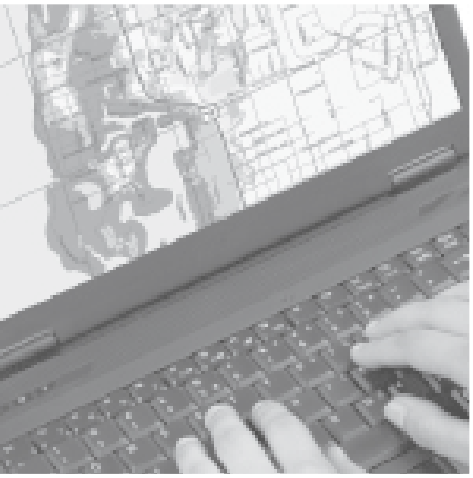
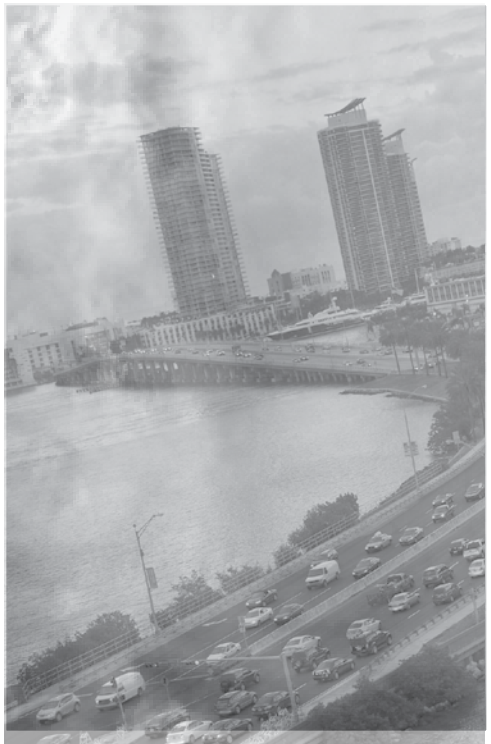
Florida Statewide Regional Evacuation Study Program



Regional Evacuation Transportation Analysis



Volume 1-11
Technical Data Report

South Florida Region

Chapter VI
Regional Evacuation Transportation Analysis

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CHAPTER VI
REGIONAL EVACUATION TRANSPORTATION ANALYSIS

The evacuation transportation analysis discussed in this chapter documents the methodology, analysis, and results of the transportation component of the Statewide Regional Evacuation Study Program (SRESP). Among the many analyses required for the SRESP study, transportation analysis is probably one of the most important components in the process. By bringing together storm intensity, transportation network, shelters, and evacuation population, transportation analysis explicitly links people's behavioral responses to the regional evacuation infrastructure and helps formulate effective and responsive evacuation policy options. Due to the complex calculations involved and numerous evacuation scenarios that need to be evaluated, the best way to conduct the transportation analysis is through the use of computerized transportation simulation programs, or transportation models.

A. Background and Purpose

Over the years, different planning agencies have used different modeling approaches with varying degrees of complexity and mixed success. Some have used full-blown conventional transportation models such as the Florida Standard Urban Transportation Modeling System (FSUTMS); others have used a combination of a simplified conventional model and a spreadsheet program, such as the Abbreviated Transportation Model (ATM). These models have different data requirements, use different behavioral assumptions, employ different traffic assignment algorithms, and produce traffic analysis results with different levels of detail and accuracy. These differences make it difficult for planning agencies to share information and data with each other. They also may produce undesirable conditions for staff training and knowledge sharing.

One of the objectives of the SRESP is to create consistent and integrated regional evacuation data and mapping, and by doing so, to facilitate knowledge sharing between state, regional, county and local partners. To achieve this objective, it is important for all Regional Planning Councils to adopt the same data format and to use the same modeling methodologies for their transportation analyses. The primary purpose of the transportation component of the SRESP is to develop a unified evacuation transportation modeling framework that can be implemented with the data collected by the Regional Planning Councils.

B. Study Area

The study area for this analysis includes the three-county South Florida Regional Planning Council area. The transportation modeling methodology includes some processes that are performed at the statewide level, in order to determine the impacts of evacuations from other regions impacting the evacuation clearance times in the South Florida region. While the impact

of other regions is included in the South Florida analysis, it is important to note that the results of the transportation analysis presented in this document are only reported for the three counties included in the South Florida RPC. Transportation analysis results for other regions and counties are reported in the corresponding Volume 4 report for those regions.

C. Input and Coordination

The development of the transportation methodology and framework required coordination and input from all eleven regional planning councils in Florida, along with the Division of Emergency Management, Department of Transportation, Department of Community Affairs, and local county emergency management teams. At the statewide level, the transportation consultant, Wilbur Smith Associates, participated in SRESP Work Group Meetings which were typically held on a monthly basis to discuss the development of the transportation methodology and receive feedback and input from the State agencies and RPCs.

At the local and regional level, Wilbur Smith Associates conducted a series of four regional meetings to coordinate with and receive input from local county emergency management, the regional planning council, local transportation planning agencies and groups, as well as other interested agencies.

D. Evacuation Modeling Methodology and Framework

The evacuation modeling methodology and framework was developed during 2008 and 2009 in coordination with all eleven Regional Planning Councils and the Division of Emergency Management. The methodology used in the South Florida RPC Evacuation Transportation Analysis was used for all eleven Regional Planning Councils and includes the following components[1]:

- **Behavioral Assumptions** – In 2008, the Statewide Regional Evacuation Study Program (SRESP) commissioned a survey of Florida residents. The purpose of this survey was to develop an understanding of the behavior of individuals when faced with the prospect of an impending evacuation. These data were used to develop a set of "planning assumptions" that describe the way people respond to an order to evacuate and are an important input to the SRESP Evacuation Model. The behavioral data provides insights into how people respond to the changing conditions leading up to and during an evacuation. The primary application of the survey data was to help anticipate how people would respond with respect to five behaviors:
  - How many people would evacuate?
  - When they would leave?
  - What type of refuge they would seek?
  - Where they would travel for refuge?

[1] Modifications to model flow rates (lane capacities) in Monroe County were made to the South Florida RPC model in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. These flow rates are different than model flow rates used throughout the rest of Florida to accommodate the unique roadway characteristics of Monroe County.

- How many vehicles would they use?

These evacuation behaviors are distinguished based on several descriptive variables as listed below:

- Type of dwelling unit (site-built home versus mobile home);
- The evacuation zone in which the evacuee reside; and
- The intensity of the evacuation that has been ordered.

- **Zone System and Highway Network** – The SRESP evacuation model relies upon data that covers the entire State of Florida as well as areas covering the States of Georgia, Alabama, Mississippi, South Carolina, North Carolina, and Tennessee. While the primary focus of the model is with evacuation behavior within Florida, areas outside of the state had to be considered in order to allow a more precise routing of evacuation traffic. This allows the model to measure the flow of traffic across the state line if needed.

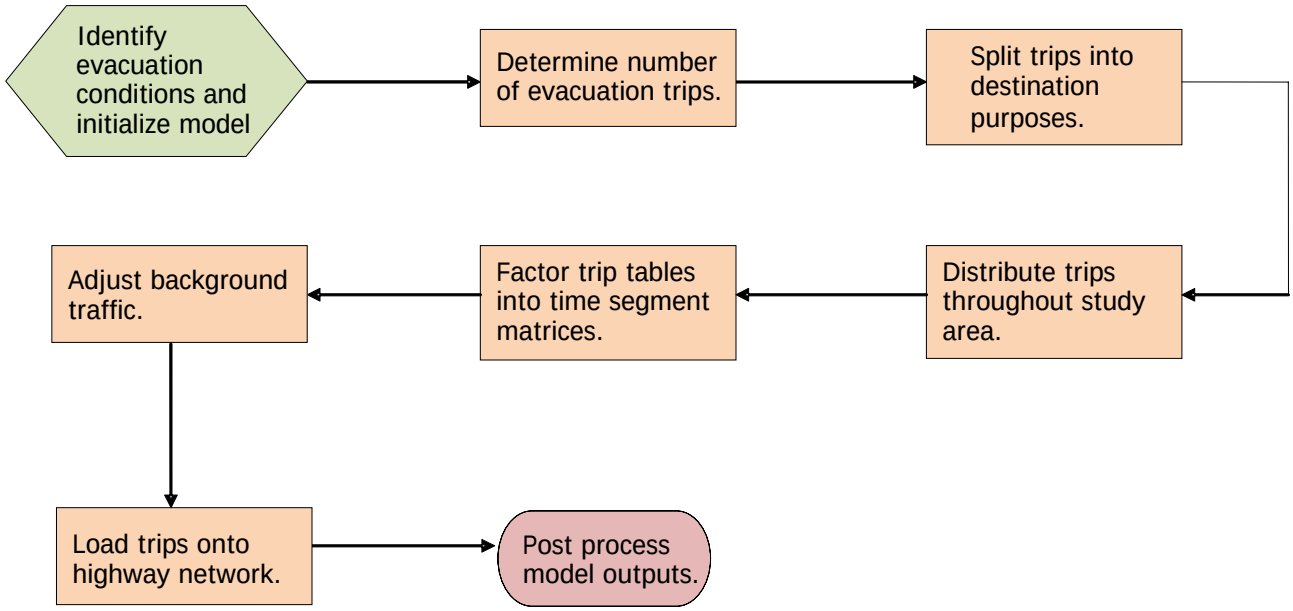
  The data included in this system contain the demographic information crucial to modeling evacuation traffic. The demographic information is labeled as "small area data". These data provide population and dwelling unit information that will identify where the individuals in the region reside. The planning assumptions developed from the behavioral analysis conducted for this study were applied to these demographic data. The result is a set of evacuation trips generated by the evacuation model. The number of these trips will vary depending on the hazard conditions that prompt the evacuation. Small area data geographies were aggregated into larger units known as Traffic Evacuation Zones (TEZ). These TEZs form the basic unit of analysis in the evacuation model. The final TEZ system for the State of Florida has 17,328 zones. This number provides sufficient detail to accurately accommodate the assignment of evacuation trips onto an evacuation network.

- **Background Traffic** – The traffic that consumes the roadway capacity of a transportation system during an evacuation can be divided into two groups. The first group is the evacuation traffic itself. Once the evacuation demand is determined, this information is converted into a number of vehicles evacuating over time. These evacuation trips are then placed on a representation of the highway network by a model. The model determines the speed at which these trips can move and proceeds to move the evacuation trips accordingly. The result is a set of clearance times.

  The second group of traffic is known as background traffic. Background traffic, as its name implies, is not the primary focus of an evacuation transportation analysis and is accounted for primarily to impede the movement of evacuation trips through the network. These trips represent individuals going about their daily business mostly unconcerned with the evacuation event. For the most part, background traffic represents trips that are relatively insensitive to an order to evacuate and are thus said to be occurring in the "background." Even though background traffic is relatively insensitive to evacuation orders, it is important to account for background traffic since it can have a dramatic impact on available roadway capacity. This in turn can severely affect evacuation clearance times.

