data files for the years 2000 and 1990. Studied large-scale highway maps of the area in the vicinity of IPEC, then conducted a detailed field survey of the highway network.
- Synthesized this information to create an analysis network representing the highway system topology and capacities within the EPZ, extending to the four bounding Interstate Highways: (1) I-87 on the west; (2) I-87/287 on the south; (3) I-684 on the east; and (4) I-84 on the north.
- Designed and sponsored a telephone survey of residents within the EPZ to gather focused data needed for this ETE study that were not contained within the census database. The survey instrument was reviewed and modified by State and county personnel prior to the survey.
- Conducted additional mail and telephone surveys and accessed county and State data files to quantify estimates of employment within the EPZ, identifying that portion who lived outside the EPZ. Other surveys obtained information on transit-dependent and transient

populations, and of available transit resources. In addition, the populations of “special facilities” (i.e., schools, health-related) were ascertained.

- The traffic demand and trip-generation rate of evacuating vehicles were estimated from the gathered data. The trip generation rate reflected the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) that was computed using the results of the telephone survey of EPZ residents.
- Following federal guidelines, the EPZ is subdivided into 51 Emergency Response Planning Areas (ERPAs). These are the same ERPAs used in the prior ETE studies. These ERPAs are then grouped to form circular areas or “keyhole” configurations (circles plus radial sectors) that define a total of 35 Evacuation Regions.
- The time-varying circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter, Autumn, Spring); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain, Snow). Two special scenarios involving activities at West Point were considered: Football Games and Commencement. A total of 14 scenarios are considered.
- The Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at IPEC that quickly assumes the status of General Emergency such that the Advisory to Evacuate is virtually coincident with the siren alert.
  - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the Advisory to Evacuate until the last vehicle exits the impacted Region, that represent “upper bound” estimates. This conservative Planning Basis is applicable for all initiating events including the prospect of a terrorist attack.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to specified school reception centers located outside the EPZ. Parents, relatives, and neighbors may pick up their children at school prior to the arrival of the buses dispatched for that purpose. The ETE for school children are calculated separately.
- Evacuees who do not have access to a private vehicle will either ride-share with relatives, friends or neighbors, or be evacuated by buses provided as specified in the county evacuation plans. Those in special facilities will likewise be evacuated with public transit, as needed: bus, van, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees and for those evacuated from special facilities.

### Computation of ETE

A total of 490 ETE were computed for the evacuation of the general public. Each ETE quantifies the aggregate evacuation time estimated for the population within one of the 35 Evacuation Regions to completely evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios ( $35 \times 14 = 490$ ). Separate ETE are calculated for transit-dependent evacuees, including school children for applicable scenarios.

Except for Region R3, which is the evacuation of the entire EPZ, only a relatively small portion of the people within the EPZ would be advised to evacuate. That is, the Advisory to Evacuate applies only to those people occupying the specified impacted region. It is assumed that 100 percent of the people within the impacted region will evacuate in response to this Advisory. The people occupying the remainder of the EPZ outside the impacted region may be advised to take shelter.

The computation of ETE assumes that a portion of the population within the EPZ but outside the impacted region, will elect to “voluntarily” evacuate. These voluntary evacuees could impede those others who are evacuating from within the impacted region. The impedance that could be caused by voluntary evacuees is considered in the computation of ETE for the impacted region.

The area outside the EPZ but within the bounding interstate highways identified earlier is identified as the Shadow Region. This study assumes that a portion of the population occupying the shadow region will also elect to travel away from IPEC over the same time frame as those evacuating from within the impacted region. This “shadow evacuation” could also impede the movement of evacuees from within the impacted region. This potential impedance of evacuees is also considered in the computations of ETE.

The computational procedure is outlined as follows:

- A link-node representation of the highway network is coded. Each link represents a unidirectional length of highway; each node usually represents an intersection or merge point. The capacity of each link is estimated based on the field survey observations and on established procedures.
- The evacuation trips are generated at locations called “zonal centroids” located within the EPZ and within the Shadow Region. The trip generation rates vary over time reflecting the mobilization process, and from one location (centroid) to another depending on population density and on whether a centroid is within, or outside, the impacted area.
- The computer models compute the routing patterns for evacuating vehicles that are compliant with federal guidelines (outbound relative to the location of IPEC), then simulate the traffic flow movements over space and time. This simulation process estimates the rate that traffic flow exits the impacted region.
- The ETE statistics provide the elapsed times for 50 percent, 90 percent, 95 percent and 100 percent, respectively, of the population within the impacted region, to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats.

