NUREG/CR-7002
SAND2010-0016P

Criteria for Development of Evacuation Time Estimate Studies

Manuscript Completed: September 2011
Date Published: November 2011

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Prepared for:
Division of Preparedness and Response
Office of Nuclear Security and Incident Response
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
NRC Job Code R-3139

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

ABSTRACT

The evacuation time estimate (ETE) is a calculation of the time to evacuate the plume exposure pathway emergency planning zone (EPZ), which is an area with a radius of about 10 miles (16 km) around a nuclear power plant. The ETE is primarily used to inform protective action decision-making and may also be used to assist in development of traffic management plans to support an evacuation. The ETE should be developed to provide the time to evacuate 90 percent and 100 percent of the total population of the EPZ. The 90 percent ETE provides the time value that would typically be used to support protective action decisions. This document provides guidance for the development of ETEs, including those associated with staged evacuation protective actions. The document also identifies the importance of using approved emergency response plans and existing traffic control information to reflect the expected response actions during an emergency. Guidance on the review and update of ETEs is also included. The format and guidance provided herein will support consistent application of the ETE methodology, and can serve as a template for the development of ETE studies. Applicants and licensees may propose an alternative method for complying with the associated relevant portions of the emergency preparedness regulations, which the NRC would need to deem acceptable if they provide the basis for the findings required for the issuance or continuance of a permit or license by the Commission.

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EXECUTIVE SUMMARY

The evacuation time estimate (ETE) is a calculation of the time to evacuate the plume exposure pathway emergency planning zone (EPZ), which is an area with a radius of about 10 miles around a nuclear power plant (NRC, 1980). Section IV of Appendix E to 10 CFR Part 50 requires that an analysis of the time required to evacuate be provided for various sectors and distances within the plume exposure pathway EPZ for transient and permanent residents. The ETE is primarily used to inform protective action decision-making and may also be used to assist in development of traffic management plans to support an evacuation. The ETE is used as an information tool, and therefore, no minimum evacuation time must be achieved. The guidance in NUREG-0654/FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Criterion J.10, provides additional information regarding the use of ETE results (NRC, 1980). ETEs should be used by licensees in the development of offsite protective action recommendations and by offsite response organizations (OROs) when making offsite protective action decisions.

This guidance document details the process for the development of ETEs for four population segments including:

- Permanent residents and transient population;
- Transit dependent permanent residents;
- Special facility residents (e.g., hospitals, prisons, nursing homes, etc.); and
- School populations.

Guidance is provided on developing evacuation demand, preparation activities, ETE modeling and reporting results. Some of the key criteria developed in this document include:

- Development of ETEs for the staged evacuation protective action;
- Emphasis on the use of existing emergency preparedness programs when developing the ETE;
- Use of traffic simulation modeling;
- Consideration of shadow evacuations in the analysis;
- Verification of commitment of resources, such as buses and ambulances, etc.;
- Consideration of the evacuation tail; and
- ETE updates.

Research in evacuations has shown that implementation of staged evacuations can be more beneficial to the public health and safety (NRC, 2007). This guidance document establishes an approach to develop ETEs for a staged evacuation.

It is important to use the information found in approved emergency plans when developing an ETE study to ensure that the results represent the expected response from authorities. This guidance document emphasizes the use of existing emergency planning methodology when developing the ETE including:

- Use of existing registration programs for people with disabilities and those with access and functional needs who do not reside in special facilities;
- Modeling of planned or approved evacuation routes;
- Use of approved traffic control plans in the analysis; and

- Use of planned bus routes for analysis of the transit dependent population evacuation.

This guidance describes the benefits of using traffic simulation modeling to calculate the ETE and establishes measures of effectiveness (MOEs) for use in the review of this ETE element. When an ETE is developed without the use of a traffic simulation model, supporting data and calculations consistent with this guidance document should be provided. The guidance also establishes the need to include a 20 percent shadow evacuation in the analysis. A shadow evacuation is defined as an evacuation of people from areas outside an officially declared evacuation zone. The shadow population is considered in the analysis to account for any effect of this population group impeding the evacuation of those under evacuation orders.

This guidance emphasizes the importance of verifying the committed resources, such as buses and ambulances, required to support evacuation of the transit dependent and school populations, as well as people with disabilities and those with access and functional needs. The number and location of available resources directly affect the ETE, and lack of available resources has been a problem in some large scale evacuations (NRC, 2008a).

ETEs provide information for use in the formulation of a licensee's protective action recommendation and the ORO's protective action decisions. It is important that the time to evacuate the public is clearly understood to ensure the most appropriate protective action is implemented. ETEs that overestimate or underestimate evacuation time are not helpful in making the best protective action decision. Research of existing evacuations (NRC, 2005a; NRC, 2007) shows that a small percentage of the public, about 10 percent, takes a longer time to evacuate. This 10 percent is defined as the "evacuation tail." Planning is established to evacuate all of the public; however, decision makers should use the 90 percent ETE values when developing procedures for the implementation of protective action decisions. The 90 percent value informs decision makers of the estimated time to evacuate the vast majority of the public, and the 100 percent ETE informs decision makers on the likely time for the EPZ to be fully evacuated. Therefore, the time to evacuate 90 and 100 percent of the population should be provided in the ETE study.

Section IV of Appendix E to 10 CFR Part 50 requires ETE updates when the EPZ permanent resident population increases such that it causes ETE values to change by 25 percent or 30 minutes, whichever is less, from the licensee's currently NRC approved or updated ETE. Additionally, in the unlikely event that the conditions of an EPZ are changed significantly due to natural phenomena hazards or other reasons (e.g., a bridge collapse), an interim update to the ETE is recommended. This guidance document also identifies the importance of developing ETE studies using traffic control plans agreed upon by the local authorities.

Use by Applicants and Licensees

Applicants and licensees[1] may voluntarily[2] use the guidance in this document to demonstrate compliance with the ETE analysis development required by the NRC in 10 CFR Part 50, Appendix E, Section IV. Each ETE analysis report should be formatted consistent with this

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1 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52, and the term "applicants" refers to applicants for licenses for nuclear power plants under 10 CFR Parts 50 and 52 and all applicants for early site permits with complete and integrated emergency plans submitted under 10 CFR Part 52.

2 In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

template and submitted to the NRC under 10 CFR 50.4 for review to confirm the completeness of the ETE analysis. Methods or solutions that differ from those described in this document may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations.

Licensees may use the information in this document for actions which do not require NRC review and approval. Licensees may use the information in this document or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with guidance in this document, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting. However, unless this document is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the guidance in this document constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this document and (2) the specific subject matter of this document is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this document or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this document. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this document, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this document to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this document. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of this guidance document, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this guidance, generic communication, or promulgation of a rule requiring the use of this document without further backfit consideration.

Additionally, an existing applicant may be required to adhere to new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

If a licensee believes that the NRC is either using this document or requesting or requiring the licensee to implement the methods or processes in this document in a manner inconsistent with the discussion in this section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409 and NRC Management Directive 8.4.

ACKNOWLEDGEMENTS

In support of this activity, the NRC Technical Leader, Jeff Laughlin, provided the technical leadership to ensure this project met the needs of the emergency preparedness program. NRC staff including Randy Sullivan, Eric Schrader, Bob Moody, Falk Kantor, and Steve LaVie provided technical insights supporting key elements of the criteria. Joe Jones, Sandia National Laboratories, led the project team and the development of the ETE criteria. Fotini Walton performed research for Sandia National Laboratories to support development of the criteria. Dr. Brian Wolshon, Louisiana State University Hurricane Center, supported development of the ETE criteria and provided technical support and consultation based on his extensive experience in evacuation and transportation analyses.

ACRONYMS

ASCE	American Society of Civil Engineers
CFR	Code of Federal Regulations
COL	Combined License
DOT	Department of Transportation
EAS	Emergency Alert System
EMO	Evacuation Management Operations
EPZ	Emergency Planning Zone
ERPA	Emergency Response Planning Area
ESP	Early Site Permit
ETE	Evacuation Time Estimate
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographical Information System
HCM	Highway Capacity Manual
LOS	Level of Service
MOE	Measure of Effectiveness
NPP	Nuclear Power Plant
ORO	Offsite Response Organization
PAR	Protective Action Recommendation
TRB	Transportation Research Board

PREFACE

Advancements in the development of ETE modeling along with the knowledge gained through research of large scale evacuations (NRC, 2005b; NRC, 2008a) have contributed to the need to update the guidance for ETE development. Additionally, NUREG/CR-6953, Volume I, "Review of NUREG-0654, Supplement 3, 'Criteria for Protective Action Recommendations for Severe Accidents'" (NRC, 2007), concludes that a staged evacuation protective action provides greater benefit than a standard radial keyhole evacuation. Guidance is provided herein on developing staged evacuation ETEs. This guidance document provides a template for the development and updating of ETE studies. It is intended to assist users in identifying contributing factors to the ETE and provide a methodical process for development of data and performance of ETE calculations.

Section 1 provides an introduction to the ETE, describes the characteristics of the EPZ, establishes general assumptions, and identifies the evacuation scenarios to be evaluated. Section 2 provides detail for consideration in developing demand estimates for permanent residents and transients, transit dependent populations, special facilities, schools, and quantifying a shadow evacuation. Section 3 describes the approach for evaluating the roadway capacity and establishes values for use in adverse weather calculations. Section 4 discusses the process for developing trip generation times and provides detail on information that should be included in an ETE study when traffic simulation modeling is used. Section 5 identifies other considerations including development of a traffic control plan, potential enhancements to the ETE, State and local review, reviews and updates of the ETE, when to include the effect of reception centers on the ETE, new reactors, and early site permits. Appendix A of the document provides an example of roadway characteristics to be provided, and Appendix B provides ETE review criteria.

Use of the format and criteria provided herein will support consistent application of ETE methodology, thereby facilitating a consistent review of initial or updated ETE studies. Licensees should use the ETE when developing procedures that support making offsite protective action recommendations and for developing those recommendations. OROs should use the ETE when developing offsite protective action strategies and when making offsite protective action decisions.

1.0 INTRODUCTION

The objective of this section is to provide a description of the emergency planning zone (EPZ), and to describe the general approach used to meet the requirements for developing an evacuation time estimate (ETE). Section IV of Appendix E to 10 CFR Part 50 requires that an analysis of the time required to evacuate be provided for various sectors and distances within the plume exposure pathway EPZ for transient and permanent residents. To address this requirement, licensees must develop an ETE, which is a calculation of the time required to evacuate the 10-mile plume exposure pathway EPZ (NRC, 1980). The ETE is used to inform the protective action decision-making process and to assist in the development of traffic management plans to support an evacuation. The licensee should use the ETE when developing procedures that support making protective action recommendations (PARs), and offsite response organizations (OROs) should use the ETE when developing offsite protective action strategies.

This NUREG/CR provides detailed information and guidance for use in developing or updating an ETE study. The format and criteria provided herein are intended to support consistent application of ETE methodology and will facilitate NRC review of initial or updated ETE studies. The format of the sections, tables, and figures presented herein should be used, as appropriate, for the specific EPZ.

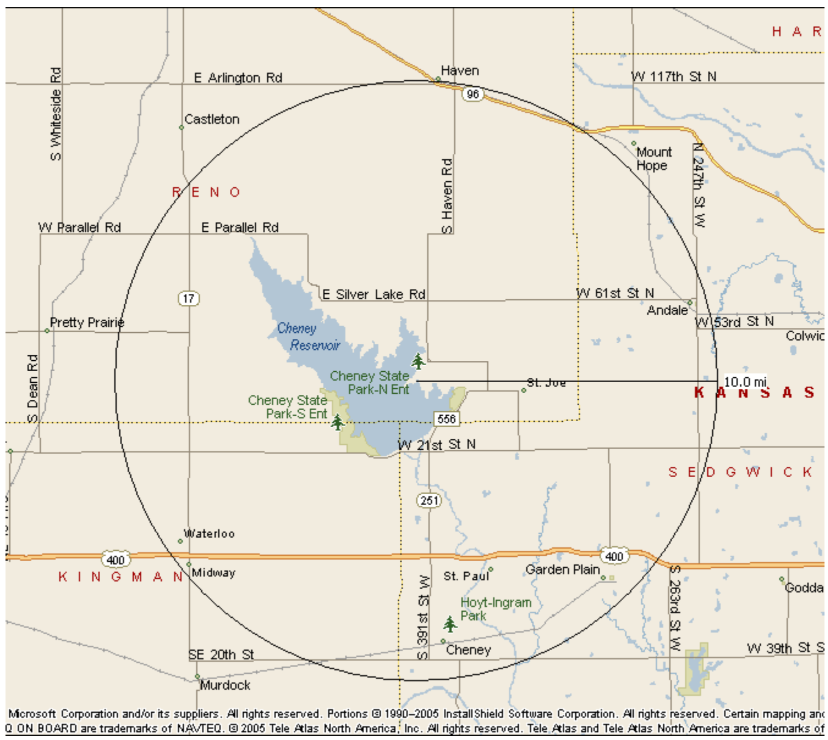

Figure 1-1 Vicinity Map

To establish the framework for the review, the ETE study begins with an introduction section. A description of the EPZ should be provided including the nuclear power plant (NPP) site location and any unique characteristics of the EPZ. A map of the plume exposure pathway EPZ depicting the roadway network, population centers, political jurisdiction boundaries, and significant topographical features such as rivers, lakes, State parks, etc., should be included. The information may be provided on one or more maps depending on the complexity of the EPZ and the ability to clearly identify the necessary features. Figure 1-1 provides an example of a vicinity map of a hypothetical EPZ. Legends should be provided for relevant symbols, acronyms, and abbreviations used in the presentation.

