# Evacuation and Resilience Practice and Research

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*Gulf Coast Center for Evacuation and Transportation Resiliency*

*Making Cities Resilient Exchange*

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# What is Disaster Resilience?

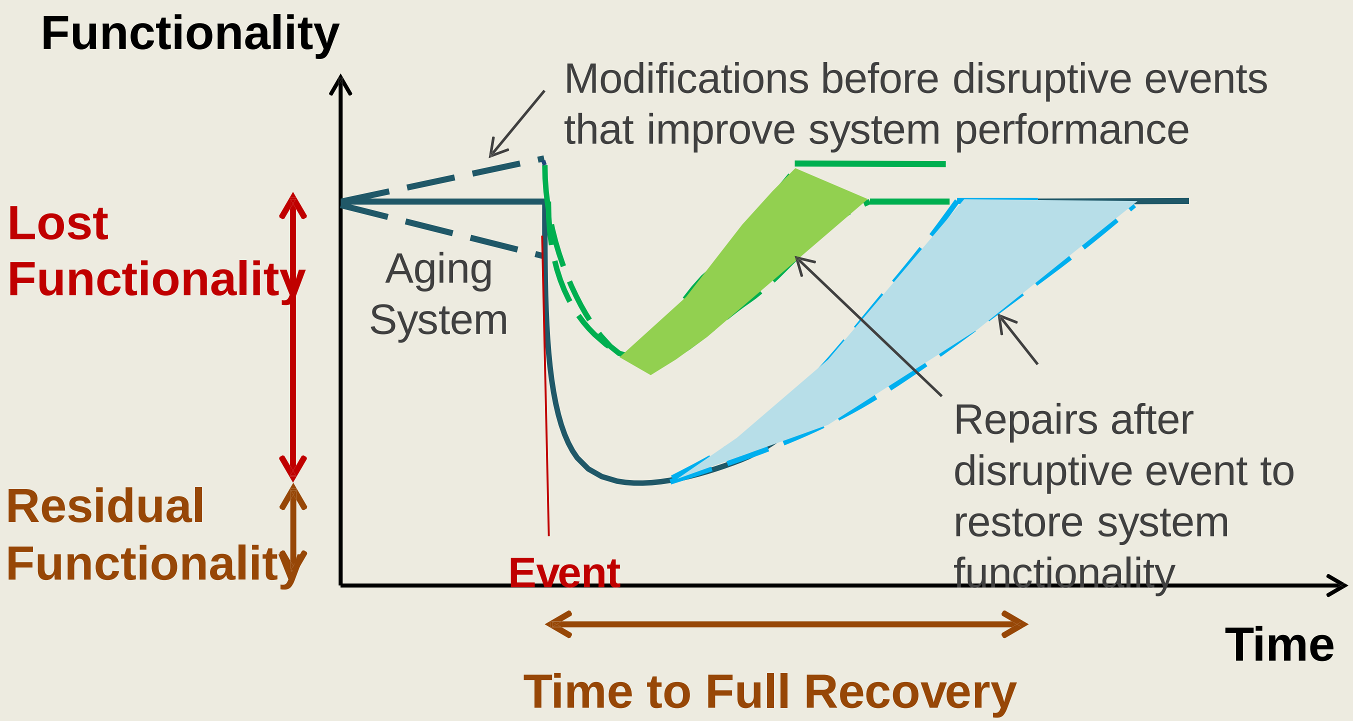
- The term "resilience" means the ability to *prepare for* and *adapt to* changing conditions and *withstand* and *recover rapidly* from disruptions*
- In the context of community resilience, the emphasis is not solely on mitigating risk, but implementing measures to ensure that the community recovers to normal, or near normal function, in a reasonable timeframe.

*As defined in Presidential Policy Directive 21.

# Resilience Concept

Maintain acceptable levels of functionality during and after disruptive events

Recover full functionality within a specified period of time




Adapted from Bruneau, 2003 and McDaniels, 2008

# Attributes of Resilience

- Functionality – Resilience should be based on the ability of social systems to resume function within a prescribed period of time following an expected event. Buildings and infrastructure must be functional to support these social systems.
- Interdependence – Resilience must consider the interdependence of buildings and infrastructure (functionality) *and* the relationship of individuals and organizations with the built environment.

# Performance Levels for After-Event Evaluations

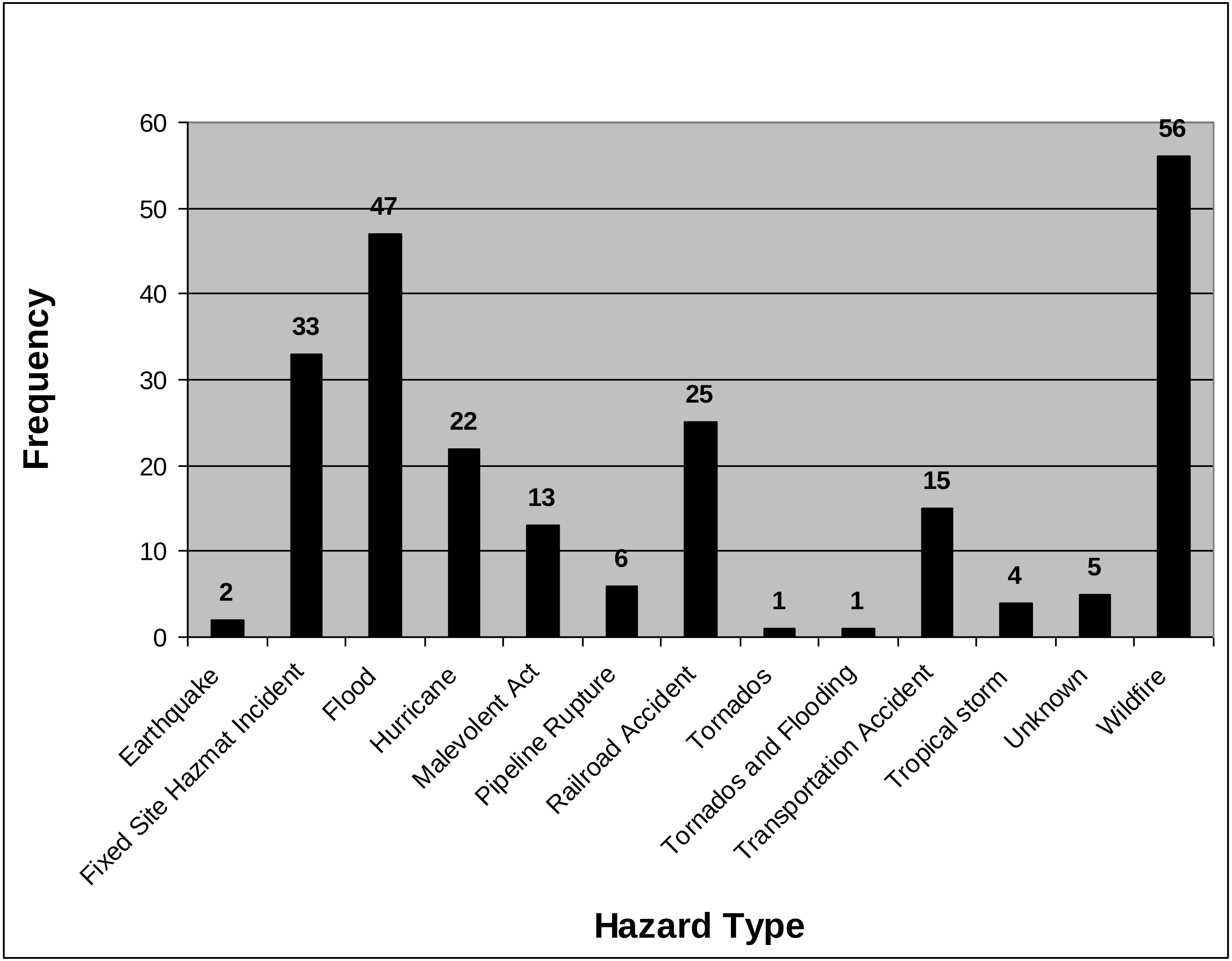
| Category | Infrastructure System Performance Standard |
|---|---|
| I | Resume 100% service within days |
| II | Resume 90% service within weeks and 100% within months |
| III | Resume 90% service within months and 100% within years |

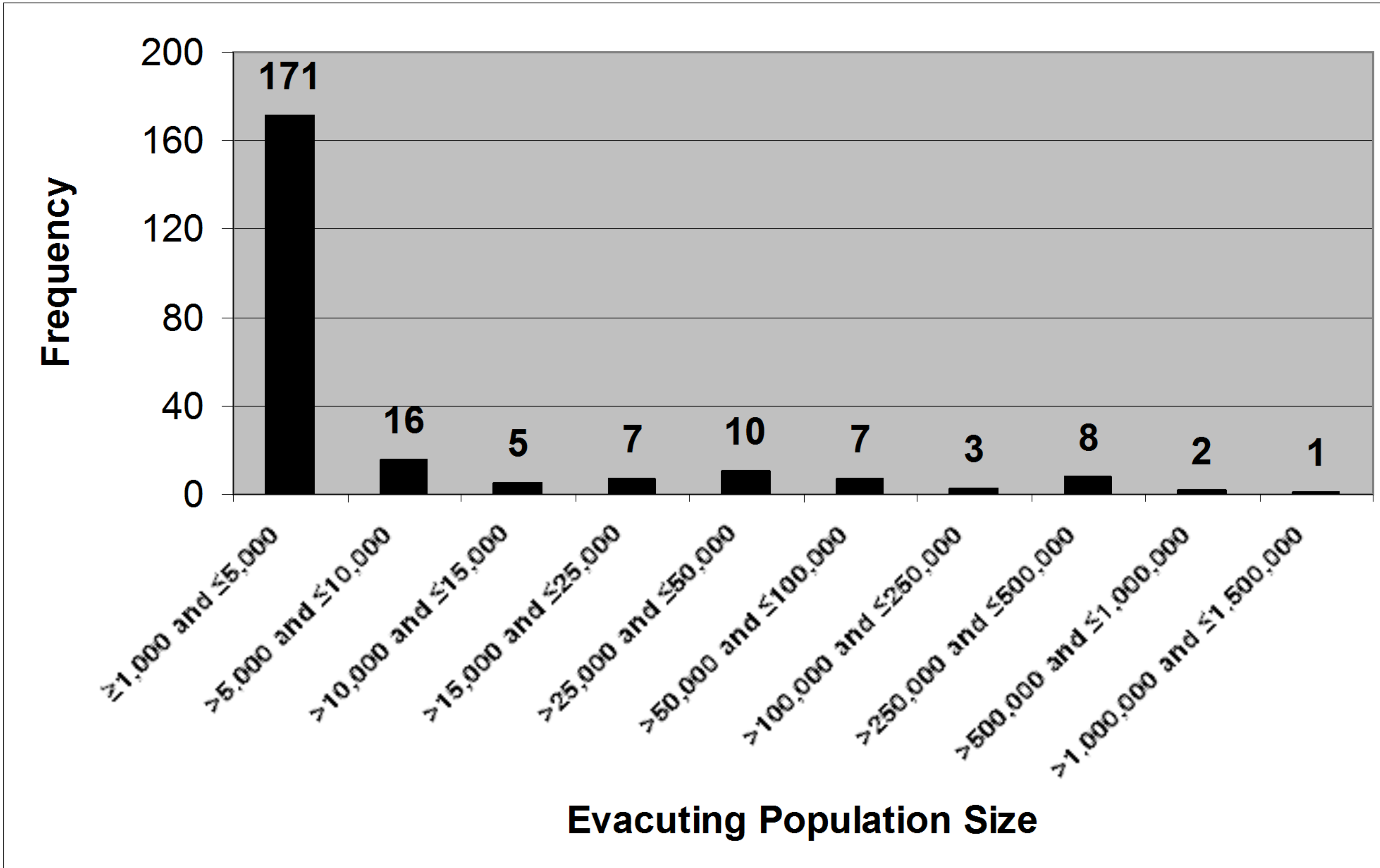
# Disaster Resilience Framework 1.0

- The Disaster Resilience Framework 1.0 will focus on the role that buildings and infrastructure lifelines play in ensuring community resilience.
- The Framework will:
  - Establish types of performance goals and ways to express them
  - Identify existing standards, codes, and best practices that address resilience
  - Identify gaps that must be addressed to enhance resilience
  - Capture regional differences in perspectives on resilience
- The Disaster Resilience Framework will be informed through a series of stakeholder workshops.