### Traffic Management

This study includes the development of a comprehensive traffic management plan designed to expedite the evacuation of people from within an impacted region. This plan is also designed to control access into the EPZ after returning commuters have rejoined their families.

The plan takes the form of detailed schematics specifying: (1) the directions of evacuation travel to be facilitated and other traffic movements to be discouraged; (2) the equipment needed (cones,

barricades) and their deployment; (3) the locations of these “Traffic Control Points” (TCP); (4) the priority assigned to each traffic control point indicating its relative importance and how soon it should be manned relative to others; and (5) the number of traffic control personnel required.

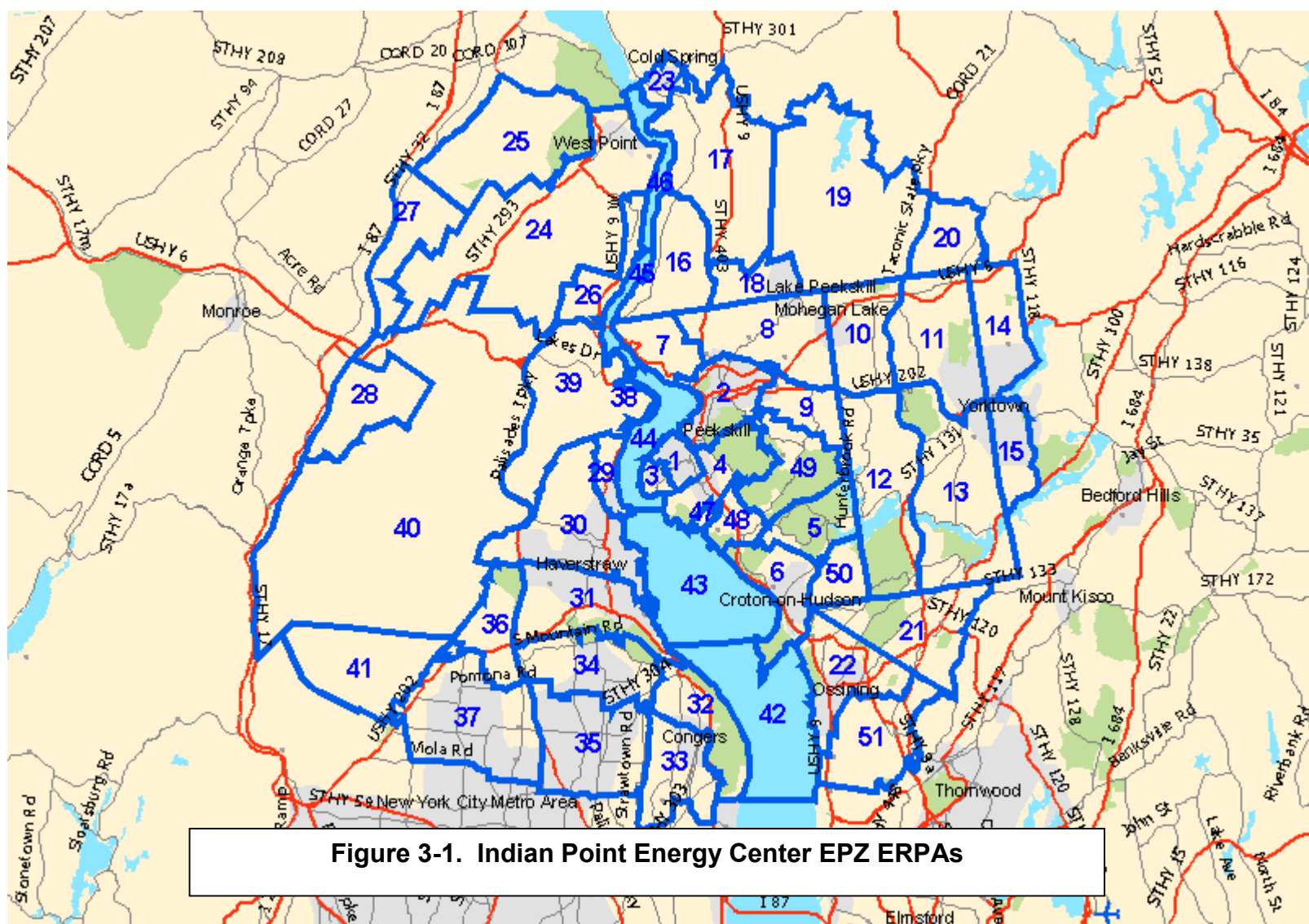
Over the coming months this plan will be reviewed with State and local law enforcement personnel. The Traffic Management Plan will incorporate revisions made as a result of this review.