When updating an ETE study it is beneficial to provide an overview of changes that have occurred since the development of the previous study. A comparison of the updated and previous ETEs should be included when updating an existing ETE. Table 1-1 identifies information that is useful in comparing the ETEs.

Table 1-1 ETE Comparison

ETE Element	Previous ETE	Updated ETE
Permanent Residents - Total population - Vehicle ratio		
Transit dependent population - Total population - Number of buses - Number of ambulances		
Transient population - Total population		
Special Facilities - Total Population - Number of buses - Other transportation resources		
Schools - Total student population - Number of buses		
Shadow evacuation percent estimated		
Special Event(s) - Population - Location - Duration		
Adverse Weather (rain, snow, ice, fog)		
Evacuation Model – name and version		
Scenarios		
Assumptions		

The availability of traffic simulation models that support ETE calculations has increased considerably in recent years. The U.S. Department of Transportation has sponsored the "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory" which is available to support the selection of an appropriate model for use in evacuation analysis (DOT, 2007). Also, the Federal Highway Administration (FHWA) has developed a toolbox for use by analysts in modeling roadway networks (FHWA, 2004a). To address the use of modeling in the analysis, this guidance document identifies measures of effectiveness (MOEs) that will be used in the review of ETE studies. The ETE development should include a description of the key inputs, assumptions, outputs, and computational processes that are included in, or result from, the simulation. When an ETE is developed without the use of a traffic simulation model, supporting data and calculations should be developed consistent with the approach provided herein.

1.1 Approach

Evacuation analysis is based on moving the population away from the hazard in the most expedient manner practical within the constraints of the roadway network. This generally equates to a radial dispersion away from the hazard. ETEs are developed with consideration of when an event may occur, weather conditions, traffic volume, and other unique considerations of the EPZ. A well defined approach will ensure that key elements are addressed. Care should be taken when using conservative values, such as "worst case" values, to ensure that the analysis does not result in an aggregate of all "worst case" values as this is not the intent of the ETE. Methods used to address data uncertainties should be described.

The approach should include a description of:

- The process used in development of the ETE;
- Meetings with planners, emergency managers, and local authorities, as related to the resolution of issues affecting the ETE;
- Field surveys of roadways and traffic control systems;
- Information sources used to develop demographic data;
- The traffic control plans used in the analysis; and
- Evacuation modeling used for the analysis.

1.2 Assumptions

The planning basis for the ETE should include the assumption that evacuation is ordered promptly and no early protective actions have been implemented. Use of this planning basis allows the ETE to be calculated beginning with the initial notification to the public. It is recognized that most States have planning in place for implementation of early protective actions, such as evacuating schools prior to the general public, when time would allow. Concurrent events that could initiate evacuations on their own, such as hurricanes, need not be assumed. For those sites where EPZs overlap, the ETE need only consider an evacuation of the NPP that is the focus of the study.

General and site specific assumptions should be provided to support the analysis. Assumptions must be technically sound, be quantified when possible (NRC, 2005a), and have a basis. General assumptions that are appropriate for use in the study are provided in Table 1-2.

Table 1-2 General Assumptions

1.	The ETE is measured from the time that instructions were first made available to the public within the EPZ (e.g., initial emergency alert system [EAS] broadcast).
2.	Mobilization of the public begins after initial notification.
3.	Schools and special facilities receive initial notification at the same time as the rest of the EPZ.
4.	Evacuation time ends when the last vehicle has exited the EPZ.
5.	Most vehicles at each residence will be used in the evacuation.
6.	Background traffic is on the roadway when initial notification occurs.
7.	A 50 percent capacity is appropriate for buses used in the evacuation of the population dependent upon public transportation.
8.	Buses used to evacuate schools and special facilities are loaded to capacity.
9.	Shadow evacuation of 20 percent of the public occurs to a distance of 15 miles from the NPP.

Additional assumptions that are specific to a section of the analysis, such as roadway capacity, should be included in the appropriate section of the ETE study.

1.3 Scenario Development

Scenarios are developed to identify combinations of variables and events to provide ETEs under varying conditions to support protective action decisions. Scenarios include season, day of the week, time of day, weather conditions, special events, roadway impact, or other circumstances that should be assessed. Multiple scenarios are intended to ensure that the ETE results encompass a reasonable range of potential evacuation situations for the specific site. Scenarios generally assume that residents evacuate from their home; however, it should not be assumed that all residents are at home when the initial notification is received. A daytime scenario should be developed for representative site-specific conditions during the work day. The evening scenarios should represent the timeframe when residents are generally at home with fewer residents dispersed within the EPZ. The number of scenarios may vary depending on site-specific considerations, and the 10 scenarios identified in Table 1-3 are expected.

Table 1-3 Evacuation Scenarios

Scenario	Season	Day	Time	Weather
1	Summer	Midweek	Daytime	Normal
2	Summer	Midweek	Daytime	Adverse
3	Summer	Weekend	Daytime	Normal
4	Summer	Midweek and Weekend	Evening	Normal
5	Winter	Midweek	Daytime	Normal
6	Winter	Midweek	Daytime	Adverse
7	Winter	Weekend	Daytime	Normal
8	Winter	Midweek and Weekend	Evening	Normal
9	Special Events			Normal
10	Roadway Impact	Midweek	Daytime	Normal

A description of each scenario used in the study should be provided similar to those provided below.

1. **Summer Midweek Daytime (normal):** This scenario represents a typical normal weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at summer activities; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer daytime levels.

2. **Summer Midweek Daytime (adverse):** This scenario represents an adverse weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at summer activities; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer daytime levels.

3. **Summer Weekend Daytime (normal):** This scenario represents a typical normal weather weekend period when permanent residents are both at home and dispersed within the EPZ performing typical summer weekend activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home or with their families; work places are staffed at typical weekend

levels; hotel and motel facilities are occupied at average summer weekend levels; and recreational facilities are at average summer weekend levels.

4. **Summer Midweek and Weekend Evening (normal):** This scenario represents a typical normal weather midweek and weekend evening period when permanent residents are generally at home with fewer dispersed within the EPZ performing evening activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical evening levels; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer evening levels.

5. **Winter Midweek Daytime (normal):** This scenario represents a typical normal weather weekday period during the winter when school is in session and the work force is at a full daytime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; students will evacuate directly from the schools; work places are fully staffed at typical daytime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter daytime levels. The number of permanent resident vehicles may be reduced appropriately in this scenario to account for the number of students at school within the EPZ, because the buses used for evacuation of students account for the vehicle load.

6. **Winter Midweek Daytime (adverse):** This scenario represents an adverse weather weekday period during the winter when school is in session and the work force is at a full daytime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; students will evacuate directly from the schools; work places are fully staffed at typical daytime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter daytime levels. The number of resident vehicles may be reduced appropriately in this scenario to account for the number of students at school within the EPZ, because the buses used for evacuation of students account for the vehicle load.

7. **Winter Weekend Daytime (normal):** This scenario reflects a typical normal weather winter weekend period when permanent residents are both at home and dispersed within the EPZ, and the work force is at a weekend level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical weekend levels; hotel and motel facilities are occupied at average winter weekend levels and recreational facilities are at winter weekend levels.

8. **Winter Midweek and Weekend Evening (normal)**: This scenario reflects a typical normal midweek and weekend evening period when permanent residents are home and the work force is at a nighttime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical nighttime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter evening levels.

9. **Special Events (normal):** This scenario should reflect a special event activity where peak tourist populations are present within the EPZ. Assumptions made should reflect the timeframe in which the special event occurs. The population attending the event should be developed considering both transients and permanent EPZ residents who may be in attendance to avoid double-counting residents. The remaining permanent resident

percentage, those not attending the event, will be assumed to evacuate from their residence. Work places will be staffed at typical levels; hotel and motel facilities are occupied at peak special event levels; and recreational facilities are at appropriate levels based on the event and time of year.

10. **Roadway Impact Midweek Daytime (normal):** The intent of this scenario is to represent a variety of conditions that may impact a roadway segment such as construction, flooding, vehicle accidents, etc. The roadway impact scenario should assume that during a summer midweek normal weather daytime scenario, one segment of one of the top five highest volume roadways will be out of service and unavailable to evacuees. An alternative to removing one roadway segment from use is to analyze the effect of a single outbound lane being shut down on an interstate highway. This analysis is conducted to understand the potential impact of such an event and to support the development of a traffic control plan by identifying areas where OROs may want to consider additional emergency planning such as the pre-positioning of response vehicles (e.g., tow trucks). The ETE for this scenario is not typically used in protective action recommendations or decisions.

1.3.1 Staged Evacuation

Evacuation research has shown that implementation of a staged keyhole evacuation can be more beneficial to the public health and safety than the normal keyhole evacuation (NRC, 2007). A staged evacuation is where one area is ordered to evacuate while adjacent areas are ordered to shelter in place until directed to evacuate. When making protective action recommendations and decisions that include a staged keyhole evacuation, it is necessary to understand the ETE for this protective action. The following description of a staged keyhole evacuation is expected in the ETE study; however, site-specific PAR logic must also be addressed in the ETE study.

For each scenario, an estimate of the time to complete a staged keyhole evacuation is needed to support protective action decision-making. A discussion should be included on the approach used in the development of a staged keyhole evacuation. This analysis involves evacuating the 0-2 mile zone while the 2-5 mile zone is under a shelter-in-place order. When approximately 90 percent of the 0-2 mile zone has cleared the 2 mile zone boundary, based on the ETE, the 2-5 mile zone would be loaded onto the evacuation network. The 2-5 mile residents enter the roadway network as the 0-2 mile population is passing through the area. During the time required for the 0-2 mile zone to evacuate, the 2-5 mile zone may be assumed to be preparing to evacuate, potentially reducing the trip generation time elements for this area. The analysis combines the time to evacuate the 0-2 mile zone with the time to evacuate the 2-5 mile keyhole area. A shadow evacuation of 20 percent should be included in this analysis as described in Section 2.5.2.

The shelter time of residents within the 2-5 mile zone would correspond to the ETE for 90 percent evacuation of the 0-2 mile zone. The ETE value for the 0-2 mile 90 percent evacuation that will be used in response procedures is the estimated value obtained from the ETE document. It is not based on actual movement of vehicles during an evacuation.

1.4 Evacuation Planning Areas

The ETE is typically developed based upon the EPZ response planning areas. These areas are commonly referred to as Emergency Response Planning Areas (ERPAs), but may also be referred to as subareas, protective action areas, protective action zones, or other site specific terminology. For purposes of this document, the term ERPA will be used; however, local terminology is appropriate and acceptable. ERPAs are defined as local areas within the EPZ for which emergency response information is provided. These areas are typically defined by geographic or political boundaries to support emergency response planning and may not conform to a precise 10-mile radius from the NPP (NRC, 1980).

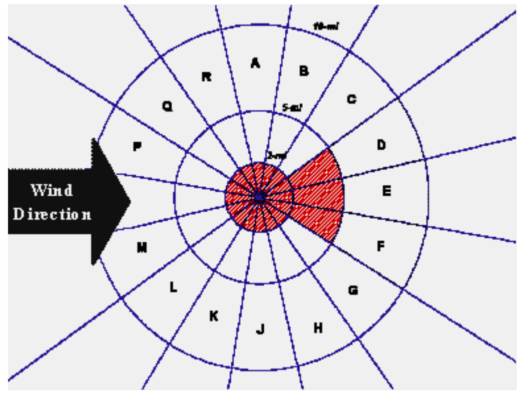

Figure 1-2 Keyhole Evacuation

ETEs should be developed for the complete evacuation of the following:

- 0-2 mile zone;
- 2-5 mile zone for a staged evacuation;
- 0-5 mile zone;
- Affected ERPAs necessary to support site-specific PAR logic (i.e., keyhole based on wind direction as shown in Tables 1-4 and 1-5); and
- Complete EPZ.

Protective actions are implemented at the ERPA level. For those sites where ERPAs are large and encompass areas out to 5 miles, the analyses, including the staged evacuation, should be based on the existing ERPAs. ERPA configurations do not need to be revised to facilitate the ETE analysis.