- **Evacuation Traffic** – The model flow for the evacuation model is divided into a total of eight modeling steps. The following eight steps are represented graphically in the flowchart in Figure VI-1:
  1. Identify evacuation conditions and initialize model;
  2. Determine number of evacuation trips;
  3. Split trips into destination purposes;
  4. Distribute trips throughout study area;
  5. Factor trip tables into time segment matrices;
  6. Adjust background traffic;
  7. Load trips onto highway network; and,
  8. Post process model outputs.

Figure VI-1 General Model Flow



- **Dynamic Traffic Assignment** - Dynamic traffic assignment (DTA) was utilized in the evacuation methodology because it is sensitive to individual time increments. DTA works by assigning a certain number of vehicles to the highway network in a given interval of time. The model then tracks the progress of these trips through the network over the interval. Another set of vehicles is assigned during the following time interval. The model then tracks the progress of these trips through the network along with the progress of the trips loaded in the previous time interval. As vehicles begin to arrive at the same segments of roadway, they interact with one another to create congestion. When vehicles that were loaded to the network in subsequent intervals of time arrive at the congested links, they contribute to the congestion as well. This results in a slowing down of the traffic and eventually spill-backs and queuing delays. It is this time dependent feature of DTA that makes it well suited to evacuation modeling. By dynamically adjusting the travel times and speeds of the vehicles moving through the network as they respond to congestion the model is able to do the following:

- The evacuation model is able to estimate the critical clearance time statistics needed for this study;
- The model takes into account the impact of compounded congestion from multiple congestion points;
- The model is able to adjust the routing of traffic throughout the network as a function of congestion as it occurs throughout the evacuation; and,
- The model is capable of adjusting its capacities from time segment to time segment, making it possible to represent such phenomena as reverse lane operations and background traffic.

- **Prototype Model Development** – Wilbur Smith Associates developed a prototype model to test the modeling methodology used to calculate evacuation clearance times. The prototype model demonstrated the viability of the methodology developed for this study. This included the use of dynamic traffic assignment, background traffic curves, regional sub-area trip balancing, the use of survey rates, the use of 100% participation rates, response curves, and county-by-county phasing of evacuations. The prototype model served as the backbone for all regional evacuation models that have been developed for this study. The models implemented for each RPC use a structure similar to the prototype with identical methodology.

E. Regional Model Implementation

The regional model developed for the South Florida Region used a series of input data provided by the RPC, including the following:

- **Regional Model Network** – The regional model network consists of the RPC designated evacuation routes as well as a supporting roadway network that facilitates movement of evacuation traffic. The 2005 Florida Department of Transportation (FDOT) Statewide Model Network was used as a basis for developing the regional model network, while the evacuation routes were obtained from the South Florida RPC. The RPC received input from the emergency managers of its constituent counties on roads designated as evacuation routes. Policy in both Miami-Dade County and Broward County encourages in-county evacuations, away from surge areas to the inland portions of the county, not out of county. As a result, some inter-county connectors had to be added in order to compose the regional evacuation network that was developed for the study.

  Lane capacities for the segments of US 1 in Monroe County were defined in accordance with the “maximum sustainable traffic flow rates per functional evacuation lane” identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. FDOT District 6 has identified potential changes in the number of functional evacuation lanes on US 1 as a result of the incorporation of completed and planned shoulder improvements within Monroe County through 2015. Study parameters do not provide for the additional scenarios required to analyze the possibility of utilizing additional lanes in an evacuation. However, through the TIME interface and the regional model for South Florida, additional analysis can be conducted on these resources in the future as part of the detailed planning process.

The resulting model network was updated to 2006 conditions and is referred to as the base model network. **Figure VI-2** identifies the model network and evacuation routes for the SFRPC. County level details of the regional model network are provided in the Volume 5-11 report. The regional model network for the South Florida Region is made up of key roadways within the three-county region, including I-75, I-95, I-195, I-395, Florida's Turnpike, US 1, US 27, US 41, US 441, SR 826, SR 836, SR 869, SR 924, and SR 997.

- **Regional Zone System** – The regional zone system is based on Traffic Evacuation Zones (TEZ) and contains the regional demographic information, which includes housing unit and population data that is essential to modeling evacuation traffic. The TEZs were developed statewide, and generally represent the aggregation of traffic analysis zones used in traffic models developed by metropolitan planning organizations, where they exist, as well as census geography where existing traffic models do not yet exist. There are 1,051 TEZs located within the three-county South Florida region, as illustrated in **Figure VI-3**. Miami-Dade County has the largest number of TEZs with 632 and Broward County follows with 379 TEZs. Monroe County contains 40 TEZS and has the lowest number of TEZs within the RPC. The larger number of TEZs generally reflects counties with dense urban structure and higher population densities.

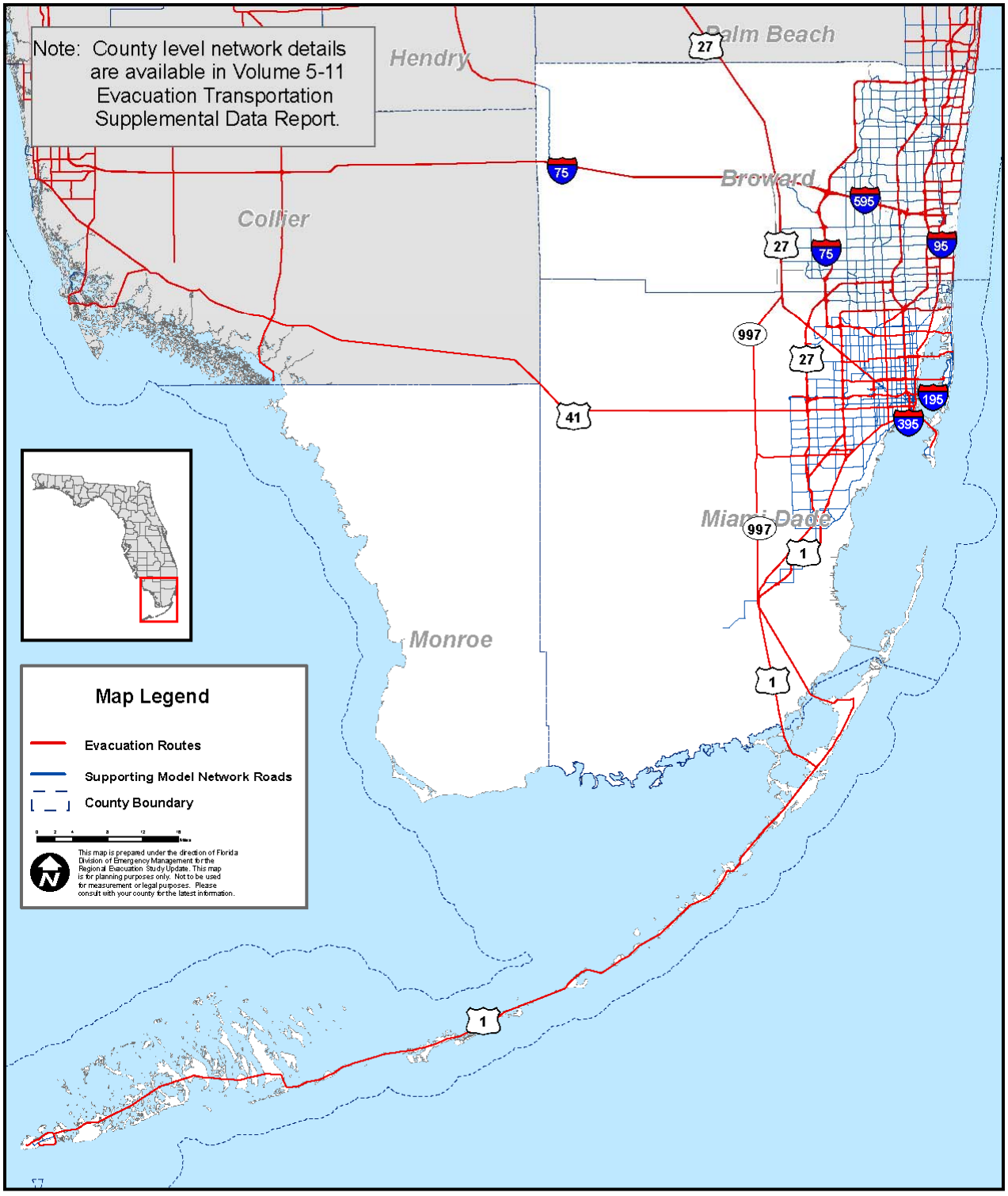
- **Regional Demographic Characteristics** – Demographic data were developed for census block groups for Monroe County and for traffic analysis zones for Broward County and Miami-Dade County. Estimates for 2006 and projections for 2010 and 2015 were prepared in each county with the aid of local planners – see the county appendices to Chapter I, Volume 1-11 for a detailed discussion of the approach used in each county. The projections for 2010 and 2015 were developed prior to the 2010 Census. It is likely that differences will be observed once the results of the 2010 Census are released, in early 2011. The regional model was designed to allow for demographic data updates, so it will be possible to conduct an update in the transportation analysis to reflect more current population estimates and new projections that are expected to follow from the release of the 2010 Census.

  A summary of the key demographic data used in the transportation analysis for each county in South Florida is presented in **Table VI-1**. The table lists the number of occupied dwelling units for site-built homes and the permanent population in site-built homes, as well as the number of occupied dwelling units for mobile homes and the permanent population in mobile homes. The mobile home category includes RVs and boats and the permanent population in those housing options. The demographic characteristics summary also includes hotels and motels because many of these units are in vulnerable areas, and the proportion of seasonal units and hotel/motel units that are occupied at any point in time will have an important impact on the total population that may participate in an evacuation.

  Miami-Dade County has the largest population in the region during all three time periods. The county is expected to reach over 2.5 million people by 2015. Broward County has the second largest population in the region, and is forecasted to have more than 1.8 million people by 2015. Monroe County, the most vulnerable of the three counties, has the fewest number of people in the South Florida region and is expected to grow very little throughout the time period.