# *Evacuation Basics*

- ***TEMPORAL AND SPATIAL***
- ***Hazard Characteristics***
  - ***Scale (how "big?" -> How far to evacuate), Amount of advanced notice, Shelter-in-place options***
- ***Evacuee Characteristics***
  - ***Who are they? Where are they? How many? How mobile? Behavior (if/when will they leave?), What are their needs?***
- ***Transportation Resources***
  - ***Modes, Highway Transit, Traffic Control, Traffic Management***
- ***Communications***
- ***To/from, Across and between all levels, jurisdictions, agencies, and evacuees, Need for situational awareness***


Frequency
60
50
40
30
20
10
0
2
33
47
22
13
6
25
1
1
15
4
5
56
Earthquake
Fixed Site Hazmat Incident
Flood
Hurricane
Malevolent Act
Pipeline Rupture
Railroad Accident
Tornados
Tornados and Flooding
Transportation Accident
Tropical storm
Unknown
Wildfire
Hazard Type



Frequency
200
160
120
80
40
0
171
16
5
7
10
7
3
8
2
1
≥1,000 and ≤5,000
>5,000 and ≤10,000
>10,000 and ≤15,000
>15,000 and ≤25,000
>25,000 and ≤50,000
>50,000 and ≤100,000
>100,000 and ≤250,000
>250,000 and ≤500,000
>500,000 and ≤1,000,000
>1,000,000 and ≤1,500,000
Evacuting Population Size

**Photo Source: Lt. John Denholm**
**Harris Co. (TX) Sheriff's Office**

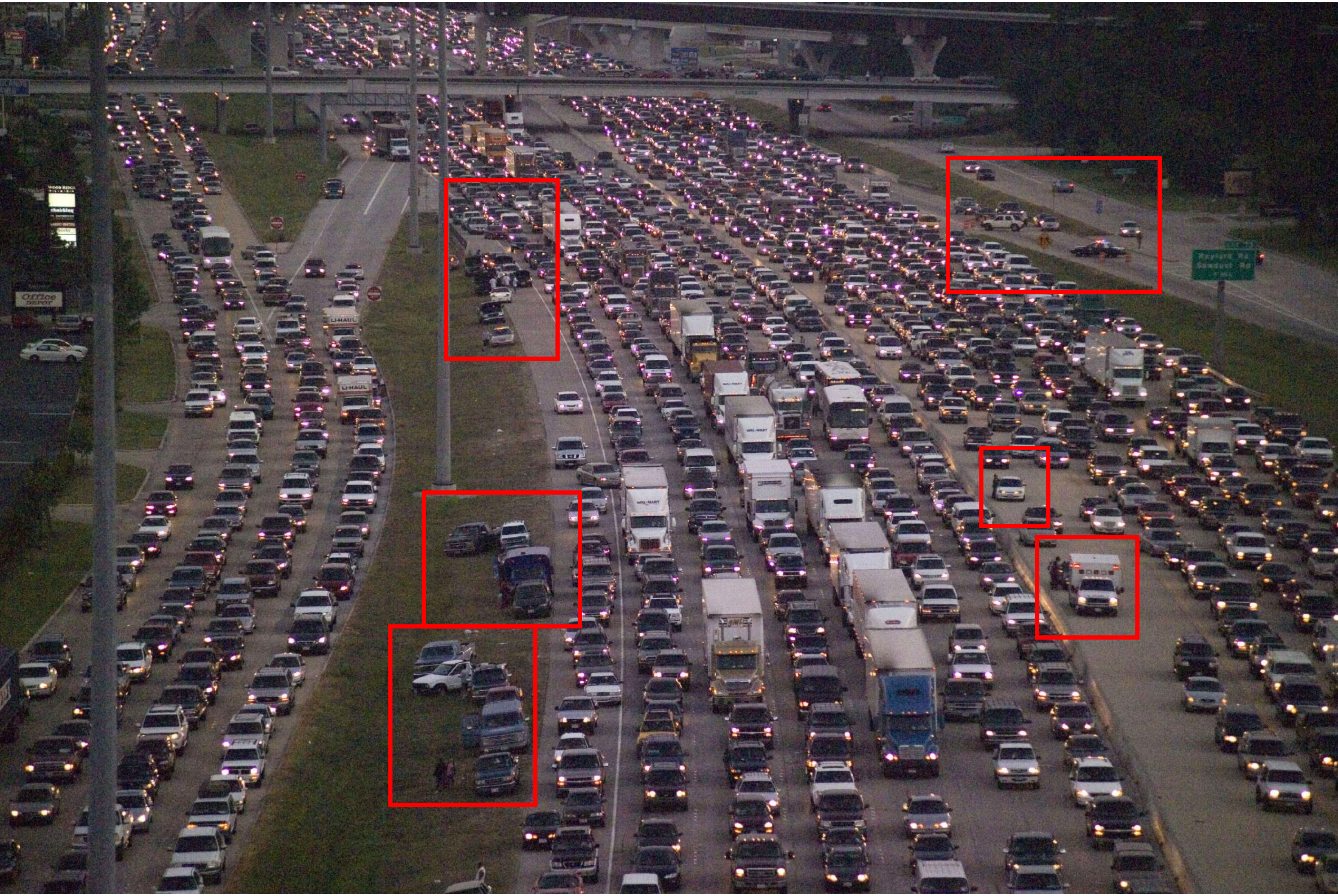
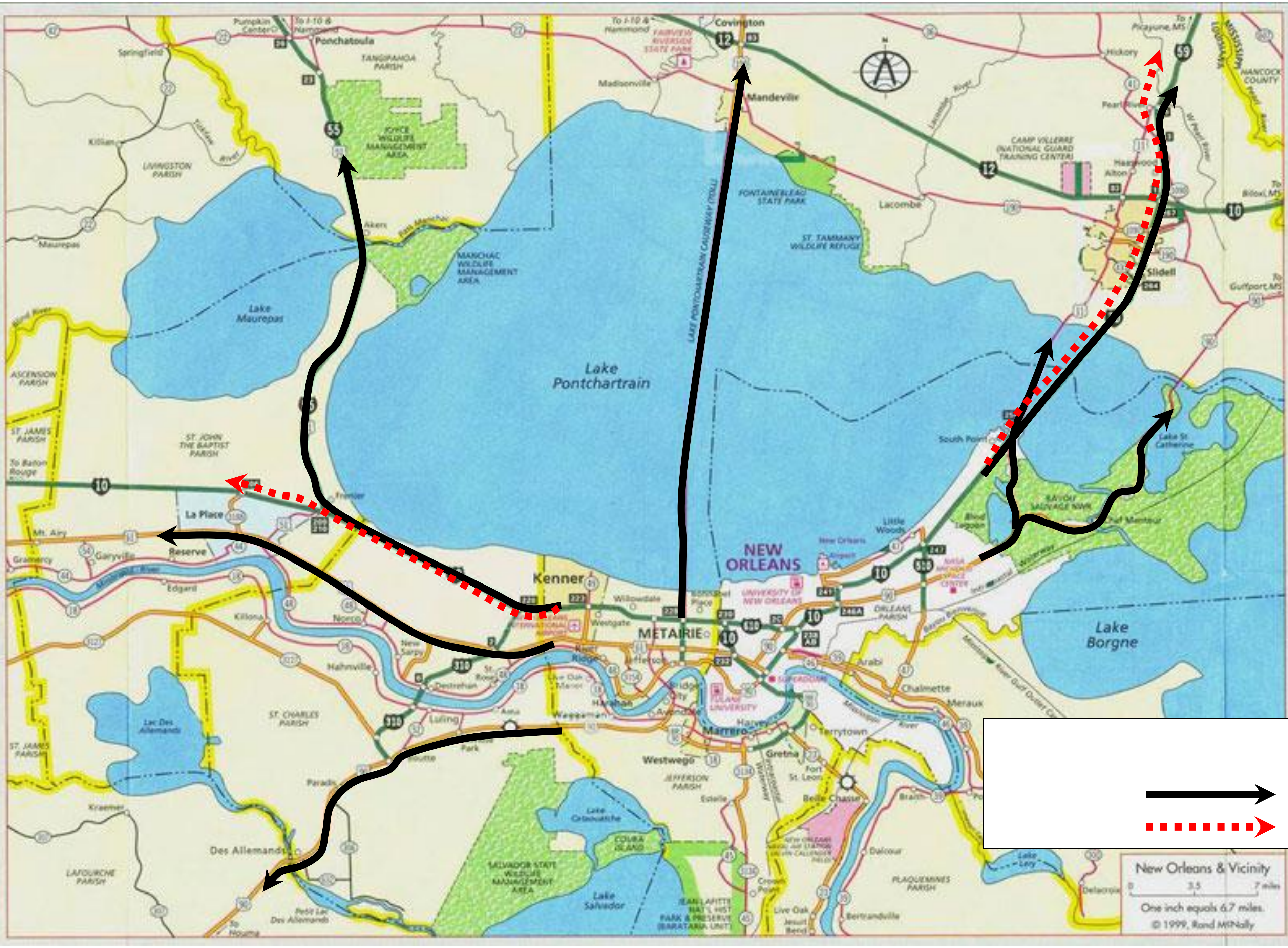


***Photo Source: Yi-Chang Chiu, University of Arizona***

# Recent History in Louisiana

# Recent History in Louisiana

- *Prior to Hurricane Georges in 2000, there was no regional traffic management plan in LA*
- *No "designated" evacuation routes*
- *1st plan was developed in 2000 and included contraflow in New Orleans*
- *Used for the first time in 2004 for Hurricane Ivan - with questionable results*
- *"Revised plan" was developed in 2004-2005 and implemented for the first time for Hurricane Katrina*
- *Evacuation was quite effective for those with the desire and means to evacuate*
- *Plans for the evacuation of low-mobility populations were obviously "lacking"*