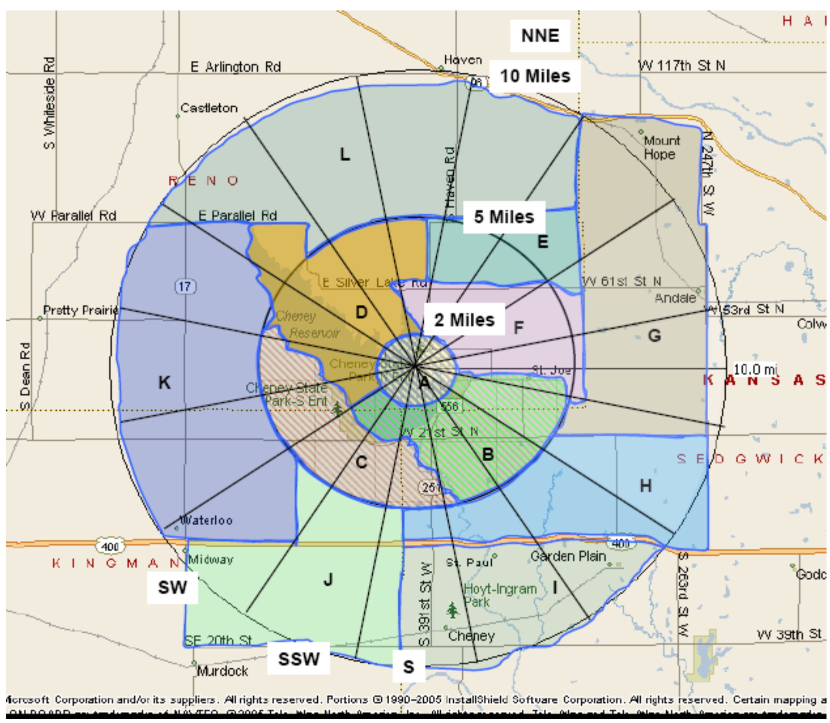

Figure 1-3 Emergency Response Planning Areas

The analyses are performed using a keyhole evacuation as the basis. The term keyhole evacuation is used because the area evacuated resembles a keyhole, including a 360 degree area around the site with a two-mile radius, and continuing in a downwind direction, typically out to 5 miles from the NPP as shown in Figure 1-2. The keyhole includes the downwind sector and adjoining sectors on each side. The calculation of the ETE for a keyhole evacuation previously included the 0-2 mile zone; however, this guidance now separates the time for the 0-2 mile zone and the 2-5 mile zone to support protective action decision making for a staged evacuation. Analysis of keyhole evacuations that include the 0-2 mile zone may still be performed, but these should be in addition to the staged evacuation analysis.

Evacuation areas are developed by assuming a plume travels in a fixed wind direction, and an ETE is calculated for all of the ERPAs within the plume sector and at least the two adjoining sectors. Figure 1-3 provides an example of an EPZ and generic ERPAs. To implement an initial keyhole evacuation, the 2-mile radius and affected downwind sectors would be evacuated to 5 miles. The affected downwind sectors in this example are the SSW and the adjacent S and SW sectors. All of the ERPAs encroached upon by these sectors would be evacuated. Development of a full suite of ETEs requires that this process be repeated for each sector rotating around the EPZ until ETEs are calculated for all wind directions and scenarios.

In the example displayed in Figure 1-3, for a wind direction from the NNE to the SSW, the 2-mile zone includes only ERPA A and the 5-mile downwind sectors encroach upon ERPAs B and C, which would also be evacuated. Therefore, Table 1-5, shows the affected ERPAs are A, B, and C. For the ETE study, a map identifying the ERPAs should be provided along with a table identifying affected ERPAs for each wind direction.

As indicated in Table 1-4, ETEs are developed for each wind direction around the EPZ. When additional ETEs are developed for the keyhole, inclusive of the 2-mile zone, the format in Table 1-5 is appropriate. ETEs for the transit dependent population, special facilities, and schools are developed separately.

Table 1-4 Evacuation Areas for a Staged Evacuation Keyhole

Affected ERPAs	Area	A	B	C	D	E	F	G	H	I	J	K	L
A	2 mile ring	X											
A thru F	5 mile ring	X	X	X	X	X	X						
A thru L	Full EPZ	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2 to 5 miles downwind													
	Wind Direction (from)	Affected ERPAs											
		A	B	C	D	E	F	G	H	I	J	K	L
BC	N		X	X									
BC	NNE		X	X									
BCD	NE		X	X	X								
BCD	ENE		X	X	X								
CD	E			X	X								
CD	ESE			X	X								
D	SE				X								
DF	SSE				X		X						
DE	S				X	X	X						
DEF	SSW				X	X	X						
DEF	SW					X	X						
EF	WSW					X	X						
BF	W		X				X						
B	WNW		X				X						
B	NW		X										
BC	NNW		X	X									

Table 1-5 Evacuation Areas for a Keyhole Inclusive of the 2-Mile Zone

Affected ERPAs	Area	A	B	C	D	E	F	G	H	I	J	K	L
Evacuate 2-mile zone and 5 miles downwind													
	Wind Direction (from)	Affected ERPAs											
		A	B	C	D	E	F	G	H	I	J	K	L
ABC	N	X	X	X									
ABC	NNE	X	X	X									
ABCD	NE	X	X	X	X								
ABCD	ENE	X	X	X	X								
ACD	E	X		X	X								
ACD	ESE	X		X	X								
AD	SE	X			X								
ADF	SSE	X			X		X						
ADEF	S	X			X	X	X						
ADEF	SSW	X			X	X	X						
AEF	SW	X				X	X						
AEF	WSW	X				X	X						
ABF	W	X	X				X						
ABF	WNW	X	X				X						
AB	NW	X	X										
ABC	NNW	X	X	X									

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2.0 DEMAND ESTIMATION

The objective of this section is to detail the process for developing an estimate of the number of people to be evacuated. The NRC's regulations in 10 CFR 50.47(b)(10) require that "a range of protective actions has been developed for the plume exposure pathway EPZ for emergency workers and the public." The public includes all persons located within the EPZ, including residents, transients, people with disabilities and those with access and functional needs, and any other member of the public. Demographic data, together with information and assumptions on population groups support an estimate of the public and corresponding vehicles that will be evacuating the area. Demand estimation for the following four population segments should be developed:

1. Permanent Residents and Transient Population – Permanent residents include all people having a residence in the area. The transient population includes tourists, shoppers, employees, etc., who visit but do not reside in the area.
2. Transit Dependent Permanent Residents – Permanent residents who do not have access to a vehicle or are dependent upon help from outside the home to evacuate.
3. Special Facility Residents – Residents of nursing homes, assisted living centers, and those confined to hospitals, jails, prisons, etc.
4. Schools – All private and public educational facilities within the EPZ. Colleges and universities should be assessed on a case-by-case basis, recognizing that college students typically have access to a vehicle.

Demand estimates for these four population groups are developed separately to account for all of the public within the EPZ.

2.1 Permanent Residents and Transient Population

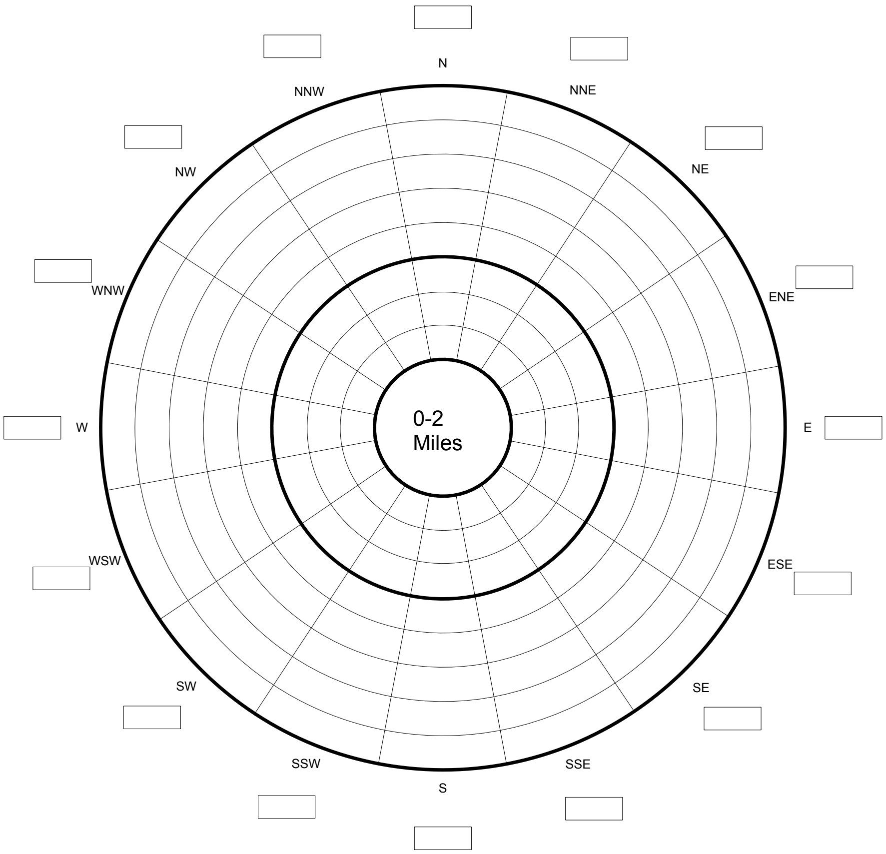
The number of permanent residents should be estimated using U.S. Census Bureau data adjusted as necessary for growth. Along with census data, local data may be used for population estimates. The population values used in the ETE should be developed for the year the ETE is prepared. The permanent resident population group is divided into two subgroups including:

1. Residents having available private transportation.
2. Transit dependent residents (dependent on others for transportation).

The distribution of permanent resident and transient populations should be provided in a format similar to Figure 2-1 with total populations provided for each sector. The rings and sectors of this figure may be extended to 15 miles to show the shadow populations.

2.1.1 Permanent Residents with Vehicles

An estimate of persons per vehicle should be provided. An estimate of 1 to 2 people per vehicle is typical. Values within this range should be used for the permanent population, unless site specific information supports the use of lower or higher values.



Population Miles	Subtotal by Ring	Cumulative Population
0-2		
2-3		
3-4		
4-5		
5-6		
6-7		
7-8		
8-9		
9-10		
10-EPZ Boundary		

Figure 2-1 Population by Sector

2.1.2 Transient Population

The transient population includes people temporarily visiting the area such as tourists, shoppers, employees who do not reside within the EPZ, etc. A list of facilities that attract transient populations should be developed, and peak and average attendance for these facilities should be listed. The use of average attendance values, by season, is generally acceptable. For example, the summer average weekday population for beach areas would be used for summer weekday scenarios, and average weekend population would be used for weekend scenarios.

The transient population should be itemized and totaled as appropriate for each scenario. For example, motel capacities may be full for evening scenarios, but empty during daytime scenarios when tourists are visiting parks or other areas. The distribution of the transient population should be provided in a format similar to Figure 2-1. Care should be taken not to double-count transient populations. To avoid double-counting transients and permanent residents, indicate the percent of permanent residents of the EPZ assumed to be at parks, shopping, or other locations. The number of people per vehicle should be identified. A value of 2.5 people per vehicle is typical, but this may vary by type of facility or location. A basis should be provided if higher vehicle occupancy rates are used. Large employers, defined as those with 50 or more employees working a single shift, should be listed and include the number of people per vehicle.

2.2 Transit Dependent Permanent Residents

An estimate is needed for the time to evacuate those residents that do not have access to a vehicle. Special services that may be needed to support the evacuation of these residents must be considered (NRC, 1980) and identified within the ETE study. Surveys are helpful in identifying the site specific demographics of this population group, including the number of individuals and specialized transport needs. This population group may include:

- Households with no vehicles;
- Households with unsupervised latchkey children;
- Households with one vehicle that is at work and would not return;
- Households where residents have limitations on driving (e.g., elderly who do not drive at night or do not drive distances of more than a few miles); and
- Households dependent on specialized transportation such as wheelchair vans or ambulances.

Local and county emergency plans should be reviewed to identify if plans are in place to provide transportation to transit dependent residents during an evacuation. Where local plans exist, these should be used in developing the ETE. Data from local and county emergency planning registration programs should be used as a first order planning tool to support the demand estimate, but should not be used as the only source of data.

Previous research (NRC, 2008b) and data reviewed on existing ETEs indicate a range of about 3 to 10 percent of EPZ permanent resident populations may be transit dependent. It is recognized that a portion of the population will rideshare during an evacuation, leaving the area with friends, neighbors, or relatives, and it is acceptable to assume that up to 50 percent of residents without vehicles will rideshare. This value is based on results of a national telephone survey conducted of EPZ residents (NRC, 2008b) which indicated more than 50 percent of residents would offer a ride to individuals waiting for transportation. Empirical data obtained from the widely studied Mississauga, Canada evacuation in 1979 (IES, 1981) also supports a value of 50 percent. If a higher value is used, a basis should be provided. Assuming that 50 percent of transit dependent persons rideshare suggests that 1.5 percent to 5 percent of the EPZ permanent resident population may require transportation. A basis should be provided for use of values lower than 1.5 percent.