Figure VI-2

South Florida Regional Model Network

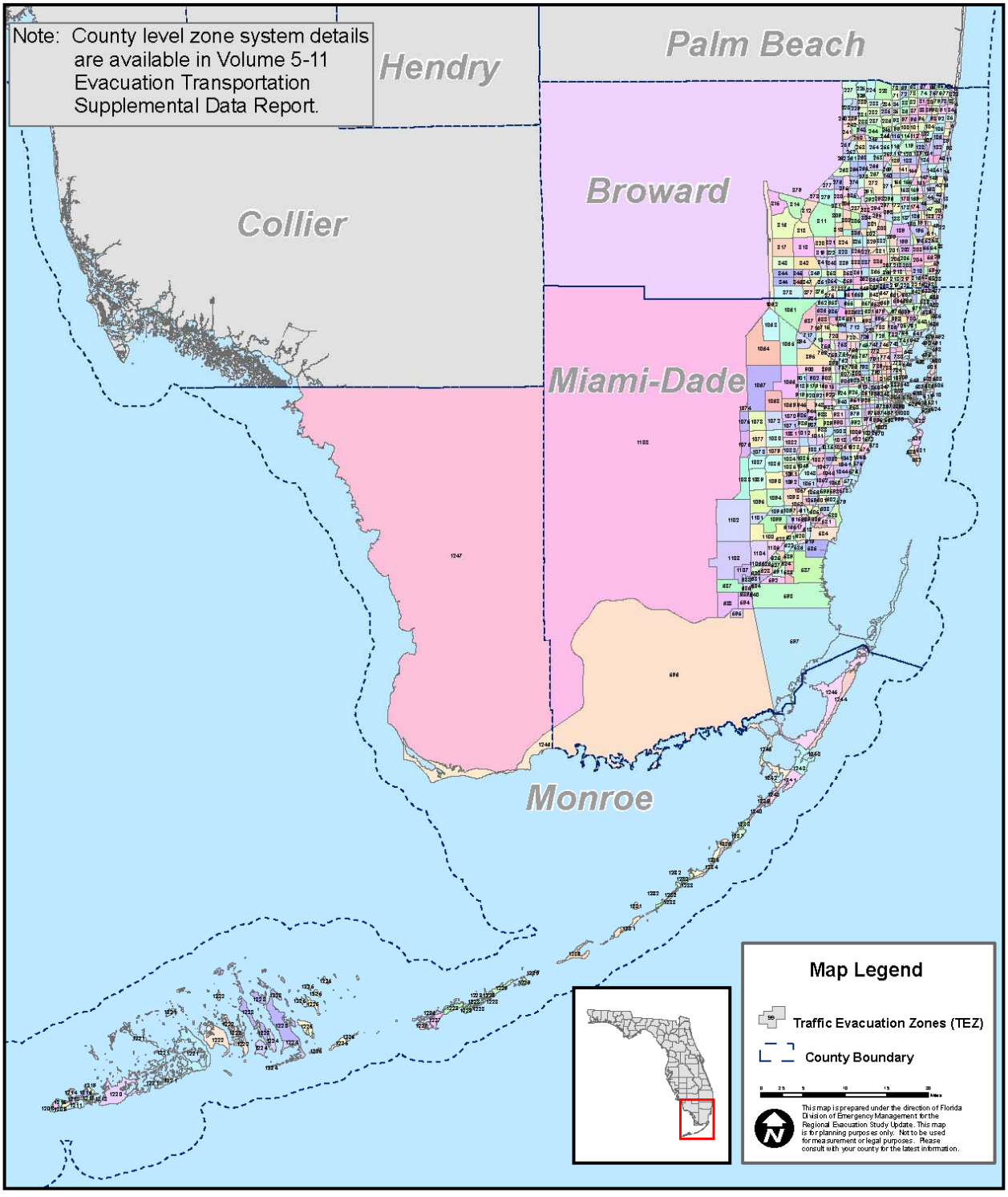


Sources: South Florida Regional Planning Council, Wilbur Smith Associates

Map Printed: December, 2010

Figure VI-3

South Florida Regional Model Transportation Evacuation (TEZ) Zone System



Sources: South Florida Regional Planning Council, Wilbur Smith Associates

Map Printed: December, 2010

Table VI-1 South Florida Demographic Characteristic Summary

County	Characteristic	Year		
		2006	2010	2015
Broward	Occupied site-built homes	659,884	662,756	690,339
	Population in site-built homes	1,686,387	1,718,826	1,819,299
	Occupied mobile homes	16,762	13,074	13,840
	Population in mobile home	38,896	30,402	32,591
	Occupied hotel/motel units	36,621	38,501	40,013
Miami-Dade	Occupied site-built homes	828,538	855,225	892,978
	Population in site-built homes	2,342,429	2,428,951	2,549,893
	Occupied mobile homes	11,429	11,492	11,639
	Population in mobile home	34,986	35,116	35,478
	Occupied hotel/motel units	46,116	46,116	46,116
Monroe	Occupied site-built homes	30,595	32,213	34,067
	Population in site-built homes	68,585	72,946	77,221
	Occupied mobile homes	6,833	5,807	5,781
	Population in mobile home	14,496	12,179	12,130
	Occupied hotel/motel units	13,086	13,665	13,665
South Florida	Occupied site-built homes	1,519,017	1,550,194	1,617,384
	Population in site-built homes	4,097,401	4,220,723	4,446,413
	Occupied mobile homes	35,024	30,373	31,260
	Population in mobile home	88,378	77,697	80,199
	Occupied hotel/motel units	95,823	98,282	99,794

Source: South Florida Regional Planning Council. See discussion on page IV-6 for more information on the source of the small area data.

- **Planned Roadway Improvements** – To correspond to the three different sets of demographic data, three model networks were ultimately developed: the base 2006 network and two future year networks to correspond to the 2010 demographic data and the 2015 demographic data. The 2006 base model network was updated to reflect roadway capacity improvement projects completed between 2006 and 2010 to create the 2010 network. The 2010 network was then updated to reflect planned roadway capacity improvement projects expected to be implemented between 2011 and 2015 to create the 2015 network.

  The planned roadway improvements that were added to the network generally include only capacity improvement projects such as additional through lanes. **Table VI-2** identifies capacity improvement projects completed between 2006 and 2010 that were included in the 2010 network. Likewise, **Table VI-3** identifies capacity improvement projects planned for implementation between 2011 and 2015. The tables identify each roadway that will be improved as well as the extent of the improvement. For example, by the end of 2015 in Broward County, SR 7 from Hallandale Beach Blvd to Fillmore St will be widened to 6 lanes.

Table VI-2 South Florida Region Roadway Improvements, 2006-2010

County	Roadway	From	To	Number of Lanes
Broward	Griffin Rd	SR 823 (Flamingo Rd)	W of I-75	4
	Bailey Rd	SR 7	NW 64th Ave	4
	Pine Island Rd	Oakland Park Blvd	Commercial Blvd	6
	Sunrise Blvd	Pine Island	Hiatus Rd	6
	SR 7	Dade County Line	Hallandale Beach Blvd	6
	Turnpike	Peters Rd	Sunrise Blvd	8
	Turnpike	Sunrise Blvd	Atlantic Blvd	8
	Andrews Ave Extn	Pompano Park Pl	S of Atlantic Blvd	4
	Davie Rd Extn	NW 72nd Ave	Stirling Rd	1/2
	Dixie Hwy	Hillsboro Blvd	Palm Beach County line	4
	Hiatus Rd	Sunrise Blvd	Oakland Park Blvd	4
	Palm Ave	Stirling Rd	Griffin Rd	4
	Pembroke Rd	SW 160th Ave	SW 136th Ave	4
	Wiles Rd	Lyons Rd	Powerline Rd	4
Miami-Dade	SR 934	Turnpike	NW 87th St	4
	SW 328th St	SW 152nd Ave	SW 137th Ave	4
	SR 997/Krome Ave	N of SW 8th St	MP 2.754	4
	SR 997/Krome Ave	US 1	Lucy St	4
	SW 117th Ave	SW 184th St	SW 152nd St	4
	SR 934	SR 826	SR 823	6
	SR 823/NW 57th Ave	Okeechobee Rd	W 23rd St	6
	SR 826	SR 878	SR 874	8
	SR 826	SR 836	US 27	10
	SW 192nd St	SW 197th Ave`	SW 177th Ave	4
	I-95	I-395	Golden Glades	12

Sources: FDOT SIS First Five Year Plan, FDOT SIS Second Five Year Plan, South Florida Regional Planning Council
Note: Projects included in this table are roadway improvement projects completed between 2006 and 2010 on roadways that are included in the regional transportation model network. Only projects that added roadway capacity, such as additional through lanes, were included. The list is not intended to be all inclusive of every transportation improvement project completed within the region. A list of historical projects completed during the last five years was included in this report because the base regional network developed for the study, along with the base demographic data, is for the year 2006.

Note regarding Monroe County: Lane capacities for the segments of US 1 in Monroe County were defined in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. FDOT District 6 has identified potential changes in the number of functional evacuation lanes on US 1 as a result of the incorporation of completed and planned shoulder improvements within Monroe County through 2015. Study parameters do not provide for the additional scenarios required to analyze the possibility of utilizing additional lanes in an evacuation. However, through the TIME interface and the regional model for South Florida, additional analysis can be conducted on these resources in the future as part of the detailed planning process.

It is important to note that Tables IV-2 and IV-3 are not intended to be all inclusive of every transportation improvement project completed within the region. The tables only identify key capacity improvement projects that impact the evacuation model network and are anticipated to have an impact on evacuation clearance times.

Table VI-3 South Florida Planned Roadway Improvements, 2011-2015

County	Roadway	From	To	Number of Lanes
Broward	SR 7	Hallandale Beach Blvd	Fillmore St	6
	Turnpike	Atlantic Blvd	Sawgrass Expressway	8
	Turnpike	Homestead Extension-Turnpike (HEFT)	Griffin Rd	8
	I-595/P3/CEI	I-75	W of I-95	10
	I-95	East Sample Rd	Palm Beach County line	10
	Andrews Ave Extn	NW 18th St	Copans Rd	4
	Pine Island Rd	I-595	Nova Dr	6
Miami-Dade/ Broward	I-95	Golden Glades	I-595	12
Miami-Dade	SR 997/Krome Ave	SW 136th St	SR 90/SW 8th St	4
	SR 823/NW 57th Ave	W 46th St/103rd St	W 53rd St	6
	NW 25th St	NW 89th Ct	NW 67th Ave	6
	SR 821 (HEFT)	S of SW 117th Ave	S of Kendall Dr	12

Sources: FDOT SIS First Five Year Plan, FDOT SIS Second Five Year Plan, South Florida Regional Planning Council
Note: Projects included in this table are roadway improvement projects planned for completion between 2011 and 2015 on roadways that are included in the regional transportation model network. Only projects that are planned to add roadway capacity, such as additional through lanes, were included. The list is not intended to be all inclusive of every transportation improvement project planned for completion within the region.

Note regarding Monroe County: Lane capacities for the segments of US 1 in Monroe County were defined in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. FDOT District 6 has identified potential changes in the number of functional evacuation lanes on US 1 as a result of the incorporation of completed and planned shoulder improvements within Monroe County through 2015. Study parameters do not provide for the additional scenarios required to analyze the possibility of utilizing additional lanes in an evacuation. However, through the TIME interface and the regional model for South Florida, additional analysis can be conducted on these resources in the future as part of the detailed planning process.

- **Behavioral Assumptions** – For the South Florida Region, evacuation rates for site-built homes and mobile/manufactured homes are provided by county and summarized in **Figure IV-4** through **Figure IV-9**. Other rates, such as out of county trip rates, vehicle use rates, public shelter use rates, friend/relative refuge use rates, hotel/motel refuge use rates, and other refuge use rates, are detailed by county, storm threat, and evacuation zone in Volume 5-11.

  A review of the evacuation rates for the South Florida region illustrates that evacuation participation rates increase as the evacuation level increases, and participation rates for persons living in mobile/manufactured homes are generally higher than for persons living in site-built homes. It should be noted that in Broward and Miami-Dade Counties a certain percentage of the population evacuates, even when they are not living in an area that is ordered to evacuate. These people are commonly referred to as shadow evacuees. Shadow evacuation rates are also included in Figure IV-4 through Figure IV-7.

Please note that the original behavioral response rates provided by SRESP in Volume 2 were modified to fit the evacuation zones created by Broward and Miami-Dade Counties. The original rates were based on a five zone system; however, the evacuation zones for those counties range from three to four zones depending upon the county. The evacuation zone systems for Broward and Miami-Dade are listed below:

- Broward County – 4 zones (for SRESP): Zone A/B, Zone C, Zone D, Zone E;
- Miami-Dade – 3 zones: Zone A, Zone B/C, Zone D/E.