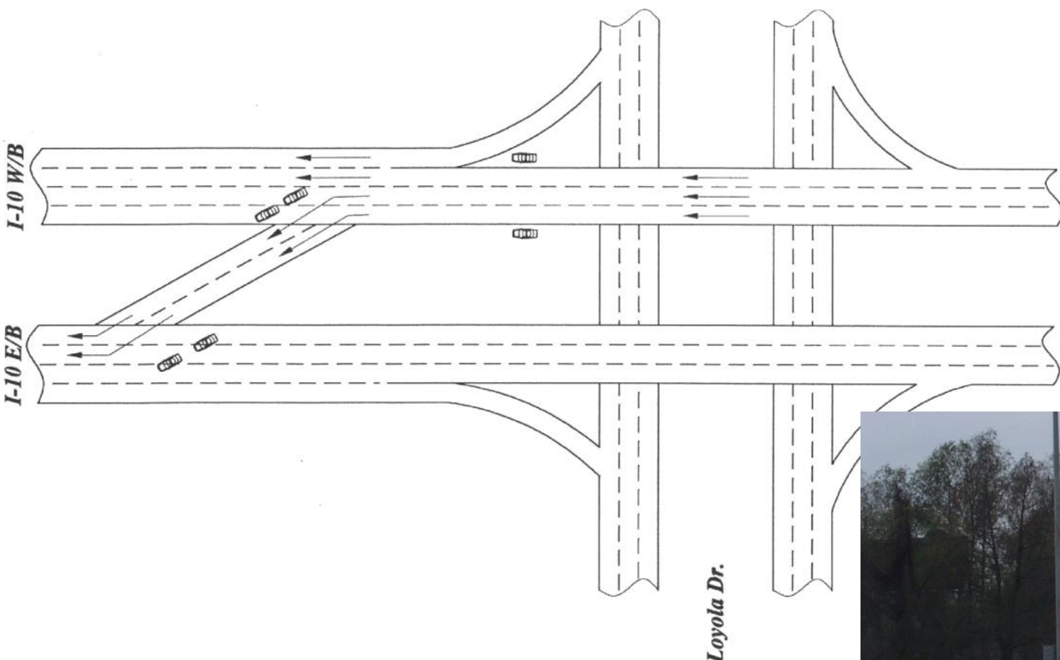


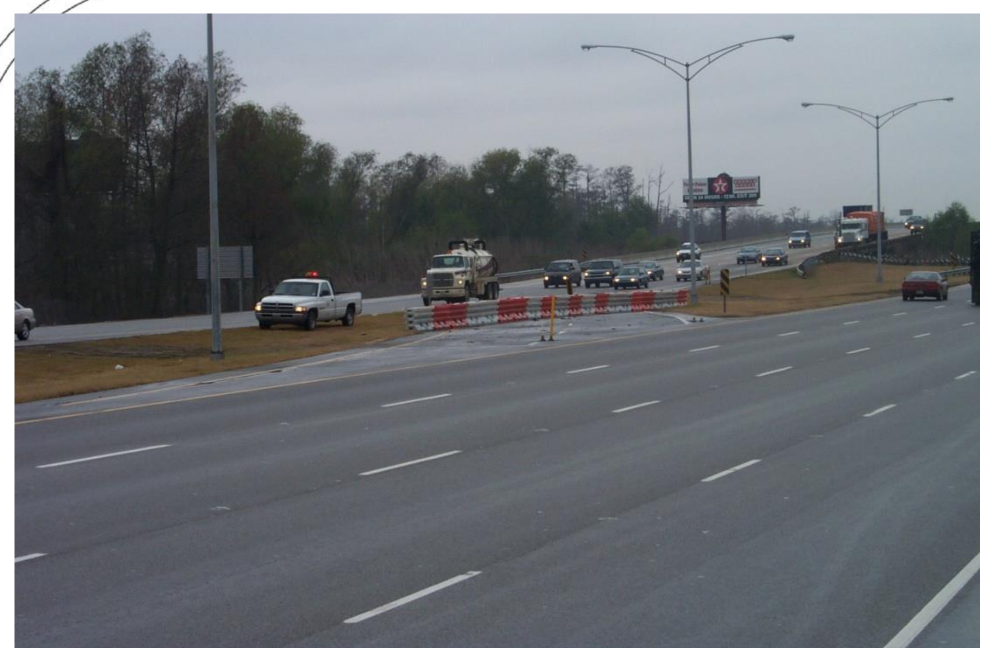
New Orleans & Vicinity
0 3.5 7 miles
One inch equals 6.7 miles.
© 1999, Rand McNally
Lake Pontchartrain
Lake Maurepas
Lake Borgne
NEW ORLEANS
METAIRIE
Kenner
Covington
Mandeville
Ponchatoula
Slidell
Lacombe
Madisonville
Springfield
Killian
Akers
Hickory
Pearl River
LIVINGSTON PARISH
TANGIPAHOA PARISH
ST. JOHN THE BAPTIST PARISH
ST. CHARLES PARISH
JEFFERSON PARISH
ORLEANS PARISH
PLAQUEMINES PARISH
LAFOURCHE PARISH
ASCENSION PARISH
ST. JAMES PARISH
HANCOCK COUNTY
MANCHAC WILDLIFE MANAGEMENT AREA
JOYCE WILDLIFE MANAGEMENT AREA
FONTAINEBLEAU STATE PARK
ST. TAMMANY WILDLIFE REFUGE
CAMP VILLERE (NATIONAL GUARD TRAINING CENTER)
SALVADOR STATE WILDLIFE MANAGEMENT AREA
LAKE PONTCHARTRAIN CAUSEWAY (TOLL)
La Place
Reserve
Garyville
Gramercy
Mt. Airy
Edgard
Killona
Norco
Hahnville
Destrehan
Luling
Boutte
Paradis
Kraemer
Des Allemands
Westgate
Willowdale
Harahan
Jefferson
Avondale
Westwego
Marrero
Harvey
Gretna
Terrytown
Belle Chasse
Arabi
Chalmette
Meraux
Dalcour
Little Woods
South Point
Lake St Catherine
Lake Cataouatche
Lake Salvador
Lac Des Allemands
To Baton Rouge
To Houma

# Problems Identified in Ivan

- *An over-reliance on the westward movement of traffic*
- *Confluence congestion created by the confluence of major evacuation routes in Baton Rouge, Hammond, Lafayette, Covington, and Slidell*
- *Inefficient loading of contraflow in New Orleans*
- *Inability to access up-to-date traffic information and provide timely and accurate traveler information to evacuees*

# New Orleans Contraflow Initiation Point



## *Hurricane Ivan Evacuation - Interstate 10 (west of New Orleans)*


***Photo Source: A. Caterella-Michel***
***Urban Systems, Inc.***

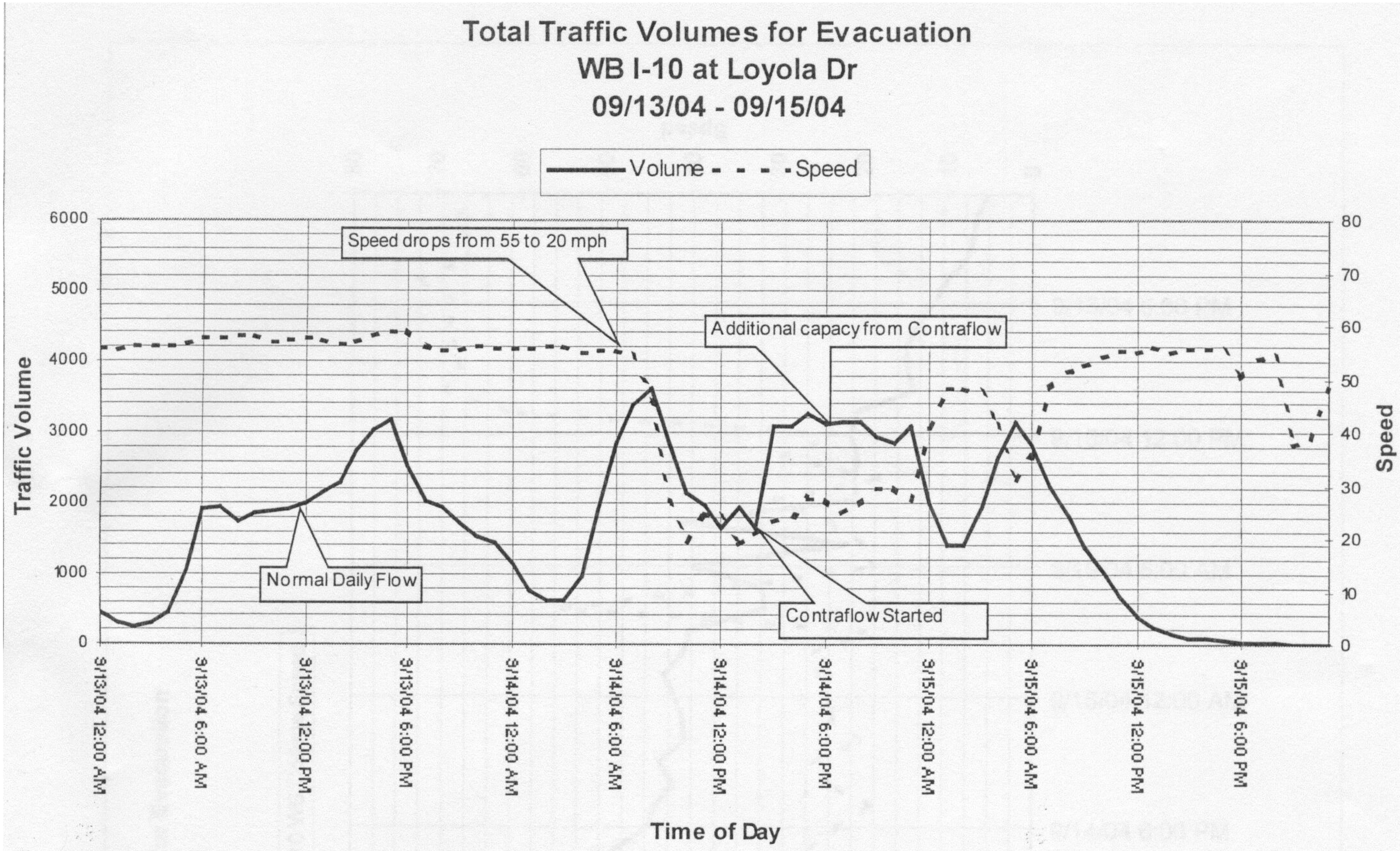
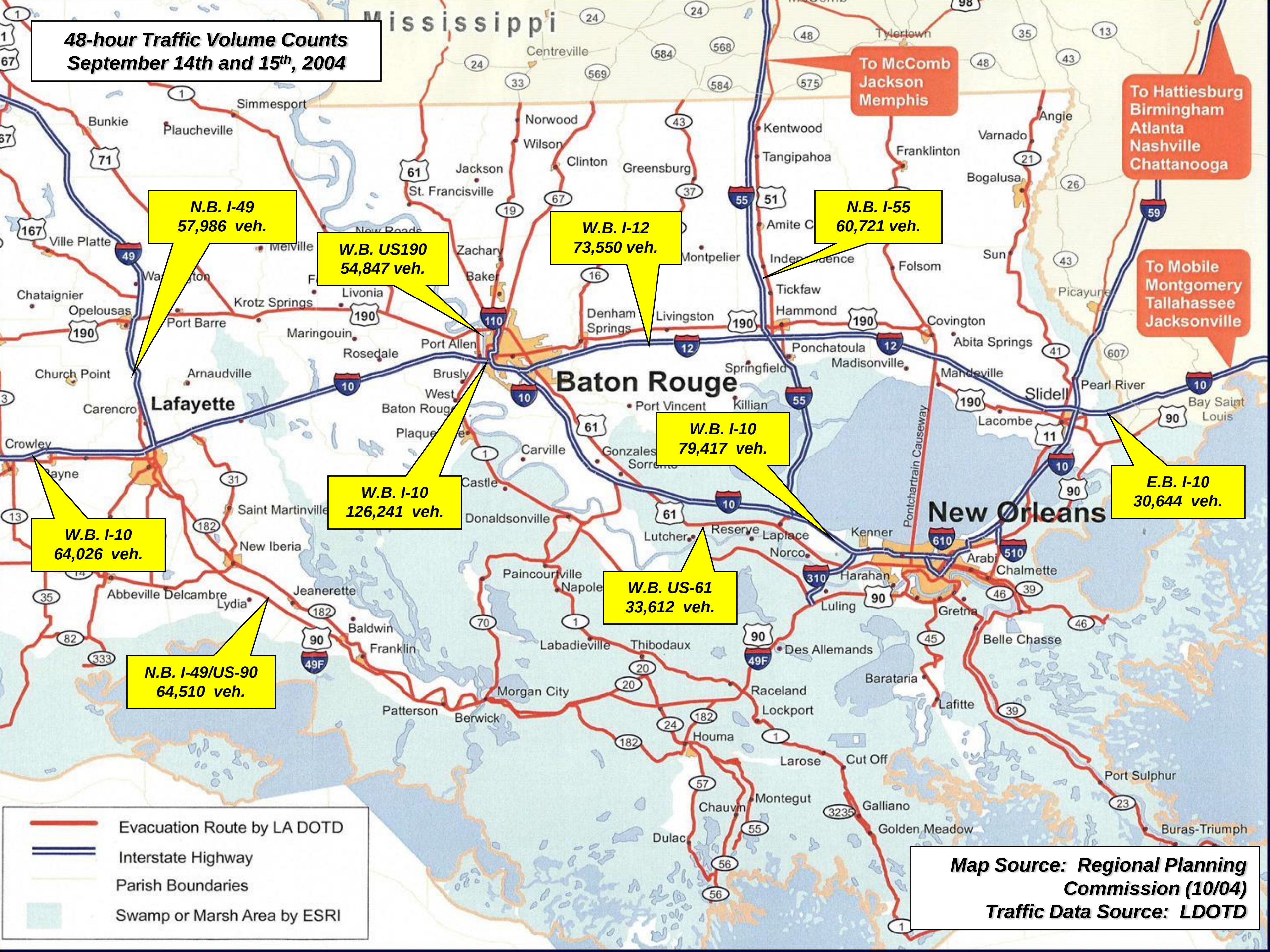