The capacity of municipal buses is based on adults, and the capacity of school buses is based on children. Considering that residents are evacuating with their belongings, including clothing, medicines, pets, etc., a reasonable estimate for buses is 50 percent of the stated seating capacity (NRC, 2008a) with no credit taken for standing room capacity. The capacities assumed for buses and other transportation should be identified and if an estimate higher than

50 percent capacity is used, a basis for the estimate should be provided. Care should be taken not to double-count resources when calculating transportation needs for populations dependent on public transport and the transportation needs for special facility residents. The availability of transportation resources and drivers should be confirmed.

A subset of transit dependent residents includes people with disabilities and those with access and functional needs that live independent of a special facility. A recent telephone survey of residents living within EPZs found that six percent of respondents said they, or someone in their household, would need assistance to evacuate (NRC, 2008b). Information on households with residents dependent on specialized transportation such as wheelchair vans or ambulances should be developed and quantified separately.

A summary of the total number of vehicles (e.g., buses, ambulances, specialized transport vehicles) available to support the evacuation of transit dependent residents, as well as people with disabilities and those with access and functional needs, not residing in special facilities should be provided. This will support the determination of how many evacuation runs may be needed.

2.3 Special Facility Residents

Special facility residents are those who reside in special facilities and are dependent upon facility personnel for transportation in an emergency. This includes, but is not limited to, hospitals, nursing homes, jails, and prisons. Special facility personnel are counted in the special facility population group. The process for obtaining special facility data should be described and typically includes contacting each facility. A list of special facilities, including the type of facility, location, and population, should be provided. The number of wheelchair and bedbound individuals should be identified. The average number of patients typically at the facility should be used. There may be unique situations where, after extensive efforts to obtain data on facilities, information is not available and assumptions must be used. In such instances, assumptions must be well documented and have a basis. For instance, considering similar facilities, such as nursing homes, an estimated capacity might be based on beds per square foot of the facility and should be comparable to other nursing homes in the area.

When evacuation cannot be accomplished with a single bus run, additional bus runs should be clearly indicated. Resources needed to evacuate special facilities typically include buses, vans, ambulances, automobiles, drivers and specially trained staff. Specially trained staff may include medical support or security support for prisons, jails, and other correctional facilities. The number and capacity of all vehicles needed to support the evacuation should be provided. Care should be taken not to double-count resources when calculating transportation needs for populations dependent on public transport and the transportation needs for special facilities. The availability of resources and drivers should be confirmed.

2.4 Schools

State and local emergency response plans typically include early protective actions for evacuation of schools prior to the general public if time allows. However, the development of ETEs should consider that school evacuations begin with the same initial notification provided to the general public. Schools present a unique issue with the expectation that some students may be picked up by parents, relatives, or friends which may reduce the student population requiring bus transportation. A list of schools, including name, location, student population, and transportation resources required to support the evacuation should be provided. The source of the school population values should be identified.

In many areas high school students drive to school, and these students would be expected to evacuate in their personal vehicles. Busing for high school students may be reduced to reflect the number of students that drive as estimated by school staff. For elementary and middle schools, transportation resources should be based on 100 percent school capacity. Discussion should be provided on the assumptions for evacuation of school staff. When evacuation cannot be accomplished with a single trip, the need for return trips should be clearly indicated.

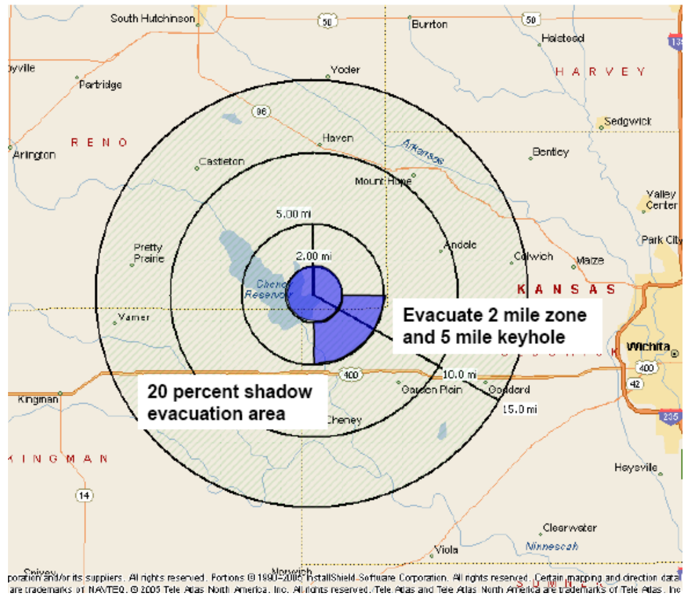


Figure 2-2 Shadow Area for Keyhole Evacuation

2.5 Other Demand Estimate Considerations

As described below, demand estimates should also be considered for peak populations during special events within the EPZ, shadow evacuations for the population extending out to 15 miles from the NPP, and for the background and pass through traffic within the EPZ.

2.5.1 Special Events

Special events occur within most EPZs and can attract large numbers of transients to the EPZ for short periods of time. Special events might include Fourth of July celebrations, Christmas parades, sporting events, or any number of activities that bring large populations into the EPZ. These events frequently define the peak tourist population that is to be included in the study (NRC, 1980). All special events that draw a large group of transients should be listed in the ETE with the estimated population, duration, and season of the event. However, only one special event that encompasses the peak tourist population needs to be analyzed as described below.

The total attendance for an event may provide information that is useful in development of the ETE but may not need to be considered as the demand estimation used. For instance, a weekend festival that draws 100,000 people over the duration of the event may not need to be assessed as an evacuation of 100,000 people. The average hourly or daily attendance may provide a better evacuation number than the total population of the festival. For events where the attendees arrive and depart at relatively the same time, such as a sporting event, the total values are appropriate for use. To avoid double-counting transients and permanent residents, indicate the percent of permanent residents of the EPZ assumed to be at special events.

2.5.2 Shadow Evacuation

A shadow evacuation occurs when people outside of any officially declared evacuation zone evacuate without having been instructed to do so. Shadow evacuations are considered in developing the demand estimation because the additional traffic generated has the potential to impede an evacuation of the EPZ. A shadow evacuation of 20 percent of the permanent resident population, based on U.S. Census Bureau data, should be assumed to occur in areas outside of the evacuation area being assessed extending to 15 miles from the NPP as shown in Figure 2-2. The 20 percent value is static to support a standardized assessment. A shadow evacuation would likely occur in a graded manner with the potential for a 20 percent shadow to occur from the areas that are closer to the declared evacuation area, decreasing with distance away from the affected area.

Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ should be provided by sector. The loading of the shadow population onto the roadway network should be applied consistent with the trip generation time developed for the permanent resident population beginning when the evacuation of the 0-2 mile area begins. It is not necessary to estimate a shadow population for transient or special facility populations.

2.5.3 Background and Pass Through Traffic

Background and pass through traffic contribute to the demand estimation. Background traffic is defined as vehicles on the roadway when the initial notification occurs and consists of both residents and transients within the EPZ. It is important to consider that these individuals may be on the roadway within the EPZ at the beginning of an emergency and the ETE should include time for activities needed to return home, when appropriate, and then evacuate. Pass through traffic includes vehicles that enter the EPZ roadway network and ‘pass through’ prior to the establishment of access control points. In some EPZs, this may account for a significant volume of vehicles. The volume of vehicles should be representative of the average daytime traffic within the EPZ. Values may be reduced for nighttime scenarios. It is appropriate to assume that pass through traffic will stop entering the EPZ about 2 hours after initial notification when access control points have been established.

2.6 Summary of Demand Estimation

The assessment of the demand estimation will provide the total number of people and vehicles to be evacuated for each of the population groups including permanent residents with vehicles, transit dependent permanent residents (those who require specialized vehicle transportation and those who only require bus transportation), transients, special facilities, schools, shadow population, and background and pass-through demand. A summary table should be provided that identifies the total populations used in the analysis for each scenario, and a separate summary table should be provided that identifies the total number of vehicles by population group for each scenario. These values should represent the input values used in the traffic simulation modeling.

3.0 ROADWAY CAPACITY

The objective of this section is to identify the methods and data used in the assessment of roadway capacities. The capacity of a roadway is defined as the maximum rate at which vehicles can be expected to traverse a section of roadway during a given time period under prevailing roadway, traffic, and control conditions. Roadway capacity influences evacuation travel time particularly as traffic demand approaches or exceeds capacity. For this reason, a detailed capacity analysis is important. Capacity analysis is performed through the application of processes and equations established in the U. S. Department of Transportation's Highway Capacity Manual (HCM) and augmented as appropriate for consideration of saturated flow conditions. As roadways become saturated, the HCM methodologies are not as well developed, and the analysis is best performed using traffic simulation models, which use numerical techniques to predict performance of traffic behavior. The method used to assess roadway capacity should be discussed.

3.1 Roadway Characteristics

Roadway characteristics are needed for proper depiction of the evacuation transportation network. Roadways should be categorized by functional class to identify the types of roadways used in the analysis. Local or regional terminology may be used for the roadway classes, and the following classes should be identified if present:

- Freeways or Interstates;
- Freeway ramps;
- Major arterials;
- Minor arterials;
- Collectors; and
- Local roadways.

In all cases, a field survey of the key routes within the EPZ should be performed to validate existing mapping and obtain roadway characteristics and information for use in the analyses. At a minimum, the following information should be obtained:

- Number of lanes;
- Lane and shoulder width;
- Grade changes of more than about 4 percent;
- Left turns in lane group;
- Right turns in lane group;
- Narrowest roadway segments on evacuation routes;
- Roundabouts or rotary intersections;
- Toll gates and associated lane channelization;
- Intersection queuing capacities;
- Posted speed limits; and
- Areas where frequent flooding of roadways occur.

A legible map of the roadway system that identifies node numbers and segments used to develop the ETE similar to Figure 3-1 should be included. An electronic version of the map may be provided to allow enlargement as needed to support a detailed review of the nodes and segments of the roadway network. Depending on the complexity of the EPZ and the number of nodes and segments, the map may be presented in quadrants or other sectors to provide the necessary clarity. A table of roadway characteristics should be presented in a format similar to that provided in Appendix A, “Roadway Network Characteristics.”

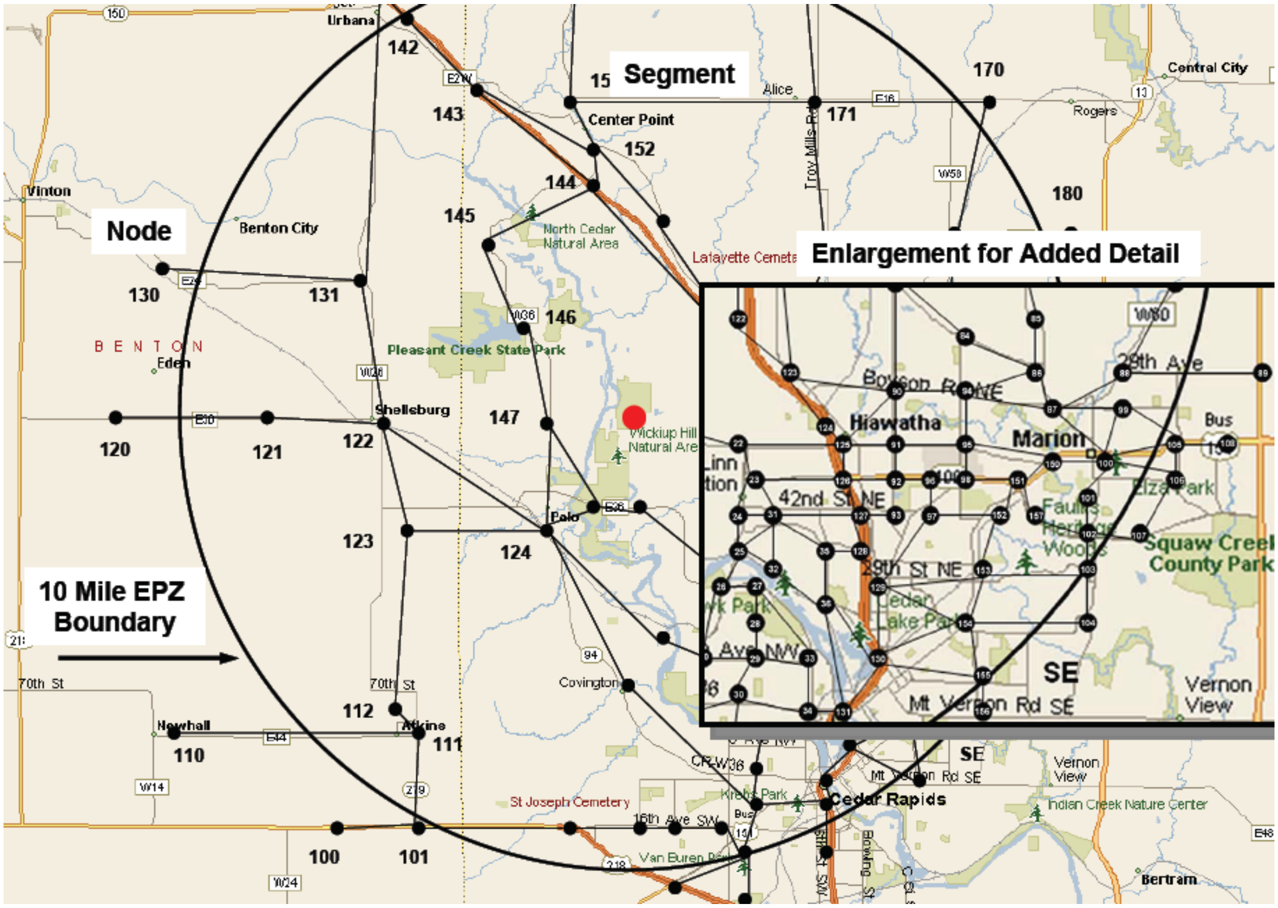


Figure 3-1 Roadway Network Identifying Nodes and Segments

3.2 Capacity Analysis

The processes outlined in the HCM for two lane highways, multi-lane highways and freeways are used to determine the capacity of roadway segments by accounting for lane width, lateral clearance, heavy vehicles, etc., through the use of adjustment factors (TRB, 2000). However, many of the computational approaches used in the HCM break down as the roadway capacity is exceeded. Because this is a prominent condition during evacuations, traffic simulation modeling is used to assess traffic behavior. These models can better assess saturated flow where evacuation time becomes more dependent on the ratio of demand to capacity (v/c ratio) under the conditions and characteristics of the roadway network and the interactions between individual vehicles on the roadway.