Monroe County's four evacuation zones are not based on storm surge, but are apportioned geographically by sub-regions of the county: Key West, Lower Keys, Middle Keys, and Upper Keys.

- **Shelters** – In order for the transportation model to accurately assign public shelter trips to the correct location, a complete list of available public shelters needs to be available. The shelters were categorized as either primary or other, with primary indicating that the shelter is compliant with American Red Cross standards for a shelter and other indicating all other shelters. In the three-county region there are a total of 110 shelters, including 40 in Broward County and 66 in Miami-Dade County. The four shelters in Monroe County are opened only for storms of category 1 or 2, since storms of category 3 or higher require a general evacuation of the entire population. Together, the 110 shelters located within the three-county region can host more than 150,000 persons during an evacuation event.

- **Evacuation Zones** – The final input variable that is needed to complete the transportation evacuation model is the delineation of evacuation zones for all coastal counties. Local county emergency managers have the responsibility of identifying and defining evacuation zones for their county. Operationally, Broward County has only two evacuation zones, one for Levels A and B and the other for Levels C, D and E. Broward County created new evacuation zones D and E for the transportation analysis of this study. County level evacuation zones are included in Volume 5-11.

Figure VI-4 - Evacuation Participation Rates: Broward County - Site-Built Homes

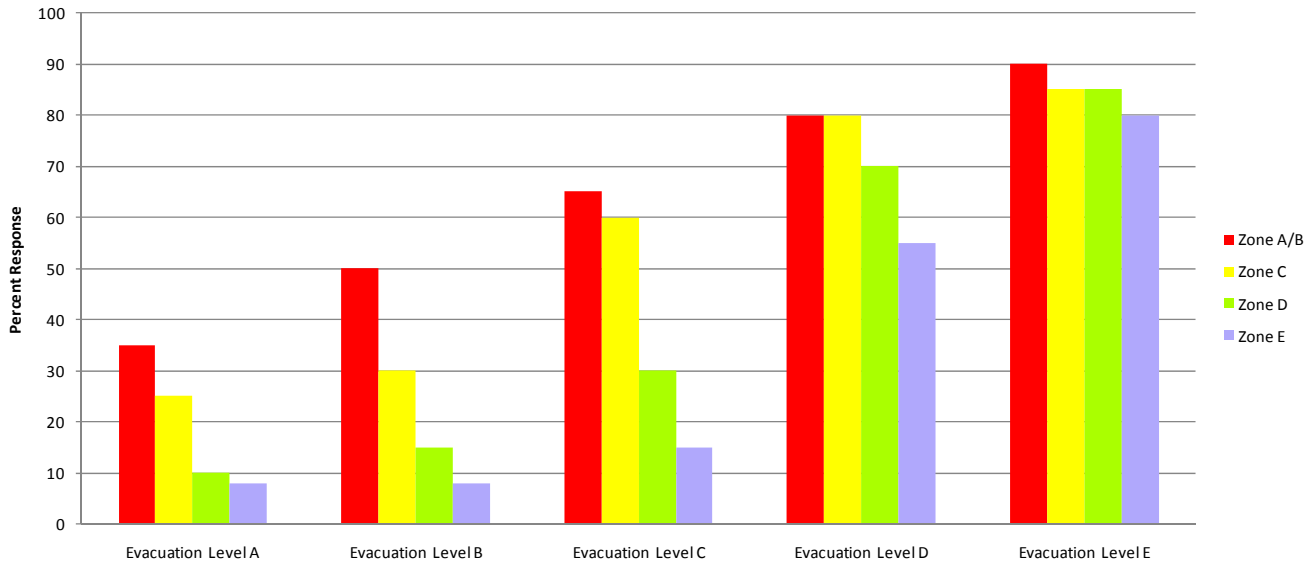
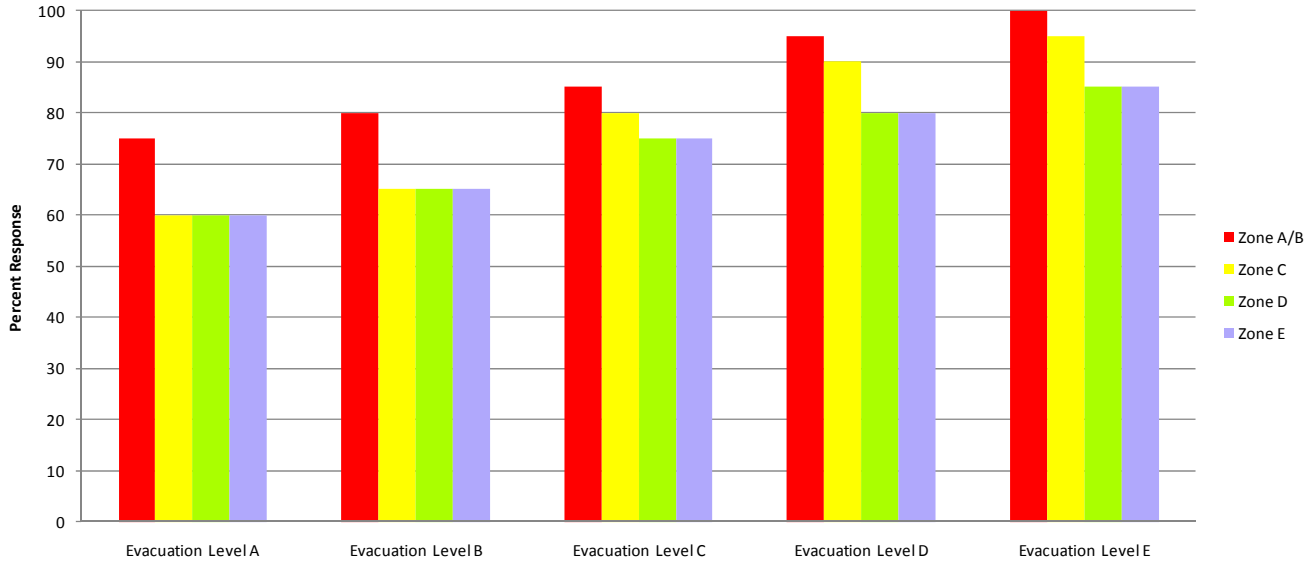


Figure VI-5 - Evacuation Participation Rates: Broward County - Mobile Homes



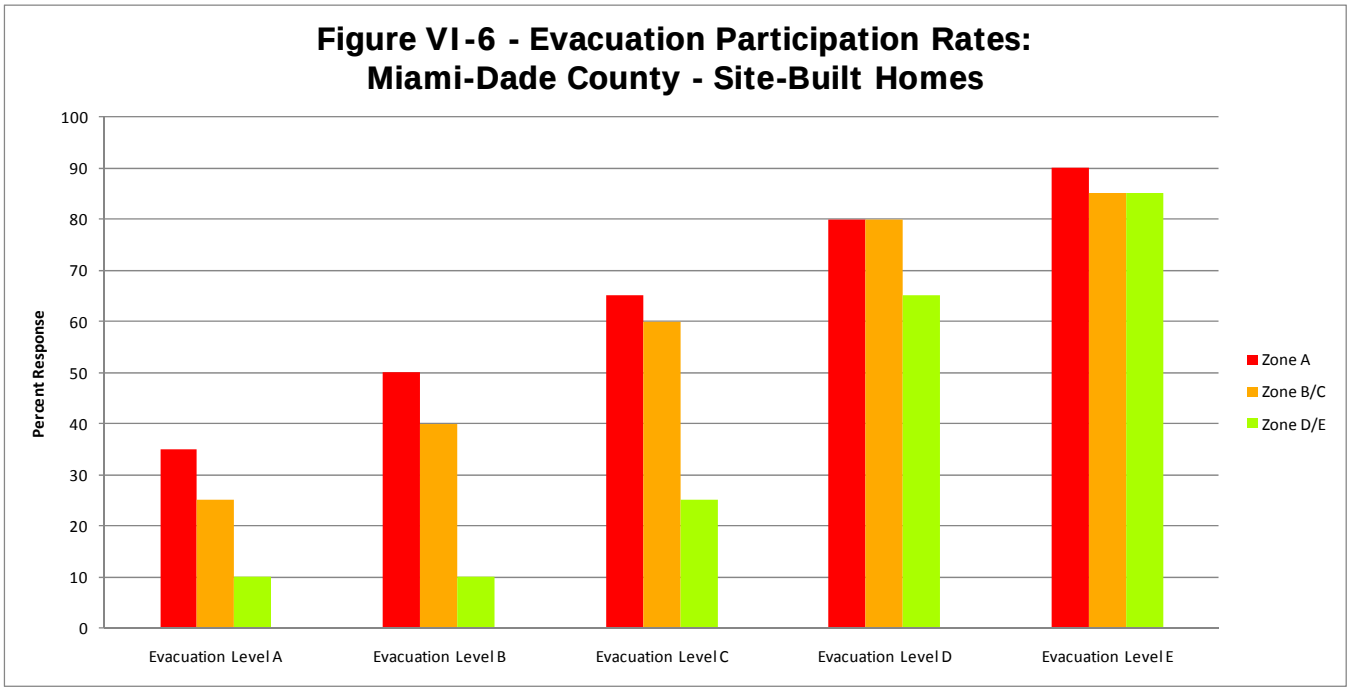


Figure VI-6 - Evacuation Participation Rates:
Miami-Dade County - Site-Built Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E
Zone A
Zone B/C
Zone D/E

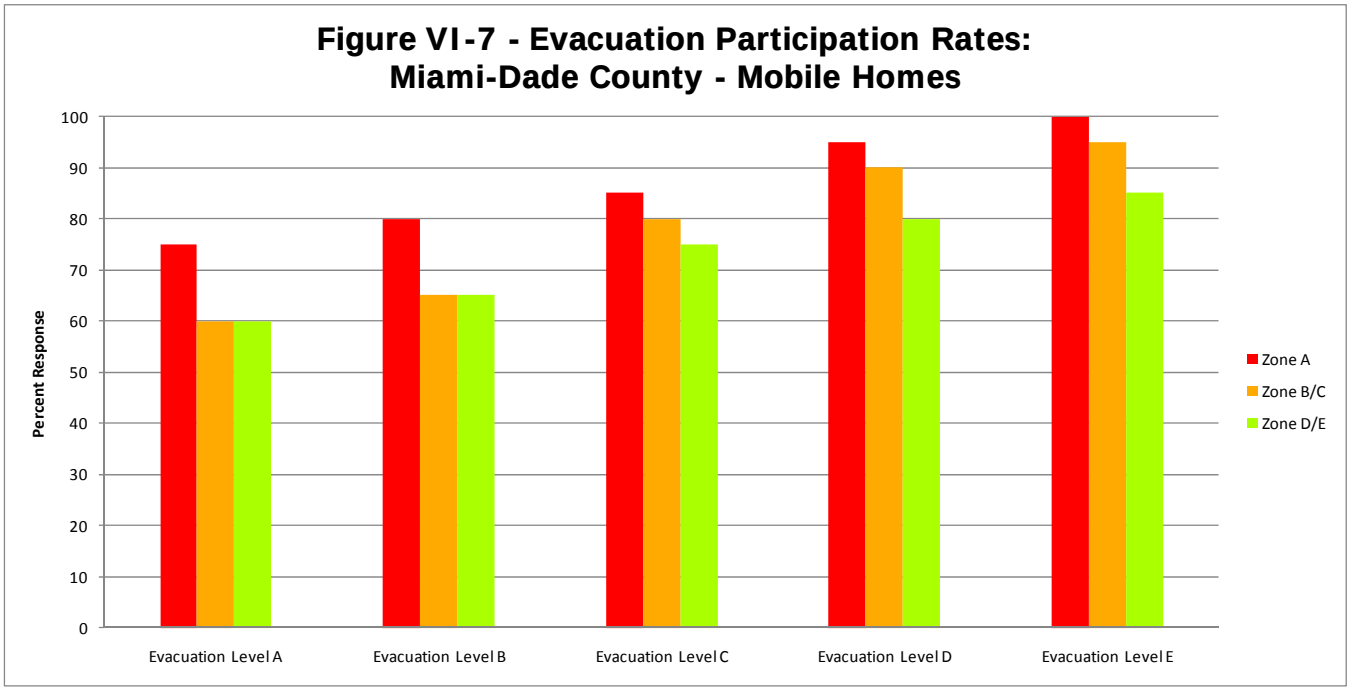


Figure VI-7 - Evacuation Participation Rates:
Miami-Dade County - Mobile Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E
Zone A
Zone B/C
Zone D/E