### Selected Results

A compilation of selected information is presented on the following pages in the form of Figures and Tables extracted from the body of the report; these are described below.

- Figure 3-1 displays a map of the IPEC site showing the layout of the 51 Emergency Response Planning Areas (ERPAs) that comprise, in aggregate, the Emergency Planning Zone (EPZ).
- Table 3-2 presents the estimates of permanent resident population in each ERPA based on the 2000 Census data. Extrapolation to the year 2003 reflects population growth rates in each county derived from census data.
- Table 6-1 defines each of the 35 Evacuation Regions in terms of their respective groups of ERPAs. The tabulation also identifies the azimuths of the underlying sectors associated with the keyhole configurations of Regions R4 through R35.
- Table 6-2 lists the 14 Evacuation Scenarios.
- Table 7-1D is a compilation of Evacuation Time Estimates (ETE). These data are the times needed to *clear the indicated regions* of 100 percent of the population occupying these regions. These computed ETE include consideration of mobilization time, and of estimated voluntary evacuations from other regions within the EPZ and from the shadow region.
- Tables 8-9, 8-10 and 8-11 present ETE for school evacuation, transit-dependent evacuees and evacuees from special facilities, respectively. All these evacuees will be transported by bus, van or ambulance, as appropriate.

We wish to express our appreciation to all the directors and staff members of the Orange, Putnam, Rockland, and Westchester County Emergency Management Offices, the various county planning offices, New York State Emergency Management Office (SEMO), and local and state law enforcement agencies, who provided valued guidance and contributed information contained in this report.



<b>Table 3-2. EPZ Permanent Resident Population Growth</b>					
<b>ERPA</b>	<b>Population</b>		<b>ERPA</b>	<b>Population</b>	
	<b>2000</b>	<b>2003</b>		<b>2000</b>	<b>2003</b>
<b>1</b>	2,171	2,206	<b>27</b>	2,200	2,270
<b>2</b>	22,459	22,826	<b>28</b>	52	54
<b>3</b>	1,273	1,294	<b>29</b>	1,143	1,170
<b>4</b>	3,534	3,592	<b>30</b>	12,968	13,271
<b>5</b>	957	973	<b>31</b>	31,314	33,267
<b>6</b>	7,589	7,713	<b>32</b>	4,973	5,089
<b>7</b>	185	188	<b>33</b>	10,616	10,864
<b>8</b>	11,156	11,338	<b>34</b>	7,428	7,602
<b>9</b>	4,486	4,559	<b>35</b>	23,681	24,235
<b>10</b>	8,021	8,152	<b>36</b>	2,601	2,662
<b>11</b>	18,086	18,382	<b>37</b>	23,220	23,763
<b>12</b>	3,102	3,153	<b>38</b>	60	61
<b>13</b>	7,124	7,240	<b>39</b>	19	20
<b>14</b>	2,688	2,732	<b>40</b>	561	579
<b>15</b>	1,284	1,305	<b>41</b>	174	178
<b>16</b>	532	553	<b>42</b>	-	-
<b>17</b>	1,927	2,005	<b>43</b>	-	-
<b>18</b>	3,533	3,675	<b>44</b>	-	-
<b>19</b>	6,851	7,127	<b>45</b>	-	-
<b>20</b>	4,110	4,275	<b>46</b>	-	-
<b>21</b>	4,785	4,863	<b>47</b>	332	337
<b>22</b>	29,454	29,936	<b>48</b>	3,483	3,540
<b>23</b>	2,523	2,625	<b>49</b>	2,820	2,866
<b>24</b>	7,134	7,360	<b>50</b>	471	479
<b>25</b>	932	962	<b>51</b>	8,277	8,412
<b>26</b>	5,353	5,523	<b>TOTAL</b>	297,642	305,276