The approach used to calculate the roadway capacity for the transportation network should be described in detail and should discuss important factors that are expressly used in the modeling, particularly those associated with the control and/or interruption of flow within the network. An approach that provides a more detailed analysis of key routes, such as evacuation routes, is suggested. Such an approach would include applying field acquired data to routes designated as evacuation routes. Routes that are not designated evacuation routes must also be evaluated, but field estimates in lieu of field measurements may be appropriate for these roadways. The capacity analysis should expressly state where field information is utilized in the ETE calculation and how it was acquired.

3.3 Intersection Control

The efficiency of roadway networks is frequently constrained by intersection capacity which is influenced by intersection control. Important characteristics of intersections include the number of approach lanes for through traffic, left and right turn lanes, and effective green time, which is the time that is used by vehicles to enter the intersection at the saturation flow rate. A discussion should be provided regarding how intersection characteristics are represented within the evacuation model. A list of intersections should be provided that includes the total number of intersections that were modeled with unsignalized control (e.g., stop signs), signalization, or traffic control personnel who physically direct traffic.

When developing the ETE, local agencies should be contacted to understand whether special signal timing plans exist for emergency conditions. Where these emergency condition timing plans exist, and are current, this information should be used in the analysis. A detailed description of the approach to modeling intersections should be provided. In particular, this should include the signal cycle timing, green time allocation to the constituent approaches, and other control variables such as whether signals work within a coordinated corridor or are coordinated across the network.

A key objective of traffic modeling is to best represent the expected traffic flow under evacuation conditions. The analysis approach should not attempt to optimize traffic flow through intersections. All signalized intersections should be included in the traffic simulation modeling; however, it is not practical or necessary to obtain individual traffic signalization timing for every intersection, because signal timing often changes throughout the day depending on traffic flow. Traffic simulation modeling should consider the following types of intersections:

- Unsignalized;
- Fixed time signals;
- Actuated signals; and
- Manned traffic controlled intersections.

Unsignalized intersections, such as those featuring stop or yield control, must be included. Fixed time signals provide a constant effective green time through the intersection for the primary and secondary roadways, and these timing durations may vary by time of day. It is acceptable to assume that all fixed time signals within a jurisdiction operate under similar timing conditions. Representative signal timing will need to be developed and may be determined by obtaining signal timing during the field survey from a representative set of signals or may be obtained from discussions with local transportation engineers. It is important that the fixed timing signal locations and timing be identified in the analysis because it is likely that these will continue to operate as fixed timing signals unless augmented by traffic control personnel. The approach to determining the fixed signal timing should be described.

Actuated signals are more complex and allocate green time based on level of demand that exists at each intersection approach, and the signal timing varies depending upon approach volumes. One method for modeling actuated signals is to allocate green time based on the level of demand flow between the primary and secondary cross streets to simulate saturated conditions in each direction. This method can effectively address the actuated signal conditions. The approach to modeling actuated signal control must be documented within the report.

Manned traffic controlled intersections are those locations where traffic control personnel will be stationed during the evacuation to support traffic movement through the intersection. One method for modeling manned traffic controlled intersections is to treat these as actuated signals and adjust the signal timing to reflect more efficient operations. It may be assumed that traffic control personnel will attempt to move traffic through the intersection in a way similar to that of an actuated signal by reducing the lost time of through traffic and turning traffic.

In general, it may be assumed that manned traffic controlled intersections operate most efficiently. Actuated signals would be less efficient, fixed timing signals still less efficient, and non-signalized intersections would be the least efficient intersections. For simulation models that adjust the signal cycle length within a single model run, a discussion of the process to adjust the cycle timing should be provided. It should be clear if signal timing is adjusted within the model for all intersections, for actuated signals, and for intersections manned by response personnel to direct traffic. Characteristics of the 10 highest volume intersections within the EPZ should be provided, including the location, signal cycle length, green time allocation, and turning lane queue capacity as used in the modeling.

3.4 Adverse Weather

The adverse weather condition is intended to represent weather conditions that are probable within the region. It is not necessary to evaluate those adverse weather conditions that may occur at frequencies of 100 years or longer. The reduction factors in Table 3-1 may be used for the adverse weather conditions. Impacts of adverse weather can vary based on the region and familiarity of the drivers to the weather condition, therefore, the factors provided in Table 3-1 are guidance and may be adjusted based on local conditions.

Table 3-1 Weather Capacity Factors

Weather Condition	Roadway Capacity	Speed
Normal	100%	100%
Adverse – Heavy Rain	90%	85%
Adverse – Heavy Snow/Ice	85%	65%
Adverse – Fog	75%	85%

The values in Table 3-1 for heavy rain and snow are derived from Chapter 22 of the HCM, Exhibit 22-7 (TRB, 2000) and the Federal Highway Administration study, "Identifying and Assessing Key Weather-Related Parameters and Their Impacts on Traffic Operations Using Simulation" (FHWA, 2004b). Little research has been conducted on ice or fog, but ice is frequently observed to have a similar effect as heavy snow.

The effect of adverse weather on mobilization should also be considered. For heavy snow scenarios, snow removal equipment may be necessary to clear access roads for the evacuation. The time for snow removal crews to mobilize and clear snow should be considered in the trip generation time developed for the site. Frequently municipal snow removal equipment is operating during snowfall to maintain access; thus, this may not have much impact on time elements. Time may need to be considered in the trip generation time for the clearance of snow from driveways by residents.

4.0 DEVELOPMENT OF EVACUATION TIMES

The objective of this section is to identify how evacuation preparation activities are developed and quantified and how to present the ETE modeling methods and data to facilitate review. Preparation activities, including the time to receive the notification and time to prepare to evacuate, are developed as elements of the trip generation time, sometimes referred to as mobilization time. The trip generation time is then integrated into the calculation of the ETE. For EPZs where the population density is low and there is minor congestion, the travel time element of the evacuation may be conducted quickly, and the total ETE may be very close to the trip generation time. For higher population density sites where there is congestion and travel is slowed during the evacuation, the travel time may be influenced more by the ratio of demand to capacity (v/c ratio) than by the trip generation time.

The ETE supports protective action recommendations and decisions and reflects the response of the public to evacuation orders. It is therefore important to understand that ETEs that overestimate or underestimate the evacuation time are not helpful in making the best protective action decision. This approach differs from traditional traffic analyses which are often conservative. During evacuations, there is a small percentage of the population that takes longer to evacuate, often referred to as the evacuation tail. The evacuation tail generally consists of the last 10 percent of evacuees. Planning is in place to evacuate 100 percent of the public; however, protective action recommendations and decisions should be based on the 90 percent ETE values. For this reason, ETEs are developed for evacuation of 90 and 100 percent of the EPZ population. The 90 percent value informs decision makers of the estimated time to evacuate the vast majority of the public, and the 100 percent ETE informs decision makers on the likely time for the EPZ to be fully evacuated. The ETE will be used by the licensee when developing procedures that support making offsite protective action recommendations and should be used by OROs when developing offsite protective action strategies. The level of data required to develop an ETE study necessitates that the analyst interact directly with State and local agencies and facilities such as hospitals, schools, etc., to obtain current and relevant information needed to support the calculations.

4.1 Trip Generation Time

The trip generation time is used to develop the vehicle loading curves. The development of trip generation times is described in NUREG/CR-6863, "Development of Evacuation Time Estimate Studies for Nuclear Power Plants," (NRC, 2005a) and includes:

- Identifying the sequence of events;
- Obtaining data for each event;
- Developing time distributions for analysis;
- Summing the distributions; and
- Calculating trip generation times.

Each population group has different considerations for trip generation times. Telephone surveys of residents within the EPZ are commonly used to develop some of the data used to develop the time distributions. When telephone surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance should be provided. The data obtained from the survey should also be summarized in the ETE.

The trip generation time is developed from site specific information for each population group and varies depending on the scenario. The ETEs for the transit dependent residents, special facility residents, and schools are each developed separately from the general public. The logistics of the trip generation times for these groups can be complex and may affect the ETE more than the actual travel time out of the EPZ.

4.1.1 Permanent Residents and Transient Population

It is important to provide sufficient detail on the logistics of evacuation elements used to develop time values. For example, the permanent resident trip generation time for an event during a normal working day may include the following elements, each of which will have a distribution of times (Urbanik, 2000):

- Notification of the public – The period of time to notify the public.
- Prepare to leave work or other activity – The time between receipt of notification and when individuals actually leave the workplace. This element should include the time for residents to leave stores, restaurants, parks, or other location.
- Travel to home – The time it takes to reach home after leaving work or other activity.
- Prepare to leave for the evacuation – The time to pack and prepare the home prior to leaving, including such activities as removal of snow from driveways, if appropriate.

Permanent residents are assumed to evacuate from their home; however, they should not be assumed to be home at all times. The notification element of the trip generation time for the transient population should consider areas where notification of persons may be difficult including campgrounds, hunting or fishing areas, parks, beaches, etc. As visitors to the EPZ, this population group will have a “prepare to leave work or other activity” element which should consider that individuals may return to hotels prior to evacuating. Where special events that draw large numbers of transients utilize transportation resources such as park and ride services, the logistics of such activities should be discussed. The trip generation time for the transient population is integrated with that of the general public to support the loading of the transportation network.

4.1.2 Transit Dependent Permanent Residents

Transit dependent residents include ambulatory people who are mobile and non-ambulatory people who need assistance. Typically, the local or county emergency management agencies will have emergency plans for evacuation that include the use of public buses along existing bus routes or along special routes for evacuation of the ambulatory transit dependent population. Existing plans and bus routes should be used in the ETE analysis when available. If new plans are developed with the ETE, the new plans should be agreed upon by the responsible authorities. A description of the means of evacuating these residents should be provided and should include the number of buses needed to support the demand estimation as previously determined. The time estimated for transit dependent residents to prepare and then travel to bus pickup points should be identified as well as the expected method of travel to the pickup points. Development of the ETE should include confirmation of the type and number of resources available and whether resources are available locally or need to be mobilized from outside the EPZ. The intent is not to physically verify each vehicle but to confirm that commitments are established to provide all of the resources needed. When buses are used, the time needed for residents to prepare and get to the bus stop should be included in the trip generation time.

The trip generation time should address the availability of buses. Municipal buses are generally used throughout the day and may not be immediately available to support an evacuation. Buses may need to complete their normal routes prior to being available. Logistical details should be evaluated and may include time to obtain buses, brief drivers, and initiate the bus route. The number of bus stops and the time needed to load passengers should be provided to support the bases of the time estimates. A map of bus routes should be provided.

The local or county emergency management agencies may also have emergency plans for evacuation of the non-ambulatory residents. The evacuation of these residents will require the use of ambulances, wheelchair vans, or other specialized vehicles. The location of these resources should be identified. The trip generation time should include time to mobilize ambulances or special vehicles, time to drive to the homes of the non-ambulatory residents, loading time, and time to drive out of the EPZ.