Figure Source: LaDOTD


48-hour Traffic Volume Counts
September 14th and 15th, 2004
N.B. I-49
57,986 veh.
W.B. US190
54,847 veh.
W.B. I-12
73,550 veh.
N.B. I-55
60,721 veh.
W.B. I-10
79,417 veh.
W.B. I-10
126,241 veh.
E.B. I-10
30,644 veh.
W.B. I-10
64,026 veh.
W.B. US-61
33,612 veh.
N.B. I-49/US-90
64,510 veh.
To McComb
Jackson
Memphis
To Hattiesburg
Birmingham
Atlanta
Nashville
Chattanooga
To Mobile
Montgomery
Tallahassee
Jacksonville
Mississippi
Baton Rouge
New Orleans
Lafayette
Evacuation Route by LA DOTD
Interstate Highway
Parish Boundaries
Swamp or Marsh Area by ESRI
Map Source: Regional Planning Commission (10/04)
Traffic Data Source: LDOTD

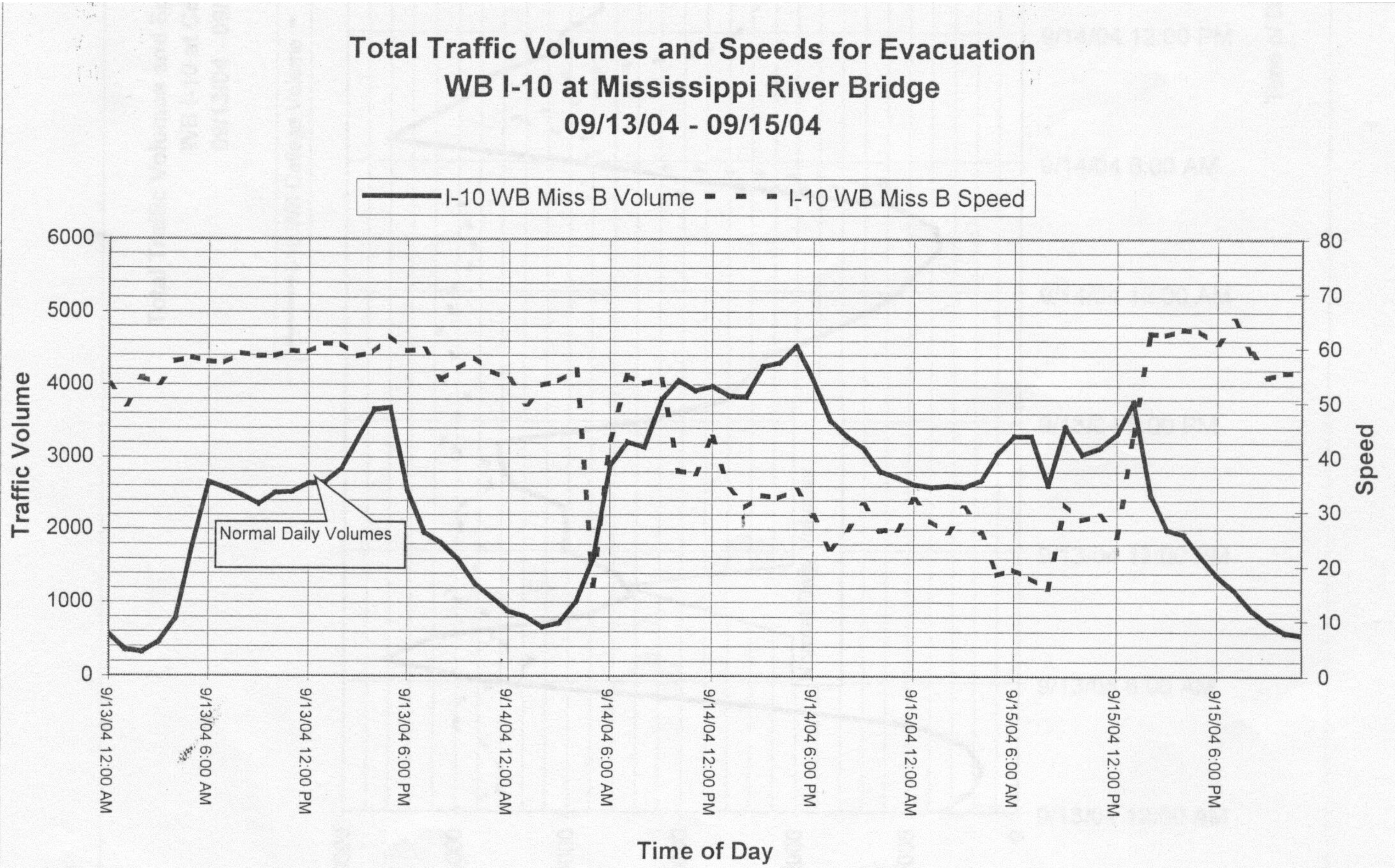



Figure Source: LaDOTD

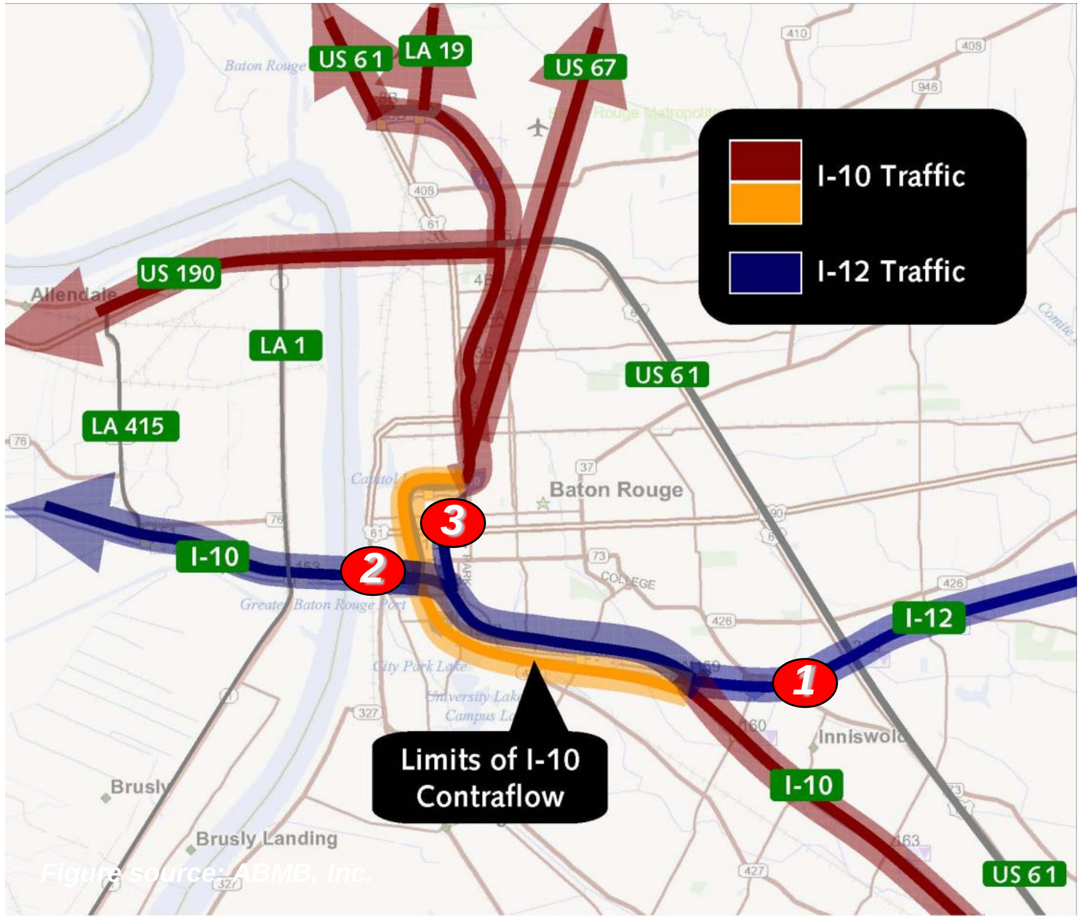
# *Proposed Solutions*

- ***Maximize the available routes out of the New Orleans area***
- ***Improve the loading of contraflow segments in New Orleans***
- ***Mitigate (eliminate?) the congestion in Baton Rouge***
- ***Inability to access up-to-date traffic information and provide timely and accurate traveler information to evacuees***