**Table 6-1. Definition of Evacuation Regions**

REGION	ERPAs IN ORANGE COUNTY	ERPAs IN PUTNAM COUNTY	ERPAs IN ROCKLAND COUNTY	ERPAs IN WESTCHESTER COUNTY	DESCRIPTION OF REGION	ERPAs IN REGION
R1	39	NONE	29, 38, 39	1-4, 7, 44	Entire 2 mile ring	1-4, 7, 29, 38, 39, 44
R2	26, 39, 40	16, 18, 45	29-31, 38-40	1-9, 43, 44, 47-49	Entire 5 mile ring	1-9, 16, 18, 24, 26, 29-31, 38-40, 43-45, 47-49
R3	24-28, 39, 40	16-20, 23, 45, 46	29-41	1-15, 21, 22, 42-44, 47-51	Full EPZ	1-51
<b>2 Mile Ring and Sector to 5 Miles</b>						
R4	26, 39, 45	16, 18, 45	29, 38, 39	1-4, 7, 8, 44	N	1-4, 7, 8, 16, 18, 26, 29, 38, 39, 44, 45
R5	39, 45	16, 18, 45	29, 38, 39, 44, 45	1-4, 7-9, 44, 45	NNE	1-4, 7-9, 16, 18, 29, 38, 39, 44, 45
R6	39	16, 18	29, 38, 39, 44	1-4, 7-9, 44, 49	NE	1-4, 7-9, 16, 18, 29, 38, 39, 44, 49
R7	39	NONE	29, 38, 39, 44	1-4, 7-9, 44, 49	ENE	1-4, 7-9, 29, 38, 39, 44, 49
R8	39	NONE	29, 38, 39, 44	1-5, 7-9, 44, 48, 49	E	1-5, 7-9, 29, 38, 39, 44, 48, 49
R9	39	NONE	29, 38, 39, 44	1-7, 9, 44, 47-49	ESE	1-7, 9, 29, 38, 39, 44, 47-49
R10	39	NONE	29, 38, 39, 43, 44	1-7, 43, 44, 47-49	SE	1-7, 29, 38, 39, 43, 44, 47-49
R11	39	NONE	29-31, 38, 39, 43, 44	1-7, 43, 44, 47-49	SSE	1-7, 29-31, 38, 39, 43, 44, 47-49
R12	39	NONE	29-31, 38, 39, 43, 44	1-4, 6, 7, 43, 44, 47, 48	S	1-4, 6, 7, 29-31, 38, 39, 43, 44, 47, 48
R13	39	NONE	29-31, 38, 39, 43, 44	1-4, 7, 43, 44	SSW	1-4, 7, 29-31, 38, 39, 43, 44
R14	39, 40	NONE	29-31, 38-40, 43, 44	1-4, 7, 43, 44	SW	1-4, 7, 29-31, 38-40, 43, 44
R15	39, 40	NONE	29-31, 38-40, 44	1-4, 7, 44	WSW	1-4, 7, 29-31, 38-40, 44
R16	39, 40	NONE	29, 30, 38-40, 44	1-4, 7, 44	W	1-4, 7, 29, 30, 38-40, 44
R17	24, 26, 39, 40, 45	45	29, 30, 38-40, 44, 45	1-4, 7, 44, 45	WNW	1-4, 7, 24, 26, 29, 30, 38-40, 44, 45
R18	24, 26, 39, 40, 45	16, 45	29, 38-40, 44, 45	1-4, 7, 44, 45	NW	1-4, 7, 16, 24, 26, 29, 38-40, 44, 45
R19	24, 26, 39, 40, 45	16, 45	29, 38, 39, 40, 44, 45	1-4, 7, 8, 44, 45	NNW	1-4, 7, 8, 16, 24, 26, 29, 38, 39, 40, 44, 45
R1	39	NONE	29, 38, 39	1-4, 7, 44	Entire 2 mile ring	1-4, 7, 29, 38, 39, 44
R2	26, 39, 40	16, 18, 45	29-31, 38-40	1-9, 43, 44, 47-49	Entire 5 mile ring	1-9, 16, 18, 24, 26, 29-31, 38-40, 43-45, 47-49
R3	24-28, 39, 40	16-20, 23, 45, 46	29-41	1-15, 21, 22, 42-44, 47-51	Full EPZ	1-51
<b>2 Mile Ring and Sector to 5 Miles</b>						
R4	26, 39, 45	16, 18, 45	29, 38, 39	1-4, 7, 8, 44	N	1-4, 7, 8, 16, 18, 26, 29, 38, 39, 44, 45
R5	39, 45	16, 18, 45	29, 38, 39, 44, 45	1-4, 7-9, 44, 45	NNE	1-4, 7-9, 16, 18, 29, 38, 39, 44, 45
R6	39	16, 18	29, 38, 39, 44	1-4, 7-9, 44, 49	NE	1-4, 7-9, 16, 18, 29, 38, 39, 44, 49
R7	39	NONE	29, 38, 39, 44	1-4, 7-9, 44, 49	ENE	1-4, 7-9, 29, 38, 39, 44, 49