In calculating the travel time to exit the EPZ, vehicle speeds should be consistent with traffic speeds for the actual route used and should not be based on the average roadway speed for the full EPZ. When there are not enough vehicles to conduct the evacuation in a single trip, the following additional information should be provided:

- Location of the destination point;
- Travel time to the congregate care center or other special facility, as appropriate;
- Time to unload;
- Travel time back through the EPZ to pick up additional residents; and
- Travel time to exit the EPZ.

The above steps are repeated as necessary until all of the transit dependent residents have been evacuated. In the multiple-trip scenario, the travel speeds may be limited by evacuation traffic and traffic control on portions of the route for both inbound and outbound vehicles.

4.1.3 Special Facilities

The evacuation logistics for special facilities requires developing information to establish the time for mobilization of resources, loading of special facility residents, and travel out of the EPZ. Specially trained staff, such as medical support or security support for prisons, jails, and other correctional facilities, may need to be contacted and mobilized along with vehicles and drivers. The logistics for mobilizing specially trained staff should be discussed when appropriate. Information on evacuation logistics should be provided for the following:

- Time needed to contact the drivers;
- Time for drivers to arrive at the transit depot;
- Time for briefing, receipt of radios, fueling of buses, etc., as applicable; and
- Inbound travel time from the depot to the special facilities.

The inbound speeds of vehicles to support the evacuation should consider that traffic control may be in place which may slow inbound traffic. The time for loading of special facility residents should be established and may be dependent on the size of the facility. Information should be provided for the following:

- Time for loading of residents. For small population facilities, this activity may be performed relatively quickly. For larger population facilities where a large number of vehicles are planned to be loaded, the details of vehicle queuing and loading should be discussed. The analysis should consider the time to cycle vehicles to the facility entrance to load residents.
- For special facilities, the number of wheelchair and bedbound individuals should be identified, and the logistics of evacuating these residents should be discussed.

The outbound speeds should be developed with consideration of the prevailing traffic conditions at the time and should be obtained from the model output for the specific routes, when available. Information on evacuation of special facilities should be provided in a comprehensive format similar to Table 4-1.

Table 4-1 Special Facilities ETE

Facility	Population	Number/Type of Vehicles	Mobilization Time	Vehicle Queue Length	Loading Time	Distance to EPZ Boundary	Outbound Travel Speed	Travel Time to EPZ Boundary	ETE

When return trips are needed, the destination of the buses is necessary to develop the ETE. For special facilities, this may be a hospital, prison, etc., outside of the EPZ rather than a congregate care center. The ETE should identify whether a reception center is used in the evacuation and if special facility residents are expected to pass through the reception center prior to being transported to their final destination. The time elements for subsequent trips should include the following:

- Time to travel to the unloading point;
- Time to unload;
- Time to travel back to the facility;
- Time to load the second group; and
- Time to travel out of the EPZ.

4.1.4 Schools

The evacuation logistics for schools also requires developing information to establish the time for mobilization of resources, loading of students, and travel out of the EPZ. Information on evacuation logistics should be provided for the following:

- Time needed to contact the drivers;
- Time for drivers to arrive at the transit depot;
- Time for briefing, receipt of radios, fueling of buses, etc., as applicable; and
- Inbound travel time from the depot to the schools.

The inbound speeds of buses to support the evacuation should consider that traffic control may be in place which may slow inbound traffic. The time for loading students should be established and may be dependent on the population of the schools. Information should be provided for the following:

- Time for loading students. For small population schools (i.e., a few hundred students), this activity may be performed relatively quickly. For larger population schools where a large number of buses are planned to be loaded, the details of bus queuing and loading should be discussed. Typically, this would include schools requiring more than 20 buses to arrive and load students at the same time.

The outbound speeds should be developed with consideration of the prevailing traffic conditions at the time and should be obtained from the model output for the specific routes, when available. Information on evacuation of schools should be provided in a comprehensive format similar to Table 4-2.

Table 4-2 Schools ETE

School Name	Population	Number of Buses	Mobilization Time	Bus Queue Length	Loading Time	Distance to EPZ Boundary	Outbound Travel Speed	Travel Time to EPZ Boundary	ETE

When return trips are needed, the destination of the buses is necessary to develop the ETE. The ETE should identify whether a reception center is used in the evacuation and if students are expected to pass through the reception center prior to being evacuated to their final destination. The time elements for subsequent trips should include the following:

- Time to travel to the unloading point;
- Time to unload;
- Time to travel back to the schools;
- Time to load the second group; and
- Time to travel out of the EPZ.

4.2 ETE Modeling

This section discusses the inputs and outputs of the traffic simulation models. Traffic simulation modeling is usually conducted to develop the ETE for the general public population group, and analysts that perform this modeling should understand traffic simulation applications. There are a variety of models and commercial services available to support a simulation analysis. The DOT sponsored "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory" is also available to support selection of an appropriate model for use in evacuation analysis (DOT, 2007). The FHWA toolbox for use in modeling roadway networks is also helpful in the development of traffic simulation (FHWA, 2004a). Note that the FHWA modeling toolbox is intended to support transportation planning and is not specific to evacuations; therefore, appropriate adjustments are necessary.

The DOT and FHWA sources discuss microscopic, mesoscopic, and macroscopic models, any of which may be appropriate for use. As the number of commercially available models and professional services to develop ETEs increases, it is important that only models that have been demonstrated for use in the development of ETEs or in assessing transportation networks be used in the development of ETEs. General information about the model should be provided to include prior use in the development of ETE studies for NPPs or other applicable commercial or government applications. It is also important for the analyst to understand the analysis tools and the sensitivities of input parameters. If an ETE is developed without the aid of a traffic simulation model, such as for a sparsely populated site, the analytical approach should be consistent with this section, and the study should include the detailed information requested, as applicable.

The use of traffic simulation modeling in the development of ETEs provides the ability to assess evacuation of EPZs with great detail. Because models produce results using embedded algorithms and input data, it has become more difficult to review the analysis. In "The Sensitivity of Evacuation Time Estimates to Changes in Input Parameters for the I-DYNEV Computer Code," (NRC, 1988b), several parameters were identified as sensitive, meaning that when these parameters were adjusted the resulting ETE was noticeably affected. The study underscores the importance of the model input values. Some sensitive parameters identified (NRC, 1988b) include:

- Number of vehicles – Evacuation times increased approximately linear to the increase in population;
- Roadway capacity – Changes in roadway capacity affect the evacuation time in a linear manner; and
- Trip Generation Time – As the trip generation time, which is used to develop vehicle loading curves, approaches evacuation time, the evacuation time increases proportionately to the trip generation time.

Traffic simulation modeling is an improved approach over simplistic comparisons of demand to capacity for the complex analyses required for an ETE, and it is necessary to develop these models in a transparent manner. For this reason, measures of effectiveness (MOEs) will be established for use in evaluating the traffic simulation activities. Key performance characteristics derived from the model output will provide these MOEs.

4.2.1 Traffic Simulation Model Input

Traffic simulation model assumptions and input parameters should be provided to support analysis. A representative set of model inputs should be provided for at least the following:

- Roadway capacity values, if necessary for the model;
- Total vehicles entering the network;
- Vehicle occupancy (persons per vehicle);
- Time based vehicle loading curves for origin nodes;
- Data input at origin nodes;
- Directional preference; and
- Destination nodes and capacities.

Not all loading data needs to be provided for review, but full data sets for at least five nodes should be provided. It is not uncommon for different models to have different definitions for similar variables (TRB, 2000); therefore, a glossary should be provided to support the review. A list that includes nodes, links, and loading input information should be provided as shown in Table A-1 of Appendix A.

4.2.2 Traffic Simulation Model Output

A discussion regarding whether the traffic simulation model used in the analysis must be in equilibrium prior to calculating the ETE should be provided. Equilibrium is established by running a model until the number of vehicles entering the roadway network is equal to the number of vehicles exiting the network. Model output provides the MOEs for the ETE study. Examples of MOEs include traffic-based performance measures such as average travel times, total number of vehicles exiting the system, and queue lengths at various times during the evacuation. At a minimum, the following output should be provided in a table for the evacuation of the whole EPZ.

- Total volume and percent of vehicles by hour at each EPZ exit node;
- Network wide average travel time;
- The longest queue length for the 10 intersections with the highest traffic volume;
- Total vehicles exiting the network;
- A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ; and
- Average speed for each major evacuation route that exits the EPZ.

Additional or alternative MOEs may be provided for sites where other performance measures might provide a better view of the traffic conditions and resulting ETEs.

To describe the operational conditions of the roadway network, the Level of Service (LOS), as defined in the HCM, provides a quality measure. The LOS represents the range of traffic operational characteristics and is designated as “A” for free flow operating conditions through “F” for forced flow or congested operating conditions. The LOS is used to describe the levels of congestion at selected time intervals during an evacuation. Color coded graphics should be provided identifying areas where congestion exists (e.g., LOS “E” and LOS “F” conditions). These graphics should be provided for various times for a full EPZ evacuation scenario.

4.3 Evacuation Time Estimates for the General Public

The ETE should include the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population of the affected ERPAs and should include an analysis of the staged evacuation protective action. The ETEs for the transit dependent population, special facilities and schools are developed separately, and only the time to evacuate 100 percent of these population groups is needed.

When developing the 100 percent ETE value for the general public, it should include all members of the general public within the affected ERPAs. Any reductions in trip generation times and truncating of trip generation time values must be explained in detail. Truncation is the reduction in trip generation time values to limit the effect of a very small number of residents who take an excessive amount of time to prepare to evacuate. Existing telephone surveys eliciting data on the expected time needed to prepare to evacuate show that a small number of residents may take considerably longer to evacuate. This extra time can extend an ETE disproportionately with respect to the remaining population. When such data is received from public surveys, adjustment or truncation of times is acceptable if a valid basis is provided.

Traffic simulation model results need to be presented such that they are readily understood and interpreted by decision makers and reviewers of the study. The 90 and 100 percent ETEs should be developed for the following:

- 0-2 mile zone;
- 2-5 mile zone for a staged evacuation;
- 0-5 mile zone;
- Affected ERPAs necessary to support site specific PAR logic (i.e., keyhole based on wind direction); and

- Complete EPZ.

Separate ETE tables should be provided for the 90 percent and for the 100 percent evacuation times for the full set of scenarios evaluated. These tables should follow the format presented in Table 4-3.

Separate ETEs should be provided for the transit dependent population, special facilities, and schools for just the 100 percent evacuation. The Special Event ETE is provided and is based on the demand estimation developed earlier. The roadway impact scenario is not included in Table 4-3 because the only purpose of this scenario is to support the development of traffic control planning.

For each scenario, an estimate of the time to complete a staged evacuation is needed. This analysis involves evacuating the 0-2 mile zone while the 2-5 mile zone is under a shelter in place order. When about 90 percent of the residents from the 0-2 mile zone have exited the 2-mile boundary per the 90 percent ETE, the 2-5 mile zone resident population begins to evacuate. During the time required for the 0-2 mile zone to evacuate, the 2-5 mile zone may be assumed to be preparing to evacuate, which may reduce the mobilization time for this area. The residents in the ERPAs beyond 5 miles should be modeled to react as does the population in the 2-5 mile zone (i.e., begin evacuation after the 90 percent ETE has expired for the 0-2 mile zone).

Historically, ETEs for the keyhole evacuation were developed for the 2-mile evacuation and 5 miles downwind, but were not developed as a staged evacuation. ETEs for keyhole evacuations may still be developed, if desired, but should be done so in addition to the staged evacuation ETEs. When ETEs are developed for the keyhole inclusive of the 2-mile zone, the format in Table 4-4 is appropriate and 90 and 100 percent values should be provided. Additionally, all ETE studies should include ETEs based on site-specific PAR logic.

Table 4-3 ETEs for a Staged Evacuation Keyhole

100 Percent Evacuation of Affected Areas										
		Summer				Winter				Special Event
		Midweek Daytime		Weekend Daytime	Midweek Weekend Evening	Midweek Daytime		Weekend Daytime	Midweek Weekend Evening	
Affected ERPAs	Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Normal	Adverse	Normal	Normal	Normal	Adverse	Normal	Normal	
	2-mile zone									
	5-mile zone									
	10-mile EPZ									
Evacuate 2 to 5 miles downwind										
	N									
	NNE									
	NE									
	ENE									
	E									
	ESE									
	SE									
	SSE									
	S									
	SSW									
	SW									
	WSW									
	W									
	WNW									
	NW									
	NNW									

Table 4-4 ETEs for a Keyhole Evacuation Inclusive of the 2-Mile Zone

100 Percent Evacuation of Affected Areas										
		Summer				Winter				Special Event
		Midweek Daytime		Weekend Daytime	Midweek Weekend Evening	Midweek Daytime		Weekend Daytime	Midweek Weekend Evening	
Affected ERPAs	Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Normal	Adverse	Normal	Normal	Normal	Adverse	Normal	Normal	
Evacuate 2-mile zone and 5 miles downwind										
	N									
	NNE									
	NE									
	ENE									
	E									
	ESE									
	SE									
	SSE									
	S									
	SSW									
	SW									
	WSW									
	W									
	WNW									
	NW									
	NNW									

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5.0 OTHER CONSIDERATIONS

The preceding sections describe the methodology and approach to calculating the ETE. In addition to the calculation of an ETE, there are other considerations that need to be addressed in the ETE study. These considerations are described below and should be included as appropriate.