# New Orleans Alternatives

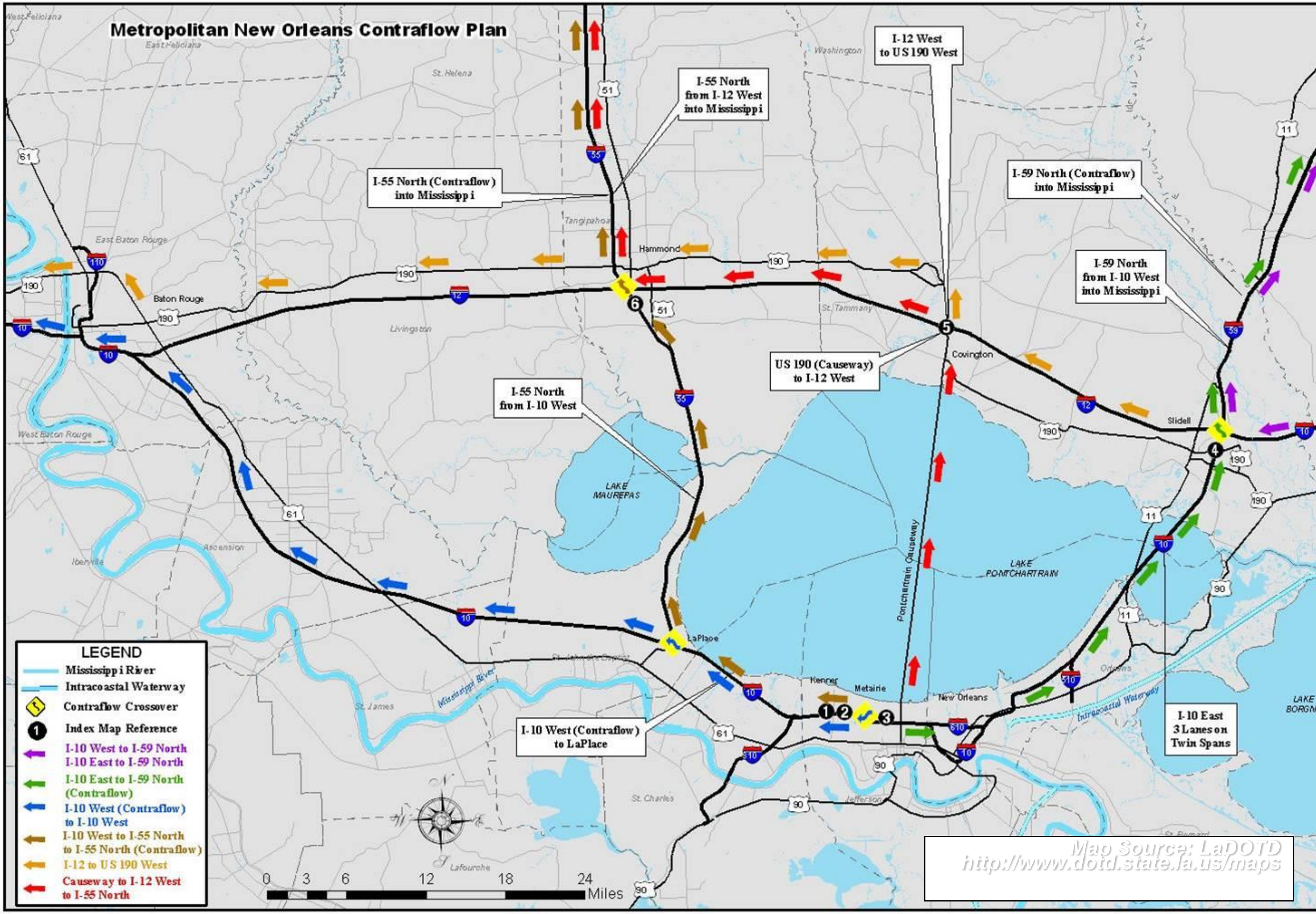

| Scenario | 12h volume at max. flow | Evacuees moved | Increase over no-c/f |
|---|---|---|---|
| *Ivan w/o contraflow* | *49,464 veh* | *123,660 people* | *-----* |
| *Ivan w/contraflow* | *67,224 veh* | *168,060 people* | *35.9%* |
| *I-10/I-610 Loading Plan* | *97,572 veh* | *243,930 people* | *97.3%* |

# Baton Rouge Alternatives




| Location | Ivan – Speed | Flow Rate | w/Contraflow – Speed | Flow Rate |
|---|---|---|---|---|
| 1 *I-12 (bef. interchange)* | *16 mph* | *2,834 vph* | *56 mph* | *5,422 vph* |
| 2 *I-10 (MS River Bridge)* | *28 mph* | *4,029 vph* | *22 mph* | *4,399 vph* |
| 3 *I-110 (aft. interchange)* | *48 mph* | *2,067 vph* | *55 mph* | *3,701 vph* |

# *The Plan and Its Effects*


Metropolitan New Orleans Contraflow Plan
I-12 West
to US 190 West
I-55 North
from I-12 West
into Mississippi
I-55 North (Contraflow)
into Mississippi
I-59 North (Contraflow)
into Mississippi
I-59 North
from I-10 West
into Mississippi
US 190 (Causeway)
to I-12 West
I-55 North
from I-10 West
I-10 West (Contraflow)
to LaPlace
I-10 East
3 Lanes on
Twin Spans
LAKE MAUREPAS
LAKE PONTCHARTRAIN
LAKE BORGNE
Pontchartrain Causeway
Hammond
Baton Rouge
Covington
Slidell
LaPlace
Kenner
Metairie
New Orleans
Intracoastal Waterway
Mississippi River
LEGEND
Mississippi River
Intracoastal Waterway
Contraflow Crossover
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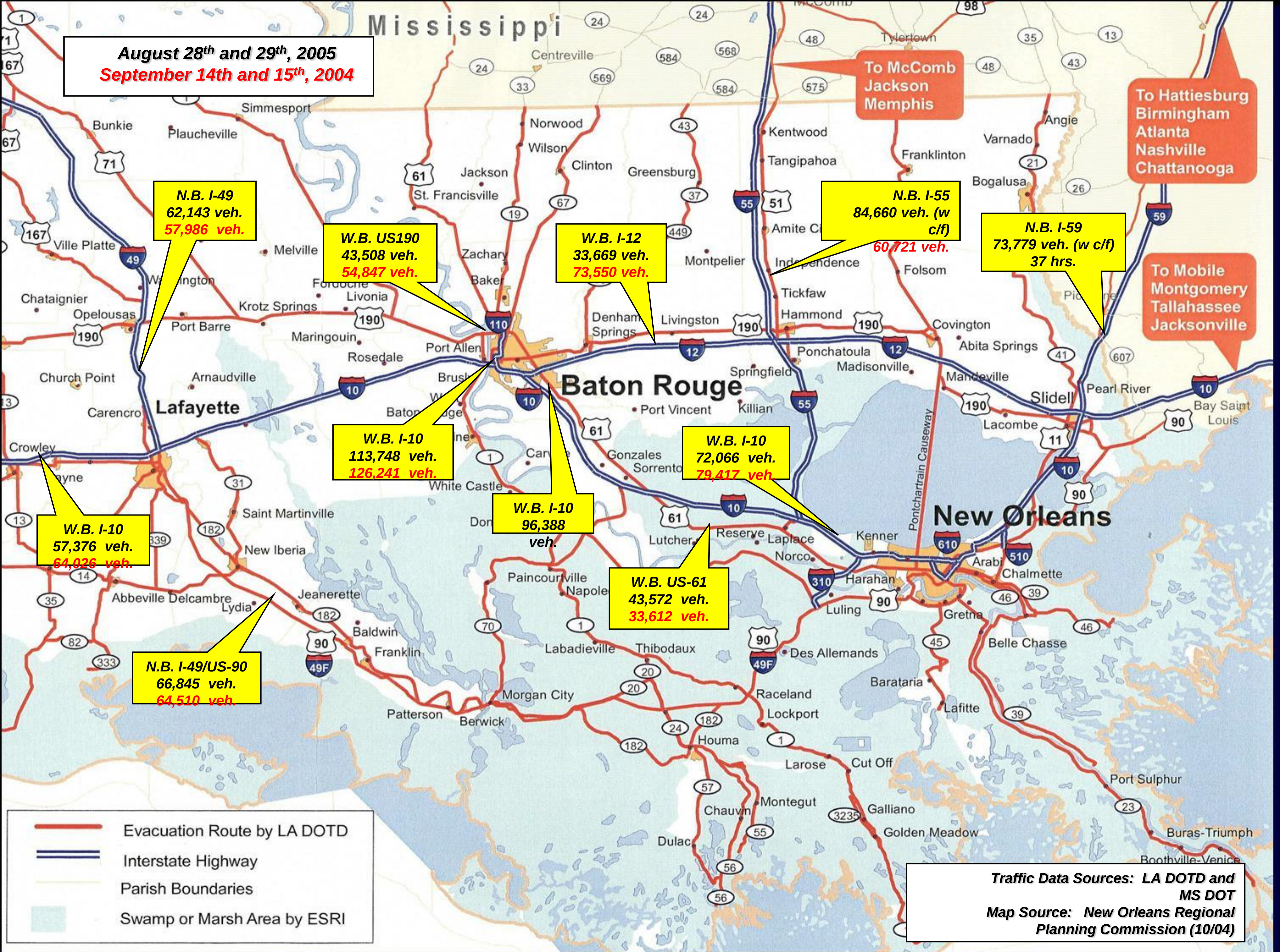
I-10 East to I-59 North
I-10 East to I-59 North (Contraflow)
I-10 West (Contraflow) to I-10 West
I-10 West to I-55 North to I-55 North (Contraflow)
I-12 to US 190 West
Causeway to I-12 West to I-55 North
0 3 6 12 18 24
Miles
Map Source: LaDOTD
http://www.dotd.state.la.us/maps