Figure VI-8 - Evacuation Participation Rates: Monroe County - Site-Built Homes

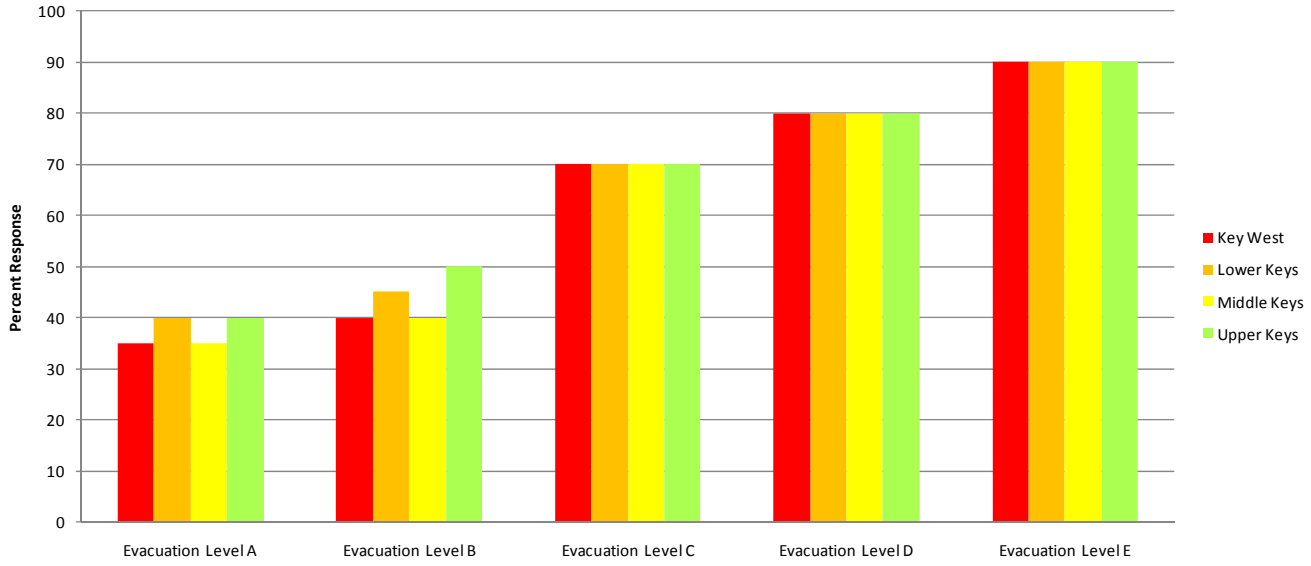
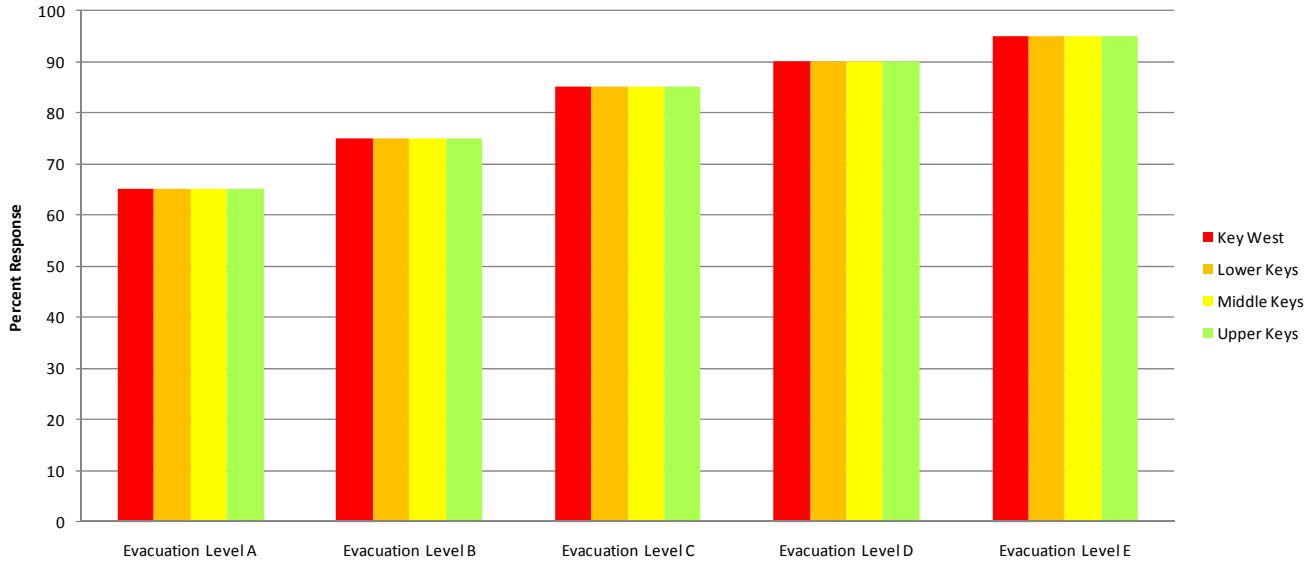


Figure VI-9 - Evacuation Participation Rates: Monroe County - Mobile Homes



F. TIME User Interface

Wilbur Smith Associates developed the Transportation Interface for Modeling Evacuations (TIME) to make it easier for RPC staff and transportation planners to use the model and implement the evacuation methodology. The TIME interface is based on an ArcGIS platform and is essentially a condensed transportation model, which provides a user friendly means of modifying input variables that would change the clearance times for various evacuation scenarios.

The evacuation model variables include a set of distinguishing characteristics that could apply to evacuation scenarios as selection criteria. These following variables may be selected using the TIME interface and allow the user to retrieve the best results from various evacuation alternatives:

- Analysis time period;
- Highway network;
- Behavioral response;
- One-way evacuation operations;
- University population;
- Tourist occupancy rates;
- Shelters;
- Counties evacuating;
- Evacuation level;
- Response curve hours; and,
- Evacuation Phasing.

G. Vulnerable Population

Using a combination of the demographic data, behavioral assumptions, and evacuation zones, the vulnerable population in each county could be determined by evacuation level. For the purposes of the transportation analysis, the vulnerable population, or population-at-risk, is defined as the total population living within the county designated evacuation zones for each evacuation level. This population is living in an area that is at risk for severe flooding during a storm event. The vulnerable population for the South Florida Region for 2010 is identified in **Table VI-4**, summarized by evacuation zone and split between site-built homes and mobile/manufactured homes. Vulnerable population for 2015 is summarized in **Table VI-5**.

Table VI-4 Vulnerable Population in South Florida for 2010

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Broward County*					
Site-built Homes	46,214		96,953	45,172	103,939
Mobile/Manuf. Homes	0		191	407	623
TOTAL	46,214		97,144	45,579	104,562
Miami-Dade County*					
Site-built Homes	148,487	153,512		144,869	
Mobile/Manuf. Homes	0	1,917		6,467	
TOTAL	148,487	155,430		151,335	
Monroe County*					
Site-built Homes	72,946				
Mobile/Manuf. Homes	12,179				
TOTAL	85,125				

Note: Vulnerable population determined using SRESP small area data and county provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone D does not include vulnerable population listed for Evacuation Zone C. See Section E for the source of the small area data.
**Note: For the purposes of this study, Broward County has a combined A/B zone, Miami-Dade County has combined B/C and D/E zones, and all of Monroe County is considered vulnerable.*

Table VI-5 – Vulnerable Population in South Florida for 2015

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Broward County					
Site-built Homes	49,121		102,701	48,840	109,787
Mobile/Manuf. Homes	0		206	440	671
TOTAL	49,121		102,907	49,280	110,458
Miami-Dade County					
Site-built Homes	153,588	174,226		163,929	
Mobile/Manuf. Homes	0	1,958		6,574	
TOTAL	153,588	176,184		170,503	
Monroe County					
Site-built Homes	77,221				
Mobile/Manuf. Homes	12,130				
TOTAL	89,351				

Note: Vulnerable population determined using SRESP small area data and county provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone D does not include vulnerable population listed for Evacuation Zone C. See Section E for the source of the small area data.
**Note: For the purposes of this study, Broward County has a combined A/B zone, Miami-Dade County has combined B/C and D/E zones, and all of Monroe County is considered vulnerable.*

In addition, based again on the demographic data, behavioral assumptions, and evacuation zones, the planned destinations of vulnerable population in each county could be determined by evacuation level. Destinations include friends and family, hotel/motel, public shelter, and other locations. Vulnerable population destinations for the South Florida Region are identified in **Table VI-6** for 2010 and in **Table VI-7** for 2015.

The vulnerable shadow population is provided in **Table VI-8** for both 2010 and 2015. The vulnerable shadow population was determined using the behavioral assumptions for evacuating shadow population and is based on evacuation level (storm category), not evacuation zone.