**Table 6-1. Definition of Evacuation Regions**

REGION	ERPAs IN ORANGE COUNTY	ERPAs IN PUTNAM COUNTY	ERPAs IN ROCKLAND COUNTY	ERPAs IN WESTCHESTER COUNTY	DESCRIPTION OF REGION	ERPAs IN REGION
<b>R8</b>	39	NONE	29, 38, 39, 44	1-5, 7-9, 44, 48, 49	E	1-5, 7-9, 29, 38, 39, 44, 48, 49
<b>R9</b>	39	NONE	29, 38, 39, 44	1-7, 9, 44, 47-49	ESE	1-7, 9, 29, 38, 39, 44, 47-49
<b>R10</b>	39	NONE	29, 38, 39, 43, 44	1-7, 43, 44, 47-49	SE	1-7, 29, 38, 39, 43, 44, 47-49
<b>R11</b>	39	NONE	29-31, 38, 39, 43, 44	1-7, 43, 44, 47-49	SSE	1-7, 29-31, 38, 39, 43, 44, 47-49
<b>R12</b>	39	NONE	29-31, 38, 39, 43, 44	1-4, 6, 7, 43, 44, 47, 48	S	1-4, 6, 7, 29-31, 38, 39, 43, 44, 47, 48
<b>R13</b>	39	NONE	29-31, 38, 39, 43, 44	1-4, 7, 43, 44	SSW	1-4, 7, 29-31, 38, 39, 43, 44
<b>R14</b>	39, 40	NONE	29-31, 38-40, 43, 44	1-4, 7, 43, 44	SW	1-4, 7, 29-31, 38-40, 43, 44
<b>R15</b>	39, 40	NONE	29-31, 38-40, 44	1-4, 7, 44	WSW	1-4, 7, 29-31, 38-40, 44
<b>R16</b>	39, 40	NONE	29, 30, 38-40, 44	1-4, 7, 44	W	1-4, 7, 29, 30, 38-40, 44
<b>R17</b>	24, 26, 39, 40, 45	45	29, 30, 38-40, 44, 45	1-4, 7, 44, 45	WNW	1-4, 7, 24, 26, 29, 30, 38-40, 44, 45
<b>R18</b>	24, 26, 39, 40, 45	16, 45	29, 38-40, 44, 45	1-4, 7, 44, 45	NW	1-4, 7, 16, 24, 26, 29, 38-40, 44, 45
<b>R19</b>	24, 26, 39, 40, 45	16, 45	29, 38, 39, 40, 44, 45	1-4, 7, 8, 44, 45	NNW	1-4, 7, 8, 16, 24, 26, 29, 38, 39, 40, 44, 45

**Table 6-2. Evacuation Scenario Definitions**

<b>Scenario</b>	<b>Season</b>	<b>Day of Week</b>	<b>Time of Day</b>	<b>Weather</b>	<b>Special</b>
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Autumn	Weekend	Midday	Good	West Point Football
14	Spring	Midweek	Midday	Good	West Point Graduation

Table 7-1D. Time To Clear The Indicated Area of 100 Percent of the Affected Population (Page 1 of 2)