August 28th and 29th, 2005
September 14th and 15th, 2004
N.B. I-49
62,143 veh.
57,986 veh.
W.B. US190
43,508 veh.
54,847 veh.
W.B. I-12
33,669 veh.
73,550 veh.
N.B. I-55
84,660 veh. (w c/f)
60,721 veh.
N.B. I-59
73,779 veh. (w c/f)
37 hrs.
To McComb
Jackson
Memphis
To Hattiesburg
Birmingham
Atlanta
Nashville
Chattanooga
To Mobile
Montgomery
Tallahassee
Jacksonville
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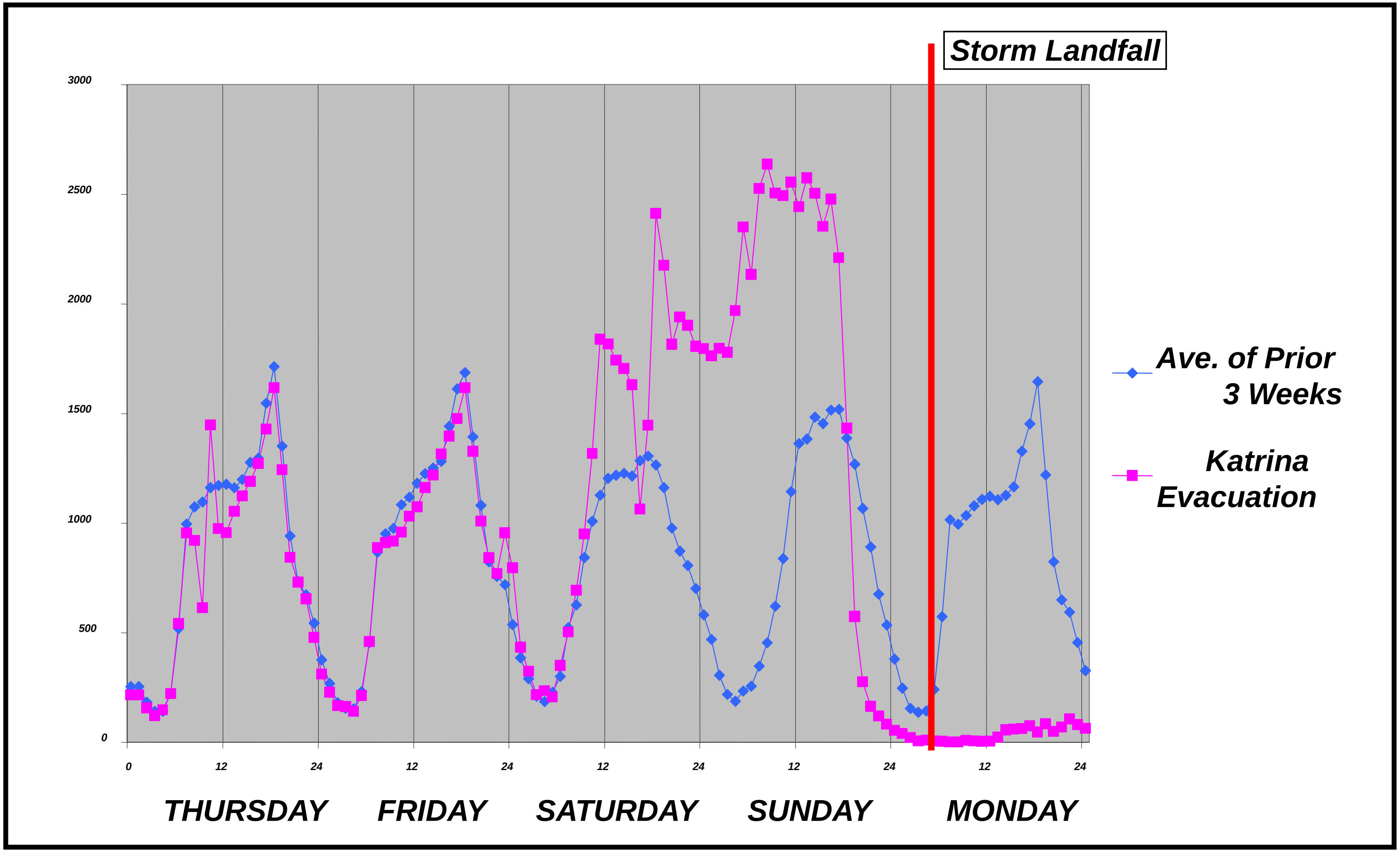
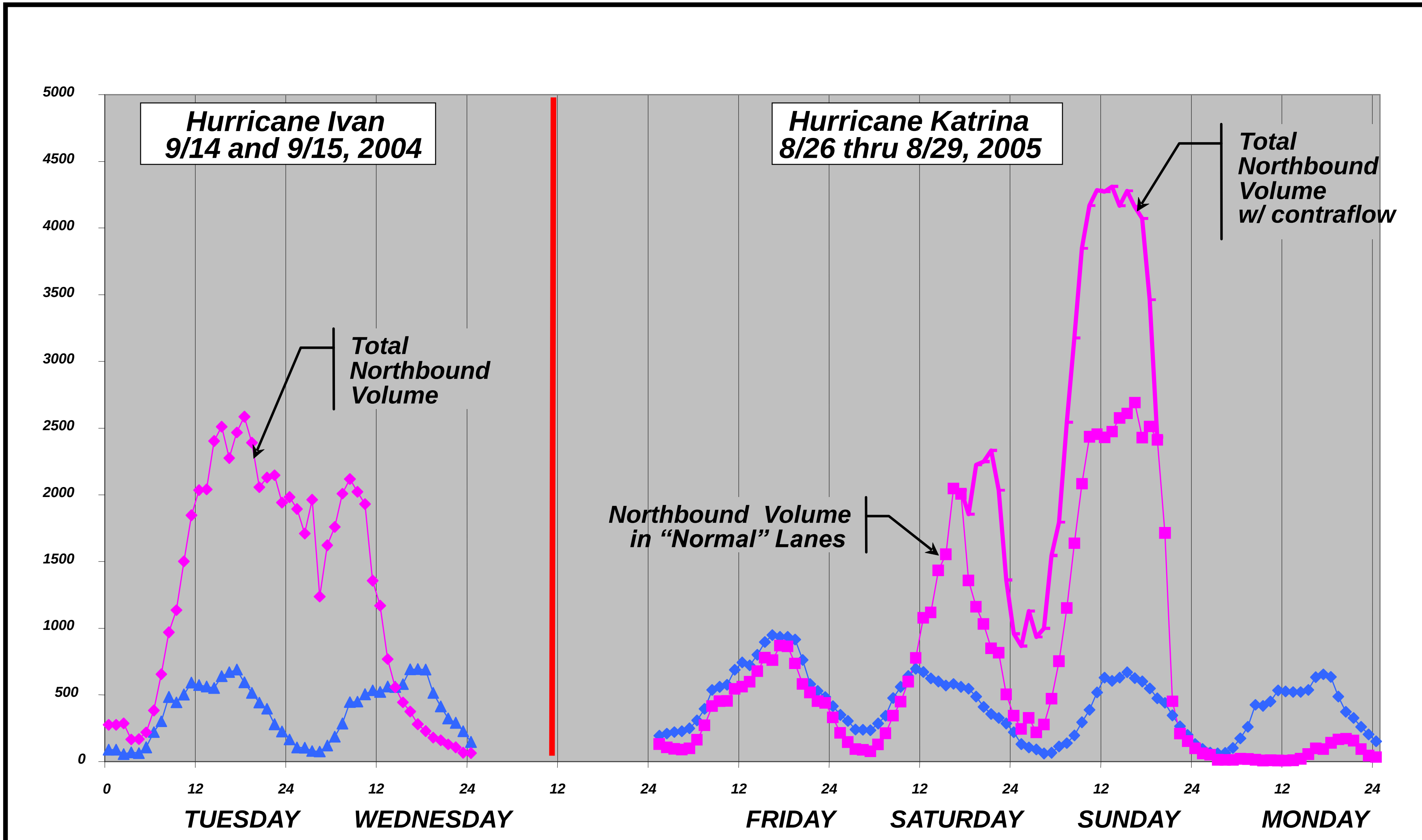
Mississippi
Baton Rouge
New Orleans
Lafayette
Evacuation Route by LA DOTD
Interstate Highway
Parish Boundaries
Swamp or Marsh Area by ESRI
Traffic Data Sources: LA DOTD and MS DOT
Map Source: New Orleans Regional Planning Commission (10/04)

# Duration of Evacuation Volume



# Effect of Contraflow on Traffic Volume



# Evacuation Traffic Control

# *Examples of Control Devices*

# *Examples of Control Devices*

# Texas EVACULANE Shoulders


***US 290***
***Houston to***
***Hempstead***

# Examples of Control Devices

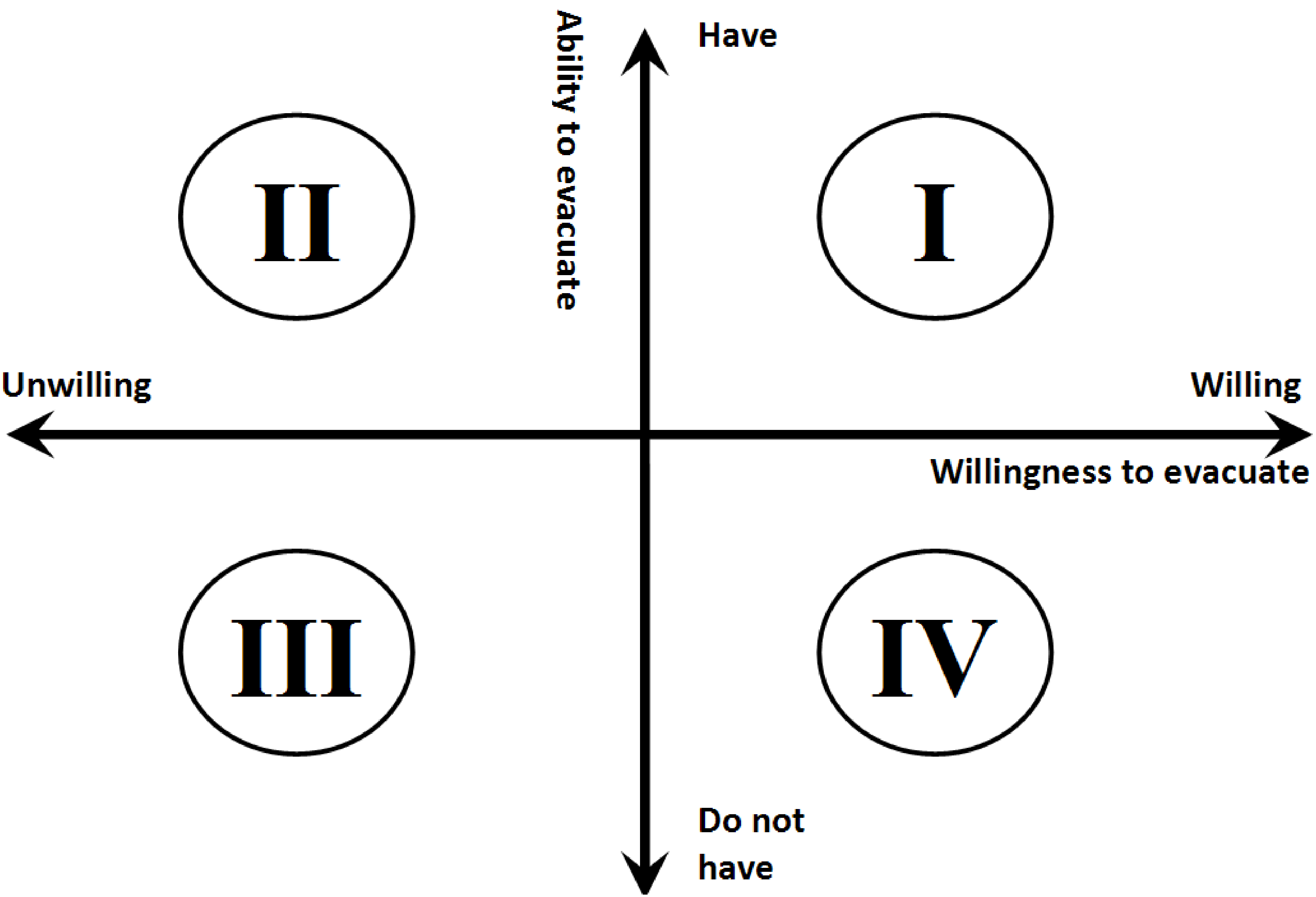
# *Variable Message Signs*

# Assisted Evacuations

# *“Low Mobility” Evacuees*

- ***Individuals without personal transportation, elderly, infirm, tourists, economically disadvantaged, prisoners, homeless, etc.***
- ***How many persons fit these description?***
- ***Where are they located?***
- ***Who are they and what are there needs? medicine, oxygen, dialysis, etc.***
- ***Who is responsible for them if they are unable to take of themselves?***
- ***Where do they go? How do they come back?***