Table VI-6 Vulnerable Population by Destination for 2010

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Broward County					
To Friends and Family	34,660		72,839	34,144	78,359
To Hotel/ Motel	6,932		14,572	6,837	15,684
To Public Shelter	924		4,867	2,299	5,259
To Other Destination	3,697		4,867	2,299	5,259
Miami-Dade County					
To Friends and Family	96,516	101,029		98,368	
To Hotel/ Motel	29,697	30,894		29,620	
To Public Shelter	7,424	7,867		15,134	
To Other Destination	14,849	15,639		8,213	
Monroe County					
To Friends and Family	48,593				
To Hotel/ Motel	20,168				
To Public Shelter	2,073				
To Other Destination	14,292				

Note: Vulnerable population destinations determined using SRESP small area data and county provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone D does not include vulnerable population listed for Evacuation Zone C. See Section E for the source of the small area data.
**Note: For the purposes of this study, Broward County has a combined A/B zone, Miami-Dade County has combined B/C and D/E zones, and all of Monroe County is considered vulnerable.*

Table VI-7 Vulnerable Population by Destination for 2015

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Broward County					
To Friends and Family	36,841		77,160	36,916	82,776
To Hotel/ Motel	7,368		15,436	7,392	16,569
To Public Shelter	982		5,156	2,486	5,556
To Other Destination	3,930		5,156	2,486	5,556
Miami-Dade County					
To Friends and Family	99,832	114,519		110,827	
To Hotel/ Motel	30,718	35,041		33,443	
To Public Shelter	7,680	8,907		17,050	
To Other Destination	15,359	17,716		9,183	
Monroe County					
To Friends and Family	51,055				
To Hotel/ Motel	21,165				
To Public Shelter	2,157				
To Other Destination	14,976				

Note: Vulnerable population destinations determined using SRESP small area data and county provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone D does not include vulnerable population listed for Evacuation Zone C. See Section E for the source of the small area data.
**Note: For the purposes of this study, Broward County has a combined A/B zone, Miami-Dade County has combined B/C and D/E zones, and all of Monroe County is considered vulnerable.*

Table VI-8 Vulnerable Shadow Evacuation Population, 2010 and 2015

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
2010					
Broward County	160,714	167,817	156,617	257,809	345,043
Miami-Dade County	206,603	172,306	194,056	251,893	450,305
Monroe County	0	0	0	0	0
2015					
Broward County	169,295	176,880	165,025	271,484	363,604
Miami-Dade County	217,855	178,334	202,928	259,579	465,523
Monroe County	0	0	0	0	0

Note: Vulnerable shadow population determined using SRESP behavioral data and county provided evacuation zones. See Section E for the source of the small area data.

H. Evacuation Model Scenarios

There are literally thousands of possible combinations of variables that can be applied using the evacuation transportation model, which will result in thousands of possible outcomes. For the purposes of this analysis, two distinct sets of analyses were conducted using the SRESP evacuation transportation model, including one set of analysis for growth management purposes and one set of analysis for emergency management purposes. The two sets of analysis include the following:

- **Base Scenarios** – The base scenarios were developed to estimate a series of worst case scenarios and are identical for all eleven RPCs across the State. These scenarios assume 100 percent of the vulnerable population evacuates and includes impacts from counties outside of the RPC area. These scenarios are generally designed for growth management purposes, in order to ensure that all residents that choose to evacuate during an event are able to do so. The base scenarios for South Florida are identified in **Table VI-9**; and,

- **Operational Scenarios** – The operational scenarios were developed by the RPCs in coordination with local county emergency managers and are designed to provide important information to emergency management personnel to plan for different storm events. These scenarios are different from region to region and vary for each evacuation level. The operational scenarios for South Florida are identified in **Table VI-10**.

Because of the numerous possible combinations of variables that can be applied in the model, the evacuation transportation model is available for use through the South Florida RPC to continue testing combinations of options and provide additional information to emergency managers.

Table VI-9 Base Scenarios

	Scenario 1 Level A 2010	Scenario 2 Level B 2010	Scenario 3 Level C 2010	Scenario 4 Level D 2010	Scenario 5 Level E 2010
Demographic Data	2010	2010	2010	2010	2010
Highway Network	2010	2010	2010	2010	2010
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	100%	100%	100%	100%	100%
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier
	Scenario 6 Level A 2015	**Scenario 7 Level B 2015**	**Scenario 8 Level C 2015**	**Scenario 9 Level D 2015**	**Scenario 10 Level E 2015**
Demographic Data	2015	2015	2015	2015	2015
Highway Network	2015	2015	2015	2015	2015
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	100%	100%	100%	100%	100%
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier

Table VI-10 Operational Scenarios

	Scenario 1 Level A 2010	Scenario 2 Level B 2010	Scenario 3 Level C 2010	Scenario 4 Level D 2010	Scenario 5 Level E 2010
Demographic Data	2010	2010	2010	2010	2010
Highway Network	2010	2010	2010	2010	2010
One-Way Operations	None	None	None	None	None
University Population	Default	Default	Default	Default	Default
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary/ Other	Primary/ Other
Response Curve	9-hour	12-hour	9-hour	12-hour	12-hour
Evacuation Phasing	Miami-Dade and Broward 24 hours after Monroe	Miami-Dade and Broward 24 hours after Monroe	Miami-Dade and Broward 24 hours after Monroe	Miami-Dade, Broward, and Palm Beach 24 hours after Monroe	Miami-Dade, Broward, and Palm Beach 24 hours after Monroe and Collier
Behavioral Response	Planning	Planning	Planning	Planning	Planning
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward Palm Beach	Monroe Miami-Dade Broward Palm Beach Collier

	Scenario 6 Level A 2010	Scenario 7 Level B 2010	Scenario 8a Level C 2010	Scenario 8b Level C 2010	Scenario 9 Level D 2010	Scenario 10 Level E 2010
Demographic Data	2010	2010	2010	2010	2010	2010
Highway Network	2010	2010	2010	2010	2010	2010
One-Way Operations	None	None	None	None	None	None
University Population	Default	Default	Default	Default	Default	Default
Tourist Rate	Default	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary/ Other	Primary/ Other
Response Curve	9-hour	9-hour	12-hour	12-hour	9-hour	9-hour
Evacuation Phasing	None	None	None	None	None	None
Behavioral Response	Planning	Planning	Planning	100%	Planning	Planning
Evacuation Zone	A	B	C	C	D	E
Counties Evacuating	Monroe Miami-Dade	Broward	Monroe	Monroe	Miami-Dade	Broward

Table VI-10 Operational Scenarios (continued)

	Scenario 11 Level A 2015	Scenario 12 Level B 2015	Scenario 13 Level C 2015	Scenario 14 Level D 2015	Scenario 15 Level E 2015
Demographic Data	2015	2015	2015	2015	2015
Highway Network	2015	2015	2015	2015	2015
One-Way Operations	None	None	None	Turnpike	Turnpike & I-75
University Population	Default	Default	Default	Default	Default
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary/Other	Primary/Other
Response Curve	9-hour	12-hour	12-hour	9-hour	12-hour
Evacuation Phasing	None	None	Miami-Dade and Broward 24 hours after Monroe	None	None
Behavioral Response	Planning	Planning	Planning	Planning	Planning
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward	Monroe Miami-Dade Broward Palm Beach	Monroe Miami-Dade Broward Palm Beach Collier
	Scenario 16 Level A 2015	**Scenario 17 Level B 2015**	**Scenario 18 Level C 2015**	**Scenario 19 Level D 2015**	**Scenario 20 Level E 2015**
Demographic Data	2015	2015	2015	2015	2015
Highway Network	2015	2015	2015	2015	2015
One-Way Operations	None	None	None	None	None
University Population	Default	Default	Default	Default	Default
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary/Other	Primary/Other	Primary/Other
Response Curve	12-hour	9-hour	12-hour	18-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	Planning	Planning	Planning	Planning	Planning
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Monroe Miami-Dade	Broward Miami-Dade	Broward	Monroe	Miami-Dade

I. Clearance Time Results

Each of the ten base scenarios and 21 operational scenarios were modeled for the South Florida Region using the regional evacuation model. Results were derived from the model to summarize the evacuating population, evacuating vehicles, clearance times, and critical congested roadways. Detailed results are discussed in Chapter IV. Clearance times are presented here, since the determination of clearance time is one of the most important outcomes from the evacuation transportation analysis.

Calculated clearance times are used by county emergency managers as one input to determine when to recommend an evacuation order. This calculation can include the population-at-risk, shadow evacuees, as well as evacuees from other counties anticipated to pass through the county. Clearance time is developed to include the time required for evacuees to secure their homes and prepare to leave, the time spent by all vehicles traveling along the evacuation route network, and the additional time spent on the road caused by traffic and road congestion. Clearance time does not relate to the time any one vehicle spends traveling along the evacuation route network, nor does it guarantee vehicles will safely reach their destination once outside the County. The four clearance times that are calculated as part of the evacuation transportation analysis include the following:

- **Clearance Time to Shelter** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the county based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from the point in time when the evacuation order is given to the point in time when the last vehicle reaches a point of safety within the county. Key points to remember for clearance time to shelter include:
  - All in-county trips reach their destination within the county; and,
  - This definition does not include any out-of-county trips.

- **In-County Clearance Time** – The time required from the point an evacuation order is given until the last evacuee can either leave the evacuation zone or arrive at safe shelter within the county. This does not include those evacuees leaving the county on their own. Key points to remember for in-county clearance time include:
  - All in-county trips reach their destination within the county;
  - All out-of-county trips exit the evacuation zone, but may still be located in the county; and,
  - This definition does not include out-of-county pass-through trips from adjacent counties, unless they evacuate through an evacuation zone.

- **Out-of-County Clearance Time** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the county based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from the point an evacuation order is given to the point in time when the last vehicle assigned an external destination exits the county. Key points to remember for out-of-county clearance time include:
  - The roadway network within the county is clear;
  - All out-of-county trips exit the county, including out-of-county pass-through trips from adjacent counties; and,
  - All in-county trips reach their destination.

- **Regional Clearance Time** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the (RPC) region based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from last vehicle assigned an external destination exits the region. Key points to remember for regional clearance time include:
  - The roadway network within the RPC is clear;
  - All out of county trips exit the RPC, including out of county pass-through trips from adjacent counties;
  - All in-county trips reach their destination; and,
  - Regional clearance time is equal to the largest out-of-county clearance time for a given scenario for any of the counties within the RPC, since the out of county clearance time includes out of county pass through trips from adjacent counties.

Clearance times for each of the base scenarios are summarized in **Table VI-11** and **VI-12**, while clearance times for each of the operational scenarios are summarized in **Table VI-13** and **Table VI-14.** Clearance time includes several components, including the mobilization time for the evacuating population to prepare for an evacuation (pack supplies and personal belongs, load their vehicle, etc.), the actual time spent traveling on the roadway network, and the delay time caused by traffic congestion.

Base Scenarios

For South Florida in 2010, in-county clearance times for the base scenarios range from 12.5 hours for the evacuation level A scenarios to 31 hours for evacuation level E scenarios. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 3 hours for Monroe County in the evacuation level A scenarios to 30 hours for Broward County for evacuation level E scenario in 2010. In-county clearance times generally remain close to the selected response curve for lower level evacuation scenarios, such as the 12-hour curves for the level A, B and C base scenarios. Clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low, such as in the Key West area of Monroe County.

In 2015, in-county clearance times for the base scenarios range from 12.5 hours for the evacuation level A scenarios to 45 hours for Broward County for the evacuation level E scenario. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 4 hours for the Monroe County evacuation level A scenario to 45 hours for Broward County for evacuation level E scenario in 2015. In-county clearance times for Miami-Dade County in level B or higher scenarios are typically equal to or above Monroe County out-of-county clearance times. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county. Miami-Dade County has a combined B/C evacuation zone where US 1 enters from Monroe County, so in-county clearance time for Miami-Dade in all level B or higher base scenarios will reflect the out-of-county clearance time for Monroe County.

In-county clearance time for Broward County increases significantly for the level E scenario from 2010 to 2015 due to significant capacity issues on I-95 in Palm Beach County, near the Okeechobee Boulevard interchange. While this capacity issue affects all scenarios, the 30,000

additional evacuating vehicles between the 2010 and 2015 level E scenario cause the queuing and spillback from Palm Beach County to more significantly impact the in-county and shelter evacuating vehicles in Broward County in 2015 than in 2010.