5.1 Development of Traffic Control Plans

Traffic simulation modeling in support of the ETE analysis can be used to assist in the development of traffic control plans to support an evacuation. Development of an ETE study provides an opportunity to model the EPZ with variations of traffic control to best affect the evacuation with the resources available. Where a new traffic control plan shows improvement in evacuation times, the new plan should be approved by responsible authorities if it is to be used in the ETE analysis. A discussion of adjustments or additions to the traffic control plan should be provided. The roadway impact scenario is used to support the development of the traffic control plan.

5.2 Enhancements in Evacuation Time

The ETE analysis is a tool that can be used to identify recommendations for enhancements that may reduce evacuation times. When evaluating potential enhancements that may reduce evacuation times, the evaluation may be limited to those roadways or sections of the EPZ that impact the ETE the greatest. This evaluation will typically include intersections and roadway segments where an LOS "F" occurs for some period of time. It is not expected that every intersection or roadway segment needs to be evaluated. The process used to select the intersections or roadway segments for evaluation should be described.

Each of the following potential areas of enhancement should be addressed with a discussion provided on the results of each evaluation. The results should include the reduction in evacuation time observed in the modeling output or the expected reduction in evacuation time for suggested enhancements. For example:

- Increased intersection throughput - Identify opportunities to increase intersection throughput, such as turn restrictions or traffic control.
- Reduced trip generation time - Identify opportunities for reducing the trip generation time.
- Reduced evacuation tail - Identify opportunities for reducing the evacuation tail.

The results of the potential enhancements that were identified should be presented to the local authorities for their consideration. Documentation of the review with those authorities should be included in the ETE report.

5.3 State and Local Review

Interaction with State and local agencies is necessary to obtain local and regional data, understand the operations and resources of the emergency response capabilities, and understand the traffic management system. The ETE should list those agencies that have been contacted, and briefly, the extent of interaction with these agencies as related to the development of the ETE. Any issues that may affect the ETE should be discussed and resolved. This will help assure that appropriate agencies, such as those providing traffic control or resources to support the evacuation, are aware of the ETE strategies, issues, and assumptions.

5.4 Reviews and Updates

Emergency planners depend on the accuracy of the ETE analysis to support evacuation decisions; therefore, it should be reviewed periodically to identify changes that may have occurred. Whenever population increases occur that cause ETE values to materially increase, the ETE analysis should be updated in accordance with the requirements of Section IV of Appendix E to 10 CFR Part 50. Licensees shall provide an updated ETE analysis to the NRC within 365 days of:

1) The later of the date of the availability of the 2010 decennial census data or the effective date of the emergency preparedness final rule;
2) The availability of subsequent decennial census data; and
3) When a population increase within the EPZ causes certain ETE values to increase by 25 percent or 30 minutes, whichever is less, as described below.

Licensees shall estimate EPZ permanent resident population changes at least annually during the years between decennial censuses using U. S. Census Bureau data. These estimates shall occur no more than 365 days apart. State/local government population data may also be used, if available. Licensees shall maintain these estimates available for NRC inspection during the period between censuses and shall submit these estimates to the NRC with any updated ETEs.

If at any time during the decennial period, the population increases so that the ETE for the 2-mile zone or 5-mile zone, including all affected ERPAs, or for the entire EPZ, increases by 25 percent or 30 minutes, whichever is less, for the scenario with the longest ETE, the ETE analysis must be updated to reflect the impact of that population increase. Licensees should perform a population sensitivity study, during development of the ETE, to determine the population value that will cause ETE values to increase by 25 percent or 30 minutes, whichever is less. The sensitivity study should be performed and included with the baseline ETE. For example, assume the sensitivity study shows that an increase of 25 percent or 30 minutes occurs with a permanent resident population increase of 10,000 people. The licensee would review the EPZ population annually and when an increase of 10,000 people occurs, an updated ETE analysis will be developed and submitted within 365 days. Licensees can assume that the roadway infrastructure and capacity values, and transient populations are unchanged from the baseline ETE analysis when performing the population sensitivity study.

The evaluation criteria in Appendix B will be used during the reviews of the updated ETE analyses to confirm their completeness. During the years between decennial censuses, NRC Headquarters staff will inform FEMA Headquarters on a quarterly basis of any updated ETE analyses received. NRC Headquarters staff will also notify FEMA Headquarters and the appropriate NRC regional office when these updated ETE analyses have been reviewed.

Since the NRC will review the updated ETE analyses for completeness, licensees are required under Sections IV.4 and IV.6 of Appendix E to submit updated ETE analyses to the NRC at least 180 days before they use them to form protective action recommendations or provide them to offsite authorities for use in developing offsite protective action strategies.

5.4.1 Extreme Conditions

In the unlikely event that the conditions of an EPZ are changed significantly due to natural phenomena hazards or for other reasons, such as a bridge collapse on a primary roadway, an update to the ETE analysis should be developed. The updated ETE is necessary to account for the current state of the EPZ when these changed conditions are expected to persist for at least a few months, as it may take that long to develop an update. Planned activities, such as construction or infrastructure projects, are expected to have compensatory measures in place such that the activities do not affect the ETE. Therefore, the extreme condition updates are intended to apply only for unplanned changes within an EPZ and are not intended to apply to planned activities. An update prepared to satisfy the extreme conditions criteria does not need to include a full revision to the ETE analysis, but rather should address only those extreme condition elements that affect the ETE. The update should be shared with appropriate OROs.

5.5 Reception Centers and Congregate Care Centers

Evacuation planning includes the use of congregate care centers, which are established as shelter facilities for evacuees. For many EPZs, reception centers are used along with congregate care centers in the evacuation process. Reception centers are those facilities where evacuees are registered, and if necessary, screened for potential contamination prior to going to a congregate care center. Evacuees do not stay at reception centers. The location of reception centers and congregate care centers may be an important factor in the ETE analysis. Schoolchildren, transit dependent residents, and people with disabilities and those with access and functional needs may be bused to reception centers for screening, and then bused to congregate care centers or other special facilities that provide appropriate care. These activities occur outside the EPZ and are not factored into the time estimates except in those cases where buses must return to the EPZ to support subsequent evacuation trips.

For EPZs where return trips are needed for buses or other vehicles, the location of these facilities and logistics of offloading passengers prior to returning to the EPZ will directly affect the evacuation time. These logistics include such actions as unloading vehicles, screening the passengers, reloading the vehicles, and travel to the congregate care center, as appropriate. A map identifying the location of congregate care centers and reception centers, if used, should be provided. Discussion should be provided on the assumptions for the time necessary for buses to return to the EPZ and start the next wave of evacuation. If it is assumed that passengers are left at the reception center and taken by separate buses to the congregate care center, this should be clearly stated and consistent with the local emergency planning.

5.6 New Reactors

The construction of new reactors may occur at sites with existing reactors where emergency response programs are established, or may occur on green field sites where such programs are not in place. For sites at which there are existing emergency response programs, the ETE analysis developed for the new reactor should be prepared to address any impacts that the new reactor may have on the evacuation time. Considerations include addressing the number of workers and suppliers at the site during the peak construction period. The addition of employees and support staff that may reside within the EPZ is also a consideration as well as potential growth throughout the EPZ during the construction phase. Generally, the support provided by local emergency response organizations has been established and development of an ETE should include confirming that any additional resources needed would be available. For green field sites, emergency response programs are not in place, evacuations plans have not been approved and tested by local authorities, and locations of congregate care centers have likely not been established. These conditions necessitate that the development of the ETE analysis be coordinated with the development of the emergency response program being prepared during the licensing phase. Assumptions used in the ETE must be consistent with the assumptions and proposed resources and infrastructure identified within the emergency response plan to provide an accurate time estimate. ETEs for new reactor applications should be developed based on the most recent decennial census data projected to the year the license application will be submitted. An ETE update for the new reactor is not needed until 365 days before the licensee's scheduled fuel load if the population increase criteria have been met. After beginning operations, the licensee must comply with NRC regulations concerning the frequency of ETE reviews and updates as for any other operating licensee.

5.7 Early Site Permits

The ETE developed in support of an early site permit (ESP) should consider all of the elements identified in this guidance document. Data and information should be provided to support current conditions and projected conditions through construction of the NPP. Assumptions may be used to augment specific elements that are not yet defined, such as the location of congregate care centers. Any significant impediments that affect evacuation times should be identified. Data and information should be updated, as appropriate, to ensure up-to-date information is used to develop the ETE, when a combined license (COL) application, which incorporates an ESP, is submitted. ETEs for ESPs should be developed based on the most recent decennial census data projected to the year the ESP will be submitted. An ETE update for the new reactor identified within the ESP is not needed unless a COL is issued for that reactor. The licensee must then perform updates as directed in Section 5.6 for new reactors.

6.0 GLOSSARY

Demand Estimation – The total number of evacuees by population group including vehicles.

Emergency Response Planning Areas (ERPAs) – Defined areas that constitute the EPZ and for which emergency response plans have been developed. These areas are typically defined by geographic or political boundaries to support emergency response planning and may also be referred to as subareas, protective action areas, or other local terminology.

Evacuation Tail – A small portion of the population that takes a longer time to evacuate than the rest of the general public and is the last to leave the evacuation area. The tail generally conforms to about the last 10 percent of the population.

Keyhole Evacuation – An evacuation of the 2-mile radius around an NPP and the downwind sectors forming a keyhole configuration.

Link – A segment of roadway between two nodes.

Loading Curve – The rate at which vehicles are entered onto the roadway network.

Measure of Effectiveness (MOE) – Statistics used to describe performance. As applied in this document, these include output data that provide key performance characteristics of the roadway network and the evacuation time.

Node – An identification designator used to connect links in a roadway network model or to apply input data onto the network. Nodes are at intersections, ramps, etc., and contain characteristics such as traffic control and may be used as input points to assign loading of vehicles.

Permanent Resident – All people having a residence in the area.

Roadway Capacity – The maximum rate at which vehicles can be reasonably expected to traverse a point or uniform section of roadway during a given time period under prevailing conditions. (TRB, 2000)

Shadow Evacuation – Evacuation of persons from areas outside any officially declared evacuation zone.

Special Event – An activity where large transient populations are present for a limited period of time.

Special Facilities – Facilities where residents are confined or dependent upon facility personnel for transportation, including nursing homes, assisted living centers, hospitals, jails, prisons, and other similar facilities.

Staged Evacuation – A protective action where one area is ordered to evacuate while adjacent areas are ordered to shelter in place until ordered to evacuate.

Transient Population – Tourists, shoppers, employees, etc., who do not reside within the EPZ, and other people temporarily visiting the EPZ.

Trip Generation Time – Time elapsed for each population group from when the evacuation order was disseminated until the time when the evacuation trip actually begins (e.g., when the car leaves the driveway).

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APPENDIX A

ROADWAY NETWORK CHARACTERISTICS

Roadway Network Characteristics

The development of an ETE requires detailed data on the characteristics of the existing roadways within the EPZ. Frequently hundreds of links and nodes are developed for an analysis. This information is used in the calculations to support roadway capacity calculations that influence the ETE. A listing of roadway characteristics should be provided and should include the following information:

Link #	The unique identifier for each roadway segment between two nodes.
U-Node	Upstream node number for associated link.
D-Node	Downstream node number for associated link.
Length	Length of the roadway segment.
Lane Width	Width of lane for the link.
Number of Lanes	Number of lanes in the direction of travel.
Roadway Type	As defined in the ETE study such as Interstate, major arterial, minor arterial, etc.
Saturation Flow Rate	The equivalent hourly rate at which vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced in vehicles per hour of green per lane.
FFS	Free flow speed over the link.

A map of the roadway network should be provided similar to Figure A-1 and should include legible values for nodes and links.