# Evacuee Categorization



# *Problems of Low Mobility Evacuation Planning*

- ***Existing traffic/transportation simulation systems are not created to model evacuation conditions***
  - ***Scale (e.g., number of vehicles)***
  - ***Scope (e.g. duration, geographic area)***
- ***Existing models do not permit the modeling and simulation of multiple modes of transportation simultaneously***
- ***Most models are not able to give analysts the MOE's they'd like or decision-makers the answers to questions they pose***
- ***Limited understanding and development of underlying behaviors of evacuation travel for different evacuee and mode types***

# *Problems of Modeling Evacuation Transportation Plans*

- ***Existing traffic/transportation simulation systems are not created to model evacuation conditions***
  - ***Scale (e.g., number of vehicles)***
  - ***Scope (e.g. duration, geographic area)***
- ***Existing models do not permit the modeling and simulation of multiple modes of transportation simultaneously***
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# Recognized Limitations

- ***Existing traffic/transportation simulation systems are not created to model evacuation conditions***
  - *Scale (e.g., number of vehicles)*
  - *Scope (e.g. duration, geographic area)*
- ***Existing models do not permit the modeling and simulation of multiple modes of transportation simultaneously***
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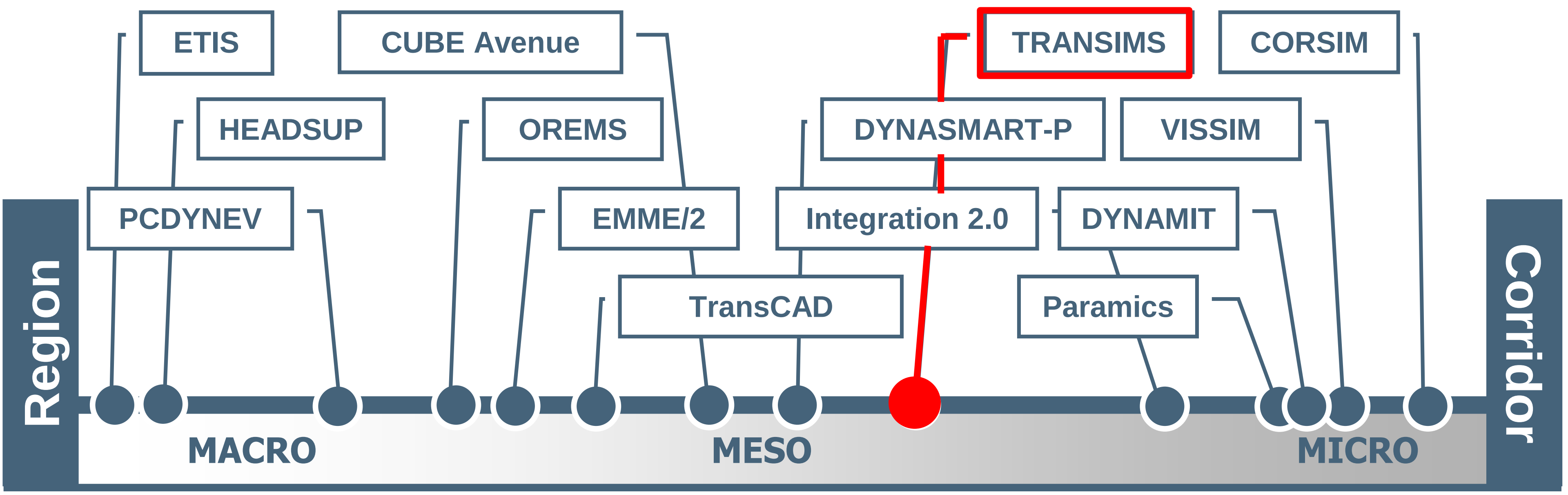
- ***Limited understanding and development of underlying behaviors of evacuation travel for different evacuee and mode types***

# Evacuation Modeling

# Evacuation Modeling Spectrum




*From: "Structuring Modeling and Simulation Analyses for Evacuation Planning and Operations"*

*By: Hardy, Wunderlich, Bunchand, and Smith*

# *Current Research*

- ***Application of the TRANSIMS system***
- ***Can be used to model very large geographical regions and large numbers of travelers***
- ***Effort and expertise required to code and run***
- ***Issues of verification, validation, and calibration***
- ***Hardware and software requirements***
- ***History, experience, and acceptance within the professional transportation community***
- ***Not developed for the purpose of evacuation***

# Evacuation Traffic Simulation

- *Has proven value*
- *Permits bottlenecks to be identified and potential solutions to be analyzed before they become problems*
- *Gives quantitative MOE results to decision-makers*
- *Allows effects of alternative strategies and adverse conditions to be assessed without consequence*

# Recognized Limitations

- *Existing traffic/transportation simulation systems are not created to model evacuation conditions*
  - *Scale (e.g., number of vehicles)*
  - *Scope (e.g. duration, geographic area)*
- *Existing models do not permit the modeling and simulation of multiple modes of transportation simultaneously*
- *Most models are not able to give analysts the MOE’s they’d like or decision-makers the answers to questions they pose*
- *Limited understanding and development of underlying behaviors of evacuation travel for different evacuee and mode types*

# TRANSIMS Project

# TRANSIMS System

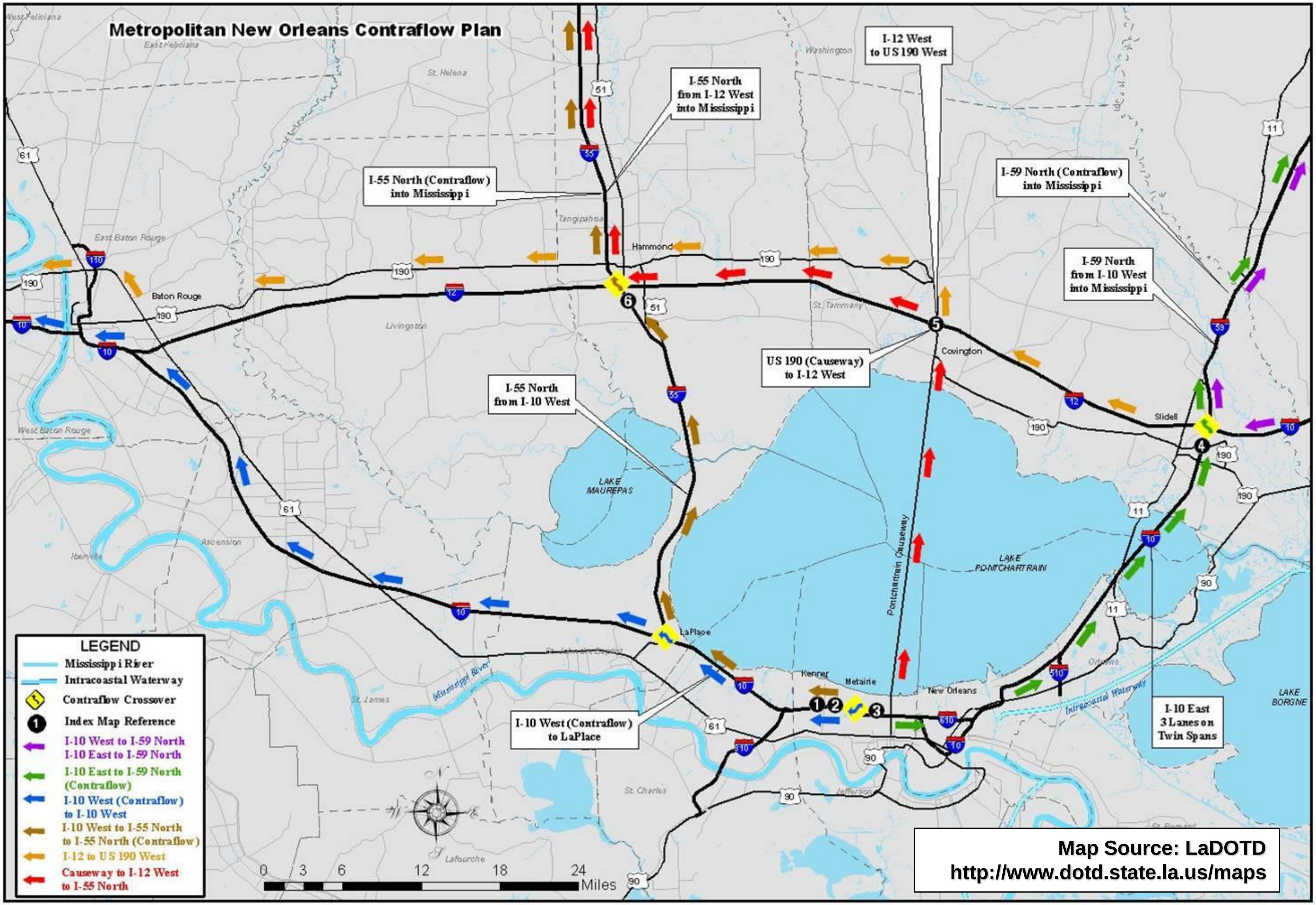
- *Incorporates aspects of planning and operations*
- *Model large geographical regions and large numbers of travelers*
- *Model populations, travel activities, routing, and analyses it with a microsimulator*
- *Open source and available*
- *Effort and expertise required to code and run*
- *Issues of verification, validation, and calibration*
- *Hardware and software requirements*
- *History, experience, and acceptance within the professional transportation community*
- *Not developed for the purpose of evacuation*