	Summer		Summer		Summer		Winter			Winter			Winter		Autumn	Spring
	Midweek		Weekend		Midweek Weekend		Midweek			Weekend			Midweek Weekend		Weekend USMA Football	Midweek USMA Graduation
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Scenario:	(13)	(14)
Region	Midday		Midday		Evening	Region	Midday			Midday			Evening	Region	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather		Good Weather	Good Weather
Entire 2-Mile Region, 5-Mile Region, and EPZ																
R1	4:55	5:30	4:50	5:25	4:45	R1	5:15	5:15	6:50	4:55	5:30	5:55	4:30	R1	5:30	5:15
R2	6:20	7:10	5:55	6:45	5:25	R2	6:20	7:00	8:00	5:55	6:25	7:20	5:25	R2	6:30	6:20
R3	9:25	10:30	8:50	9:50	7:15	R3	9:30	10:55	12:00	7:55	8:50	10:10	7:10	R3	8:45	9:30
2-Mile Ring and Keyhole to 5 Miles																
R4	5:45	6:20	5:10	5:35	4:50	R4	5:45	6:25	7:30	5:15	5:30	6:35	4:45	R4	5:55	5:45
R5	6:00	6:45	5:25	5:50	5:15	R5	6:10	7:00	8:00	5:25	5:45	7:10	5:15	R5	5:55	6:10
R6	6:00	6:45	5:25	5:50	5:15	R6	6:10	7:00	8:00	5:25	5:45	7:10	5:15	R6	5:55	6:10
R7	6:10	6:40	5:20	5:50	5:10	R7	6:10	6:45	8:00	5:20	5:40	7:05	5:15	R7	6:00	6:10
R8	6:10	6:35	5:20	5:50	5:10	R8	6:05	6:45	8:00	5:20	5:45	7:10	5:15	R8	6:00	6:05
R9	5:55	6:25	5:55	6:40	4:35	R9	6:00	6:30	7:35	5:10	5:30	6:45	4:35	R9	6:00	6:00
R10	5:25	5:45	5:55	6:40	4:25	R10	5:20	5:55	6:45	4:40	5:25	5:55	4:25	R10	5:30	5:20
R11	6:20	6:55	5:55	6:40	5:25	R11	6:20	6:55	7:45	5:55	6:20	7:20	5:25	R11	6:30	6:20
R12	6:20	6:55	5:55	6:40	5:25	R12	6:20	6:55	7:45	5:55	6:20	7:20	5:25	R12	6:30	6:20
R13	6:20	7:10	5:55	6:45	5:25	R13	6:20	6:55	7:40	5:55	6:25	7:15	5:25	R13	6:30	6:20
R14	6:20	7:10	5:55	6:45	5:25	R14	6:20	6:55	7:40	5:55	6:25	7:15	5:25	R14	6:30	6:20
R15	6:20	7:10	5:55	6:45	5:25	R15	6:20	6:55	7:40	5:55	6:25	7:15	5:25	R15	6:30	6:20
R16	5:25	5:40	4:50	5:10	4:25	R16	5:10	5:45	6:45	4:45	5:30	5:55	4:25	R16	5:30	5:10
R17	5:25	5:40	4:50	5:10	4:25	R17	5:10	5:45	6:45	4:45	5:30	5:55	4:25	R17	6:50	5:10
R18	5:20	5:40	4:50	5:15	4:25	R18	5:15	5:50	6:45	4:45	5:30	5:50	4:25	R18	6:50	6:00
R19	5:40	6:20	4:55	5:30	4:45	R19	5:40	6:35	7:30	5:15	5:30	6:35	4:45	R19	5:55	5:40

Table 8-9. School Evacuation Time Estimates						
County	ETE to Leave EPZ			ETE to Reception Center		
	Good Weather	Rain	Snow	Good Weather	Rain	Snow
Orange	2:55	3:05	3:40	3:25	3:35	4:20
Putnam	2:45	2:50	3:25	3:30	3:35	4:25
Rockland	2:55	3:05	3:40	4:25	4:35	3:30
Westchester	3:05	3:30	4:05	4:05	4:30	5:20

Table 8-10. Transit-Dependent Evacuation Time Estimates									
County	Region Extends to 5 Miles			Region Extends to EPZ Boundary			Second Wave Completion (if needed)		
	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Rain	Snow
Orange	4:35	4:50	5:25	5:05	5:20	5:55	7:30	7:55	9:35
Putnam	4:15	4:50	5:00	4:40	4:50	5:25	6:50	7:10	8:05
Rockland	4:35	4:50	5:25	5:05	5:20	5:55	8:00	8:10	9:10
Westchester	4:50	5:30	6:05	5:20	6:15	6:50	8:25	9:40	10:35

Table 8-11. Ambulatory Evacuees from Special Facilities Evacuation Time Estimates			
County	ETE to Leave EPZ		
	Good Weather	Rain	Snow

Orange	3:50	4:00	4:35
Putnam	3:40	3:45	4:20
Rockland	3:50	4:00	4:35
Westchester	4:00	4:25	5:00