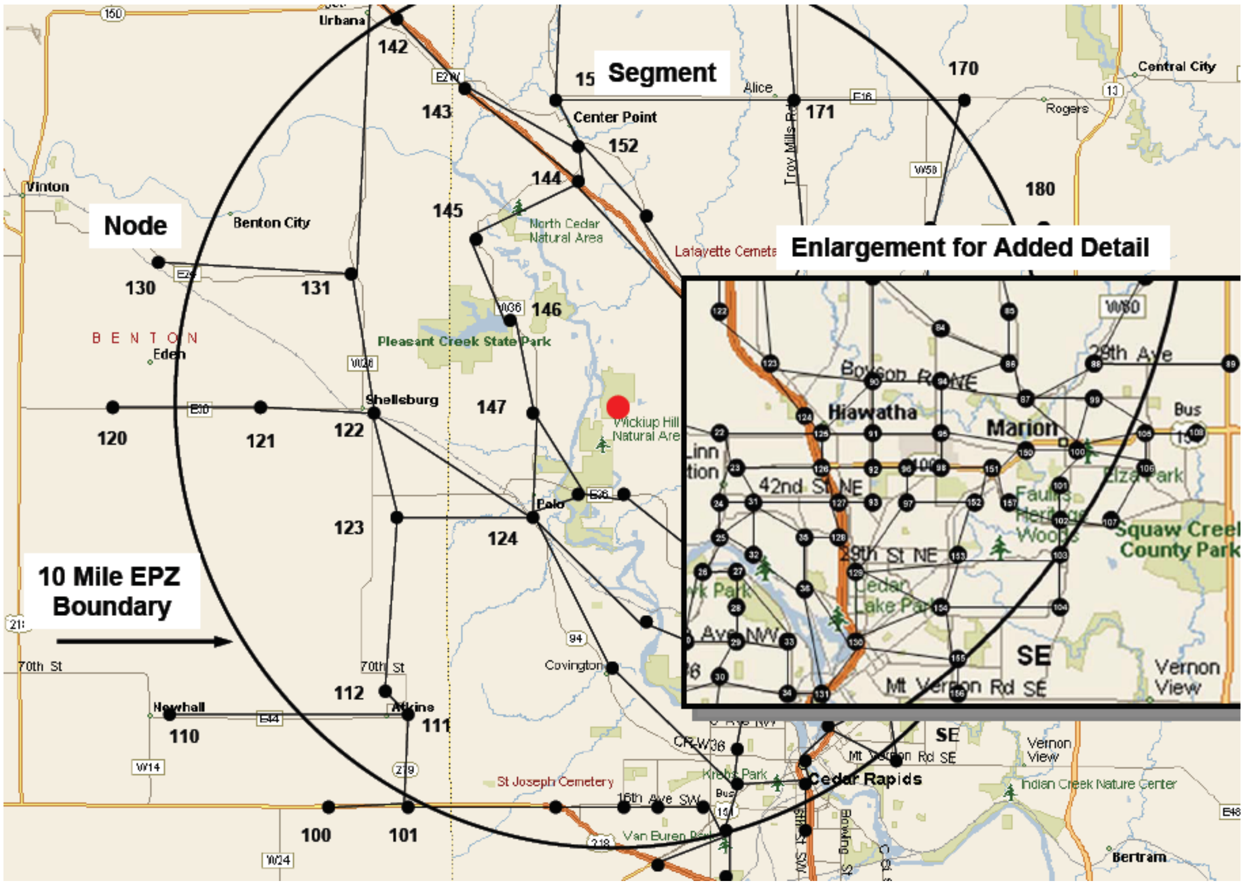

Figure A-1 Roadway Network Nodes and Segments

Table A-1 should be included to provide detailed information on each roadway segment considered in the ETE calculations. The links and nodes in Table A-1 should correspond to the roadway network and should represent the values used in the analysis.

Table A-1 Roadway Characteristics

Roadway Characteristics								
Link #	U-Node	D-Node	Length	Lane Width	Number of Lanes	Roadway Type	Saturation Flow Rate	FFS

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APPENDIX B

EVACUATION TIME ESTIMATE

EVALUATION CRITERIA

Table B-1 ETE Review Criteria Checklist

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area should be described.		
b. A map should be included that identifies primary features of the site, including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.		
c. A comparison of the current and previous ETE should be provided and includes similar information as identified in Table 1-1, "ETE Comparison," of NUREG/CR-7002.		
1.1 Approach		
a. A discussion of the approach and level of detail obtained during the field survey of the roadway network should be provided.		
b. Sources of demographic data for schools, special facilities, large employers, and special events should be identified.		
c. Discussion should be presented on use of traffic control plans in the analysis.		
d. Traffic simulation models used for the analyses should be identified by name and version.		
e. Methods used to address data uncertainties should be described.		
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation is ordered promptly and no early protective actions have been implemented.		
b. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 should be provided and include the basis to support their use.		
1.3 Scenario Development		
a. The ten scenarios in Table 1-3, Evacuation Scenarios, should be developed for the ETE analysis, or a reason should be provided for use of other scenarios.		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.		
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) should be included.		
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.		
c. A table similar to Table 1-4, “Evacuation Areas for a Staged Evacuation Keyhole,” of NUREG/CR-7002 should be provided and includes the complete evacuation of the 2, 5, and 10 mile areas and for the 2 mile area/5 mile keyhole evacuations.		
2.0 Demand Estimation		
a. Demand estimation should be developed for the four population groups, including permanent residents of the EPZ, transients, special facilities, and schools.		
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another credible source should be provided.		
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.		
c. A sector diagram should be included, similar to Figure 2-1, “Population by Sector,” of NUREG/CR-7002, showing the population distribution for permanent residents.		
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value should be between 1 and 2 or justification should be provided for other values.		
b. Major employers should be listed.		
2.1.2 Transient Population		
a. A list of facilities which attract transient populations should be included, and peak and average attendance for these facilities should be listed. The source of information used to develop attendance values should be provided.		
b. The average population during the season should be used,		

	Criterion Addressed in ETE Analysis	Comments
	(Yes/No)	
itemized and totaled for each scenario.		
c. The percent of permanent residents assumed to be at facilities should be estimated.		
d. The number of people per vehicle should be provided. Numbers may vary by scenario, and if so, discussion on why values vary should be provided.		
e. A sector diagram should be included, similar to Figure 2-1 of NUREG/CR-7002, showing the population distribution for the transient population.		
2.2 Transit Dependent Permanent Residents		
a. The methodology used to determine the number of transit dependent residents should be discussed.		
b. Transportation resources needed to evacuate this group should be quantified.		
c. The county/local evacuation plans for transit dependent residents should be used in the analysis.		
d. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities should be provided. Data from local/county registration programs should be used in the estimate, but should not be the only set of data.		
e. Capacities should be provided for all types of transportation resources. Bus seating capacity of 50% should be used or justification should be provided for higher values.		
f. An estimate of this population should be provided and information should be provided that the existing registration programs were used in developing the estimate.		
g. A summary table of the total number of buses, ambulances, or other transport needed to support evacuation should be provided and the quantification of resources should be detailed enough to assure double counting has not occurred.		
2.3 Special Facility Residents		
a. A list of special facilities, including the type of facility, location, and average population should be provided. Special facility staff should be included in the total special		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
facility population.		
b. A discussion should be provided on how special facility data was obtained.		
c. The number of wheelchair and bed-bound individuals should be provided.		
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.		
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.		
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be provided. The source of this information should be provided.		
b. Transportation resources for elementary and middle schools are based on 100% of the school capacity.		
c. The estimate of high school students who will use their personal vehicle to evacuate should be provided and a basis for the values used should be provided.		
d. The need for return trips should be identified if necessary.		
2.5.1 Special Events		
a. A complete list of special events should be provided and includes information on the population, estimated duration, and season of the event.		
b. The special event that encompasses the peak transient population should be analyzed in the ETE.		
c. The percent of permanent residents attending the event should be estimated.		
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent should be included for areas outside the evacuation area extending to 15 miles from the NPP.		
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
c. The loading of the shadow evacuation onto the roadway network should be consistent with the trip generation time generated for the permanent resident population.		
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic should be based on the average daytime traffic. Values may be reduced for nighttime scenarios.		
b. Pass-through traffic should be assumed to have stopped entering the EPZ about two hours after the initial notification.		
2.6 Summary of Demand Estimation		
a. A summary table should be provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand used in each scenario.		
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity should be discussed.		
3.1 Roadway Characteristics		
a. A field survey of key routes within the EPZ has been conducted.		
b. Information should be provided describing the extent of the survey, and types of information gathered and used in the analysis.		
c. A table similar to that in Appendix A, "Roadway Characteristics," of NUREG/CR-7002 should be provided.		
d. Calculations for a representative roadway segment should be provided.		
e. A legible map of the roadway system that identifies node numbers and segments used to develop the ETE should be provided and should be similar to Figure 3-1, "Roadway Network Identifying Nodes and Segments," of NUREG/CR-7002.		
3.2 Capacity Analysis		
a. The approach used to calculate the roadway capacity for the transportation network should be described in detail and		

	Criterion Addressed in ETE Analysis	Comments
	(Yes/No)	
identifies factors that are expressly used in the modeling.		
b. The capacity analysis identifies where field information should be used in the ETE calculation.		
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel.		
b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.		
c. Discussion should be provided on how time signal cycle is used in the calculations.		
3.4 Adverse Weather		
a. The adverse weather condition should be identified and the effect of adverse weather on mobilization should be considered.		
b. The speed and capacity reduction factors identified in Table 3-1, “Weather Capacity Factors,” of NUREG/CR-7002 should be used or a basis should be provided for other values.		
c. The study identifies assumptions for snow removal on streets and driveways, when applicable.		
4.0 Development of Evacuation Times		
4.1 Trip Generation Time		
a. The process used to develop trip generation times should be identified.		
b. When telephone surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance should be provided.		
c. Data obtained from telephone surveys should be summarized.		
d. The trip generation time for each population group should be developed from site specific information.		
4.1.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
generation time includes the assumption that a percentage of residents will need to return home prior to evacuating.		
b. Discussion should be provided on the time and method used to notify transients. The trip generation time discusses any difficulties notifying persons in hard to reach areas such as on lakes or in campgrounds.		
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.		
d. Effect of public transportation resources used during special events where a large number of transients are expected should be considered.		
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.		
4.1.2 Transit Dependent Residents		
a. If available, existing plans and bus routes are used in the ETE analysis. If new plans are developed with the ETE, they should have been agreed upon by the responsible authorities.		
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.		
c. The number, location and availability of buses, and other resources needed to support the demand estimation are provided.		
d. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are provided.		
e. Discussion should identify the time estimated for transit dependent residents to prepare and then travel to a bus pickup point, and describes the expected means of travel to the pickup point.		
f. The number of bus stops and time needed to load passengers should be discussed.		
g. A map of bus routes should be included.		
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time,		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
and time to drive out of the EPZ should be provided.		
i. Information should be provided to support analysis of return trips, if necessary.		
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.		
b. Discussion should be provided on the inbound and outbound speeds.		
c. The number of wheelchair and bed-bound individuals should be provided, and the logistics of evacuating these residents should be discussed.		
d. Time for loading of residents should be provided.		
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.		
f. If return trips are needed, the destination of vehicles should be provided.		
g. Discussion should be provided on whether special facility residents are expected to pass through the reception center prior to being evacuated to their final destination.		
h. Supporting information should be provided to quantify the time elements for the return trips.		
4.1.4 Schools		
a. Information on evacuation logistics and mobilization times should be provided.		
b. Discussion should be provided on the inbound and outbound speeds.		
c. Time for loading of students should be provided.		
d. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.		
e. If return trips are needed, the destination of school buses should be provided.		
f. If used, reception centers should be identified. Discussion should be provided on whether students are expected to pass through the reception center prior to being evacuated		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
to their final destination.		
g. Supporting information should be provided to quantify the time elements for the return trips.		
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.		
b. If a traffic simulation model is not used to conduct the ETE calculation, sufficient detail should be provided to validate the analytical approach used. All criteria elements should have been met, as appropriate.		
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.		
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.		
4.2.2 Traffic Simulation Model Output		
a. A discussion regarding whether the traffic simulation model used must be in equilibration prior to calculating the ETE should be provided.		
b. The minimum following model outputs should be provided to support review: 1. Total volume and percent by hour at each EPZ exit mode. 2. Network wide average travel time. 3. Longest Queue length for the 10 intersections with the highest traffic volume. 4. Total vehicles exiting the network. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.		
c. Color coded roadway maps should be provided for various times (i.e., at 2, 4, 6 hrs., etc.) during a full EPZ evacuation scenario, identifying areas where long queues exist including level of service (LOS) “E” and LOS “F” conditions,		

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
if they occur.		
4.3 Evacuation Time Estimates for the General Public		
a. The ETE should include the time to evacuate 90% and 100% of the total permanent resident and transient population.		
b. The ETE for 100% of the general public should include all members of the general public. Any reductions or truncated data should be explained.		
c. Tables should be provided for the 90 and 100 percent ETEs similar to Table 4-3, “ETEs for Staged Evacuation Keyhole,” of NUREG/CR-7002.		
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.		
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis should be provided.		
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.		
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.		
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.		
5.3 State and Local Review		
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.		
b. Information should be provided on any unresolved issues that may affect the ETE.		
5.4 Reviews and Updates		
a. A discussion of when an updated ETE analysis is required to be performed and submitted to the NRC.		
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers should be provided.		
b. If return trips are required, assumptions used to estimate		

	Criterion Addressed in ETE Analysis	Comments
	(Yes/No)	
return times for buses should be provided.		
c. It should be clearly stated if it is assumed that passengers are left at the reception center and are taken by separate buses to the congregate care center.		

Technical Reviewer ______________________________ Date ______________________________

Supervisory Review ______________________________ Date ______________________________