Out-of-county clearance times for the base scenarios range from 24 hours for the base evacuation level A scenario to 39.5 hours in Broward County for the evacuation level E scenario. Out-of-county clearance times range from 24.5 hours for the base evacuation level A scenario to 46 hours in Broward County in 2015.

Regional clearance time for the three-county SFRPC region ranges from 26 hours to 39.5 hours in 2010 and from 26.5 to 46 hours in 2015.

Operational Scenarios

In-county clearance times for the 2010 operational scenarios range from 5.5 hours to 47 hours, depending upon the scenario. Clearance Time to Shelter for the 2010 operational scenarios range from 4.5 hours to 23.5 hours, depending upon the county and the scenario. In-county clearance times for Broward County remain close to the selected response curve for lower level evacuation scenarios, such as 9.5 hours for scenario 1, 12.5 hours for scenario 2, and 9.5 hours for scenario 3. These three scenarios use different response curves (9-hour curves for scenarios 1 and 3 and a 12-hour curve for scenario 2). Clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low.

In 2015, in-county clearance times for the operational scenarios vary from 9.5 hours to 47 hours for the level E evacuation in Broward County. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 5.5 hours to 46 hours depending upon the scenario. In-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county. Miami-Dade County has a combined B/C evacuation zone where US 1 enters from Monroe County, so in-county clearance time for Miami-Dade in all level B or higher evacuations that also include a Monroe County evacuation will reflect the out-of-county clearance time for Monroe County.

Out-of-county clearance times for the 2010 operational scenarios range from 9.5 hours to 65 hours for Scenario 4. The out-of-county clearance time for Scenario 4 is significantly larger than the out-of-county clearance time for Scenario 5, even though the number of evacuating vehicles is less for Scenario 4. The lower time for Scenario 5 is due to the phasing used on the scenario, where Collier and Monroe Counties evacuate 24 hours prior to the remaining counties. When westbound evacuating traffic from Broward County arrives in Collier County, most of Collier County is clear of traffic and better able to accommodate evacuating traffic. In Scenario 4, only Monroe County evacuates 24 hours prior to the remaining counties, and Collier County does not evacuate, and is operating under normal background traffic conditions. The background traffic in Collier County creates significant issues for westbound Broward County evacuating traffic and causes the out-of-county clearance time to increase nearly 20 hours. Out-of-county clearance times range from 10 to 47 in 2015 depending upon the scenario.

Regional clearance time for the three-county SFRPC region ranges from 10 hours to 66.5 hours in 2010. This time ranges from 13 to 47 hours in 2015. It is important to note that for six of the operational scenarios (scenarios 1, 2, 3, 4, 5, and 13), regional clearance time is larger than the highest out-of-county clearance time from any of the counties in the region. This is due to the 24-hour phasing used as part of the scenario, where one or more counties evacuate 24 hours prior to the remaining counties. The regional clearance time begins calculating when the first county orders its evacuation, while the out-of-county clearance time does not begin for each county until the first evacuating vehicle enters the roadway network within the county.

Table VI-11 2010 Clearance Times for Base Scenarios

	Evacuation Level A Base Scenario 1	Evacuation Level B Base Scenario 2	Evacuation Level C Base Scenario 3	Evacuation Level D Base Scenario 4	Evacuation Level E Base Scenario 5
Clearance Time to Shelter					
Key West	3.0	2.5	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A
Monroe County	3.0	2.5	N/A	N/A	N/A
Miami-Dade County	13.0	13.0	13.0	13.0	13.5
Broward County	12.5	12.5	13.0	19.0	30.0
In-County Clearance Time					
Key West	12.5	12.5	15.5	15.5	15.5
Lower Keys	17.5	18.5	22.5	22.5	22.5
Middle Keys	22.0	23.0	27.5	27.5	27.5
Upper Keys	24.0	26.0	31.0	31.0	31.0
Monroe County	24.0	26.0	31.0	31.0	31.0
Miami-Dade County	13.0	26.5	31.0	31.0	31.0
Broward County	12.5	12.5	13.5	20.0	31.0
Out of County Clearance Time					
Key West	12.5	12.5	15.0	15.0	15.0
Lower Keys	17.0	18.0	22.0	22.0	22.0
Middle Keys	21.5	22.5	27.0	27.0	27.0
Upper Keys	24.0	25.5	30.5	30.5	30.5
Monroe County	24.0	25.5	30.5	30.5	30.5
Miami-Dade County	25.5	27.0	31.5	31.5	32.0
Broward County	26.0	27.5	32.0	32.0	39.5
Regional Clearance Time					
South Florida Region	26.0	27.5	32.0	32.0	39.5

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12 hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out of county clearance times for all level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including Miami-Dade's combined B/C evacuation zone located where US 1 enters from Monroe County.

Table VI-12 2015 Clearance Times for Base Scenarios

	Evacuation Level A Base Scenario 6	Evacuation Level B Base Scenario 7	Evacuation Level C Base Scenario 8	Evacuation Level D Base Scenario 9	Evacuation Level E Base Scenario 10
Clearance Time to Shelter					
Key West	4.0	3.0	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A
Monroe County	4.0	3.0	N/A	N/A	N/A
Miami-Dade County	13.0	13.0	13.0	13.0	14.5
Broward County	12.5	12.5	13.0	21.0	45.0
In-County Clearance Time					
Key West	12.5	12.5	16.5	16.5	16.5
Lower Keys	17.5	18.5	24.0	24.0	24.0
Middle Keys	22.5	23.5	29.0	29.0	29.0
Upper Keys	25.0	27.0	32.5	32.5	32.5
Monroe County	25.0	27.0	32.5	32.5	32.5
Miami-Dade County	13.0	27.0	32.5	32.5	32.5
Broward County	12.5	12.5	13.0	21.0	45.0
Out of County Clearance Time					
Key West	12.5	12.5	16.0	16.0	16.0
Lower Keys	17.0	18.0	23.5	23.5	23.5
Middle Keys	22.0	23.0	28.5	28.5	28.5
Upper Keys	24.5	26.5	32.0	32.0	32.0
Monroe County	24.5	26.5	32.0	32.0	32.0
Miami-Dade County	26.0	27.5	33.0	33.0	35.0
Broward County	26.5	28.0	33.5	33.5	46.0
Regional Clearance Time					
South Florida Region	26.5	28.0	33.5	33.5	46.0

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12 hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out of county clearance times for all level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including Miami-Dade's combined B/C evacuation zone located where US 1 enters from Monroe County.

Table VI-13 2010 Clearance Times for Operational Scenarios

	Evacuation Level A Operational Scenario 1	Evacuation Level B Operational Scenario 2	Evacuation Level C Operational Scenario 3	Evacuation Level D Operational Scenario 4	Evacuation Level E Operational Scenario 5
Clearance Time to Shelter					
Key West	5.5	4.5	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A
Monroe County	5.5	4.5	N/A	N/A	N/A
Miami-Dade County	9.5	13.0	10.0	13.0	23.5
Broward County	9.5	12.5	9.5	20.5	23.5
In-County Clearance Time					
Key West	9.5	12.5	10.0	13.0	13.5
Lower Keys	16.0	17.5	16.5	19.0	21.0
Middle Keys	19.5	22.0	20.0	22.5	25.0
Upper Keys	22.5	25.0	22.5	25.5	28.0
Monroe County	22.5	25.0	22.5	25.5	28.0
Miami-Dade County	9.5	36.5	33.5	36.5	47.0
Broward County	9.5	12.5	9.5	20.5	42.0
Out of County Clearance Time					
Key West	9.5	12.5	9.5	12.5	13.0
Lower Keys	15.5	17.0	16.0	18.5	20.5
Middle Keys	19.5	21.5	19.5	22.0	24.5
Upper Keys	22.5	24.5	22.0	25.0	27.5
Monroe County	22.5	24.5	22.0	25.0	27.5
Miami-Dade County	34.0	37.0	34.0	40.5	49.5
Broward County	34.5	36.5	45.5	65.0	46.5
Regional Clearance Time					
South Florida Region	35.5	38.0	46.5	66.5	49.5

Notes: For scenarios 1, 2, 3, 4, and 5, regional clearance time is larger than the highest out-of-county clearance time from any of the counties in the region due to the 24-hour phasing used as part of the scenario.

In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. In-county clearance time for Broward County in scenarios 1, 2, and 3 illustrate this, as these scenarios used a 9-hour, 12-hour, and 9-hour response curve, respectively.

In-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including Miami-Dade's combined B/C evacuation zone located where US 1 enters from Monroe County.

Out-of-county clearance time for Broward County in Scenario 4 is significantly larger than the out-of-county clearance time for Broward County in Scenario 5 due to the phasing used in Scenario 5, where Collier and Monroe Counties evacuate 24 hours prior to the remaining counties.

Table VI-13 2010 Clearance Times for Operational Scenarios (continued)

	Evacuation Level A Operational Scenario 6	Evacuation Level B Operational Scenario 7	Evacuation Level C Operational Scenario 8a	Evacuation Level D Operational Scenario 8b	Evacuation Level E Operational Scenario 9	Evacuation Level E Operational Scenario 10
Clearance Time to Shelter						
Key West	5.0	N/A	N/A	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A	N/A
Monroe County	5.0	N/A	N/A	N/A	N/A	N/A
Miami-Dade County	9.5	N/A	N/A	N/A	10.0	N/A
Broward County	N/A	9.5	N/A	N/A	N/A	9.5
In-County Clearance Time						
Key West	9.5	N/A	12.5	15.0	N/A	N/A
Lower Keys	16.0	N/A	16.5	22.0	N/A	N/A
Middle Keys	19.5	N/A	20.0	27.0	N/A	N/A
Upper Keys	22.5	N/A	22.5	30.5	N/A	N/A
Monroe County	22.5	N/A	22.5	30.5	N/A	N/A
Miami-Dade County	9.5	N/A	N/A	N/A	10.0	N/A
Broward County	5.5	9.5	N/A	N/A	N/A	9.5
Out of County Clearance Time						
Key West	9.5	N/A	12.5	15.0	N/A	N/A
Lower Keys	15.5	N/A	16.5	22.0	N/A	N/A
Middle Keys	19.5	N/A	20.0	27.0	N/A	N/A
Upper Keys	22.5	N/A	22.5	30.5	N/A	N/A
Monroe County	22.5	N/A	22.5	30.5	N/A	N/A
Miami-Dade County	23.5	9.5	23.5	31.5	10.5	11.0
Broward County	24.0	10.0	22.5	30.5	13.0	24.0
Regional Clearance Time						
South Florida	24.0	10.0	23.5	31.5	13.0	24.0

Table VI-14 2015 Clearance Times for Operational Scenarios

	Evacuation Level A Operational Scenario 11	Evacuation Level B Operational Scenario 12	Evacuation Level C Operational Scenario 13	Evacuation Level D Operational Scenario 14	Evacuation Level E Operational Scenario 15
Clearance Time to Shelter					
Key West	5.5	4.0	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A
Monroe County	5.5	4.0	N/A	N/A	N/A
Miami-Dade County	10.0	13.0	13.0	10.0	13.0
Broward County	9.5	12.5	12.5	22.5	46.0
In-County Clearance Time					
Key West	10.0	12.5	13.0	12.0	14.5
Lower Keys	16.5	18.0	17.5	19.5	22.0
Middle Keys	20.0	22.5	21.0	23.5	26.0
Upper Keys	23.0	26.0	24.0	26.0	29.5
Monroe County	23.0	26.0	24.0	26.0	29.5
Miami-Dade County	10.0	26.0	36.5	26.5	29.5
Broward County	9.5	12.5	12.5	22.5	47.0
Out of County Clearance Time					
Key West	10.0	12.5	12.5	11.5	14.0
Lower Keys	16.0	17.5	17.0	19.0	21.5
Middle Keys	20.0	22.0	20.5	23.0	25.5
Upper Keys	23.0	25.5	23.5	25.5	29.0
Monroe County	23.0	25.5	23.5	25.5	29.0
Miami-Dade County	24.0	26.5	37.0	27.0	44.5
Broward County	24.5	27.0	43.0	46.5	47.0
Regional Clearance Time					
South Florida Region	24.5	27.0	44.5	46.5	47.0

Notes: For scenario 13, regional clearance time is larger than the highest out-of-county clearance time from any of the counties in the region due to the 24-hour phasing used as part of the scenario.

In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. In-county clearance time for Broward County in scenarios 11, 12, and 13 illustrate this, as these scenarios used a 9-hour, 12-hour, and 12-hour response curve, respectively.

In-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including Miami-Dade's combined B/C evacuation zone located where US 1 enters from Monroe County.

Table VI-14 2015 Clearance Times for Operational Scenarios (continued)

	Evacuation Level A Operational Scenario 16	Evacuation Level B Operational Scenario 17	Evacuation Level C Operational Scenario 18	Evacuation Level D Operational Scenario 19	Evacuation Level E Operational Scenario 20
Clearance Time to Shelter					
Key West	4.0	N/A	N/A	N/A	N/A
Lower Keys	N/A	N/A	N/A	N/A	N/A
Middle Keys	N/A	N/A	N/A	N/A	N/A
Upper Keys	N/A	N/A	N/A	N/A	N/A
Monroe County	4.0	N/A	N/A	N/A	N/A
Miami-Dade County	13.0	10.0	N/A	N/A	13.0
Broward County	N/A	9.5	12.5	N/A	N/A
In-County Clearance Time					
Key West	12.5	N/A	N/A	19.0	N/A
Lower Keys	17.0	N/A	N/A	20.5	N/A
Middle Keys	21.0	N/A	N/A	24.0	N/A
Upper Keys	24.0	N/A	N/A	27.0	N/A
Monroe County	24.0	N/A	N/A	27.0	N/A
Miami-Dade County	13.0	10.5	N/A	N/A	13.5
Broward County	N/A	9.5	12.5	N/A	N/A
Out of County Clearance Time					
Key West	12.5	8.5	N/A	18.5	N/A
Lower Keys	16.5	9.5	N/A	20.0	N/A
Middle Keys	20.5	9.5	N/A	23.5	N/A
Upper Keys	23.5	10.0	N/A	26.5	N/A
Monroe County	23.5	10.0	N/A	26.5	N/A
Miami-Dade County	24.5	10.5	12.5	27.5	13.5
Broward County	25.0	25.5	13.0	26.5	17.0
Regional Clearance Time					
South Florida Region	25.0	25.5	13.0	27.5	17.0

J. Maximum Evacuating Population Clearances

From an emergency management standpoint, it is important to get an understanding of the maximum proportion of the evacuating population that can be expected to evacuate at various time intervals during an evacuation. Should storm conditions change during an evacuation, emergency managers will need to be able to estimate what portion of the evacuating population is estimated to still remain within the county trying to evacuate.

Using the base scenarios, which assume 100% of the vulnerable population is evacuating, along with shadow evacuations and evacuations from adjacent counties, an estimate was made of the evacuating population actually able to evacuate out of each county by the time intervals of 12, 18, 24, and 36 hours. The estimated maximum evacuating population by time interval for 2010 is identified in **Table VI-15** and for 2015 in **Table VI-16**.

It is important to note that these estimates take into account many variables, including roadway capacity, in-county evacuating trips, out of county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary slightly between evacuation level and either increase or decrease from one evacuation level to the next.

K. Sensitivity Analysis

As discussed previously, there are literally thousands of possible combinations of variables that can be applied using the evacuation transportation model, which will result in thousands of possible outcomes. As part of the analysis process, a sensitivity analysis was conducted using the prototype model to evaluate the effect of different response curves on the calculated evacuation clearance times. Calculated clearance times will never be lower than the designated response time, since some evacuating residents will wait to evacuate until near the end of the response time window. For example, using a 12-hour response curve in the analysis means that all residents will begin their evacuation process within 12-hours, and some residents will choose to wait and begin evacuating more than 11.5 hours from when the evacuation was ordered. This will generate a clearance time of more than 12 hours.

The sensitivity analysis identified that clearance times will vary by scenario and by any of the numerous parameters that can be chosen in a particular scenario model run (demographics, student population, tourist population, different counties that are evacuating, response curve, phasing, shadow evacuations, etc.). A few general rules of thumb did emerge from the sensitivity analysis that can provide some guidance to the region regarding the sensitivity of the response curve to the calculated clearance times:

- For low evacuation levels A and B, clearance time will vary by as much as 40 percent depending on the response curve. Low evacuation levels A and B have fewer evacuating vehicles that can be accommodated more easily on the transportation network. In most cases, clearance times typically exceed the response curve by one to two hours. Thus, a 12-hour response curve may yield a clearance time of 13 or 14 hours, while an 18-hour response curve may yield a clearance time of 19 or 20 hours. This leads to a higher level of variability than larger evacuations;

- For mid-level evacuations such as C and sometimes D, clearance time varied by as much as 25 percent during the sensitivity analysis. The number of evacuating vehicles is considerably higher than for levels A and B, and lower response curves tend to load the transportation network faster than longer response curves. The variability in clearance times is less in these cases than for low evacuation levels; and,

- For high-level evacuations such as some level D evacuations and all E evacuations, clearance time variability is reduced to about 10 to 15 percent. Large evacuations involve large numbers of evacuating vehicles, and the sensitivity test identified that clearance times are not as dependent on the response curve as lower level evacuations since it takes a significant amount of time to evacuate a large number of vehicles.

Table VI-15 Maximum Evacuating Population by Time Interval for 2010

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
Estimated Evacuating Population Clearing Monroe County					
12-Hour	36,195	36,205	28,669	28,669	28,669
18-Hour	54,293	54,308	43,004	43,004	43,004
24-Hour	72,390	72,410	57,339	57,339	57,339
36-Hour		76,936	72,868	72,868	72,868
Estimated Evacuating Population Clearing Miami-Dade County					
12-Hour	167,101	211,655	189,704	269,389	339,584
18-Hour	250,652	317,482	284,556	404,083	509,376
24-Hour	334,202	423,309	379,408	538,777	679,168
36-Hour	355,090	476,223	497,973	707,145	905,557
Estimated Evacuating Population Clearing Broward County					
12-Hour	95,505	93,395	112,491	167,530	193,987
18-Hour	143,258	140,093	168,736	251,295	290,981
24-Hour	191,010	186,791	224,981	335,060	387,975
36-Hour	206,928	214,031	299,975	446,746	581,962

Note: These estimates take into account many variables, including roadway capacity, in-county evacuating trips, out-of-county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary between evacuation level and either increase or decrease from one evacuation level to the next. See section E for the source of the small area data.

Table VI-16 Maximum Evacuating Population by Time Interval for 2015

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
Estimated Evacuating Population Clearing Monroe County					
12-Hour	36,219	35,669	28,928	28,928	28,928
18-Hour	54,328	53,504	43,392	43,392	43,392
24-Hour	72,438	71,339	57,857	57,857	57,857
36-Hour	73,947	78,770	77,142	77,142	77,142
Estimated Evacuating Population Clearing Miami-Dade County					
12-Hour	171,435	221,719	193,709	276,311	331,131
18-Hour	257,153	332,578	290,564	414,466	496,696
24-Hour	342,870	443,438	387,418	552,621	662,261
36-Hour	371,443	508,106	532,700	759,854	965,798
Estimated Evacuating Population Clearing Broward County					
12-Hour	98,905	96,858	113,571	169,358	176,183
18-Hour	148,358	145,286	170,357	254,037	264,275
24-Hour	197,811	193,715	227,142	338,717	352,367
36-Hour	218,416	226,001	317,053	472,792	528,550

Note: These estimates take into account many variables, including roadway capacity, in-county evacuating trips, out-of-county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary between evacuation level and either increase or decrease from one evacuation level to the next. See section E for the source of the small area data.

The counties within the South Florida Region are encouraged to test additional scenarios beyond what has been provided in this study. Each model run will provide additional information for the region to use in determining when to order an evacuation. Due to advancements in computer technology and the nature of the developed transportation evacuation methodology, this study includes a more detailed and time consuming analysis process than used in previous years studies. Counties interested in testing various response curves for each scenario can easily do so using the TIME interface to calculate clearance times for different response curves.

L. Summary and Conclusions

Through a review of the results of the 31 different scenarios (10 base and 21 operational), several conclusions could be reached regarding the transportation analysis, including the following:

- Critical transportation facilities within the SFRPC region include US 1, I-95, I-75, I-595, I-395, and the Turnpike. For large storm events, such as level D and E evacuations, other State facilities also play an important role in evacuations, such as US 41 in Miami-Dade County and US 27 in Broward County;

- During the level A and B evacuation scenarios, the roadway segments with the highest vehicle queues are primarily concentrated along the major Interstate and State Highway system. During these levels of evacuation, State and County officials should coordinate personnel resources to provide sufficient traffic control at interchanges and major intersections along these routes;

- In contrast, for the higher level C, D, and E evacuation scenarios, many other roadway facilities, both within and outside of the region, will require personnel resources for sufficient traffic control at interchanges and major intersections;

- The SFRPC counties, in coordination with the State, should continue public information campaigns to clearly define those that are vulnerable and should evacuate versus those who choose to evacuate on their own. During large storm events in the operational scenarios, evacuations by the vulnerable population in the three SFRPC counties are impacted by shadow evacuations occurring in other parts of the counties and in areas outside the SFPRC region;

- The Florida Department of Transportation should continue to work with local counties on implementing intelligent transportation system (ITS) technology, which will provide enhanced monitoring and notification systems to provide evacuating traffic with up-to-date information regarding expected travel times and alternate routes;

- The State can use the data and information provided in this report (specifically the evacuating vehicle maps in Volume 5-11) to estimate fuel and supply requirements along major evacuation routes to aid motorists during the evacuation process;

- For major evacuation routes that have signalized traffic control at major intersections, traffic signal timing patterns should be adjusted during the evacuation process to provide maximum green time for evacuating vehicles in the predominate north and west directions; and,

- The counties within the South Florida Region are encouraged to test additional transportation scenarios beyond what has been provided in this study. Each model run will provide additional information for the region to use in planning for an evacuation. Counties interested in testing various response curves for each scenario can easily do so using the TIME interface to calculate clearance times for different evacuation conditions, such as different evacuation levels, different behavioral response assumptions, and different response curves.