# TRANSIMS Structure

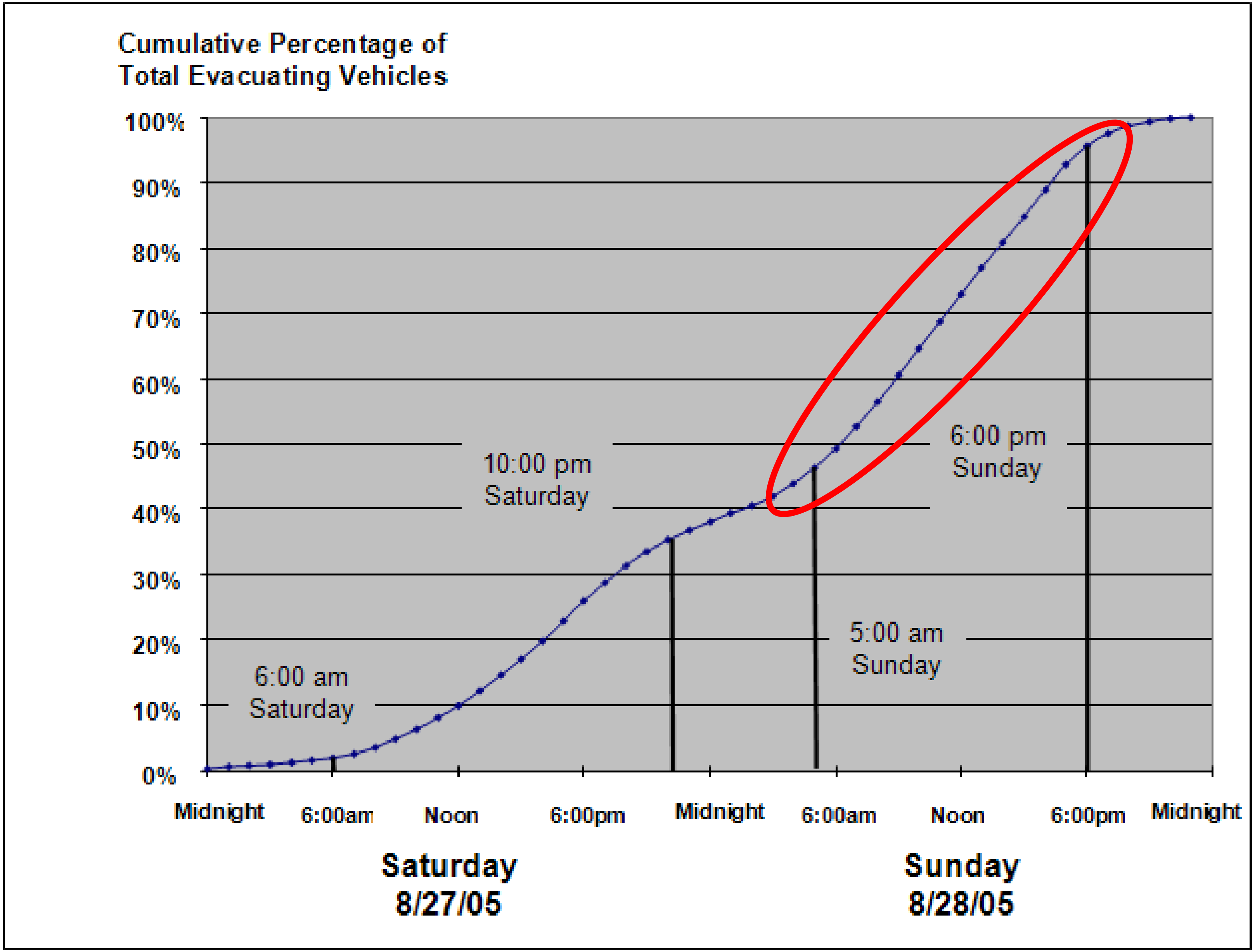
- *Network Input*
  - *Structure and characteristics of the transportation network (control, capacity, etc.) and activity locations*
- *Population Synthesizer*
  - *Creates a disaggregate synthetic population based on aggregate census zonal information*
- *Activity Generator*
  - *Travel surveys or observation of past evacuations*
- *Router*
  - *Spatial and temporal travel behavior and route assignments*
- *Microsimulator*
  - *Tracks and compiles movements and statistics of each agent (vehciles & peds)*
- *Visualizer*
  - *3rd party developer Balfour Technologies Inc.*

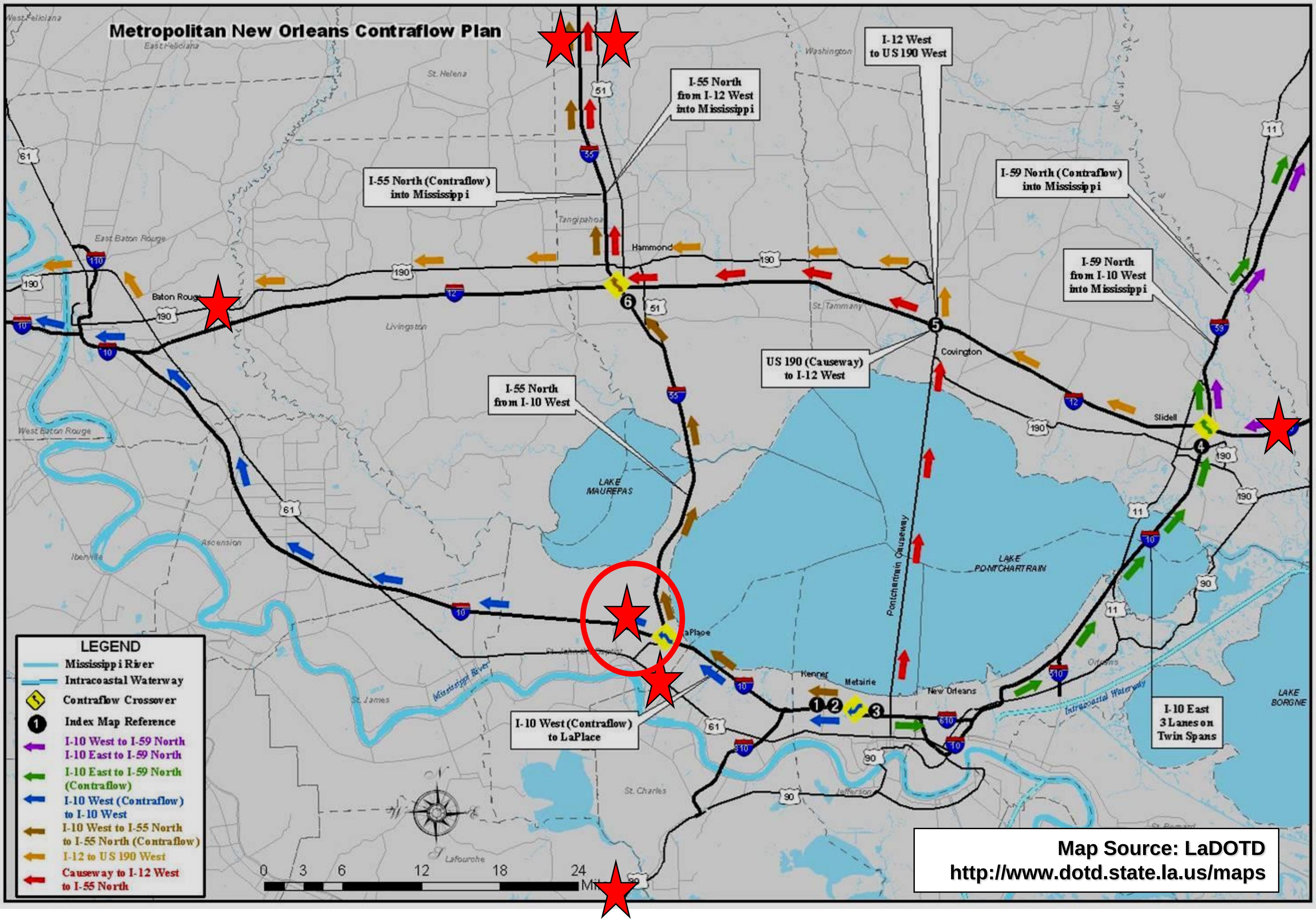
# LSU Study - Approach

- Step 1 – Network development
- Step 2 - “Base Model” validation and calibration based on 2005 Katrina evacuation
- Step 3 - Code “New” New Orleans multimodal plan
- Step 4 - “Base Model” validation and calibration based on 2005 Katrina evacuation
- Step 5 - Code and test alternative plans and ideas




Map Source: LaDOTD
http://www.dotd.state.la.us/maps


Cumulative Percentage of
Total Evacuating Vehicles
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
6:00 am
Saturday
10:00 pm
Saturday
5:00 am
Sunday
6:00 pm
Sunday
Midnight
6:00am
Noon
6:00pm
Midnight
6:00am
Noon
6:00pm
Midnight
Saturday
8/27/05
Sunday
8/28/05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I-12 West
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LaPlace
Livingston
St. Tammany
Tangipahoa
Washington
St. Helena
East Feliciana
West Feliciana
East Baton Rouge
West Baton Rouge
Ascension
Iberville
St. James
St. Charles
Jefferson
Orleans
St. Bernard
Lafourche
LEGEND
Mississippi River
Intracoastal Waterway
Contraflow Crossover
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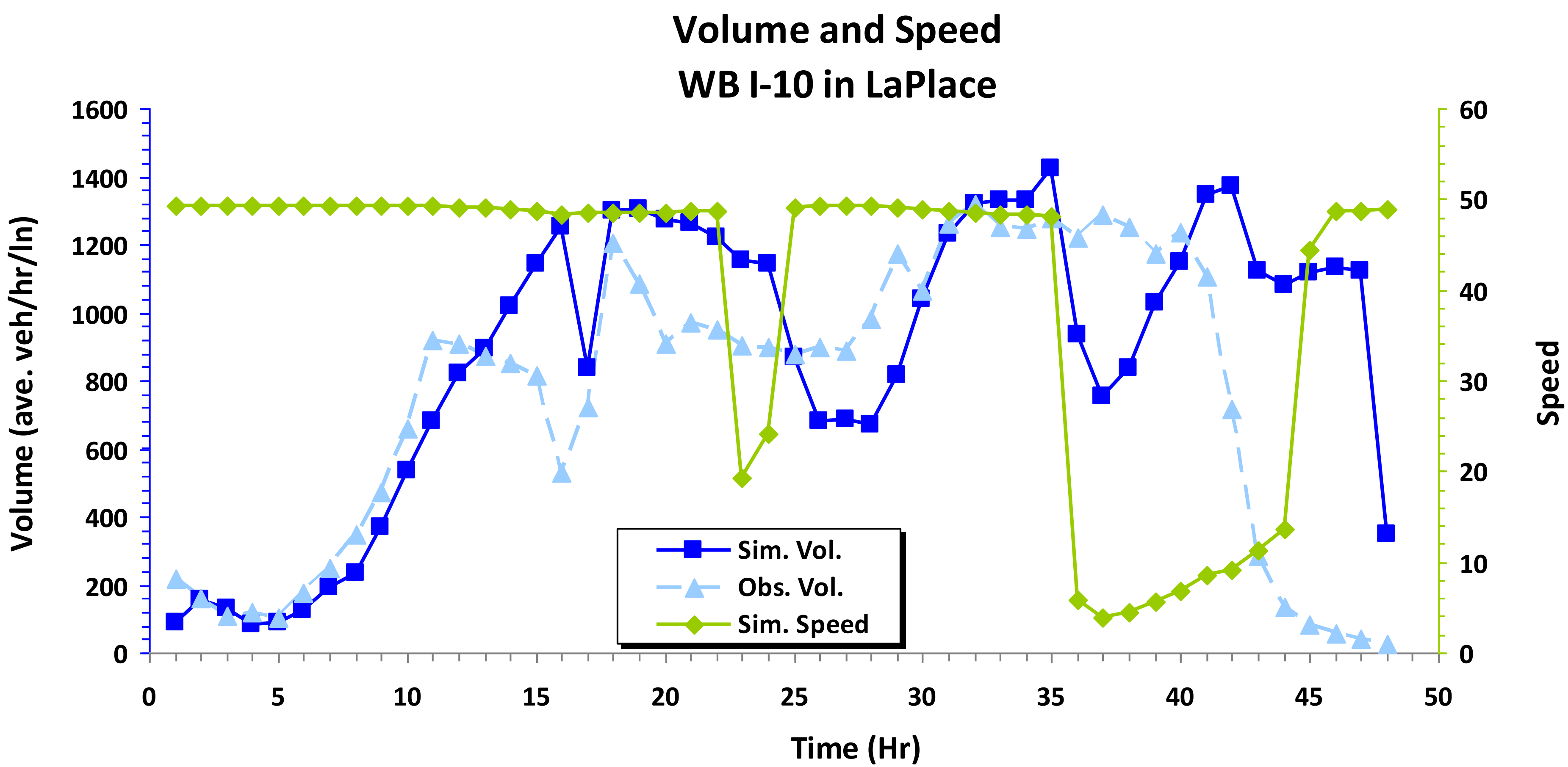
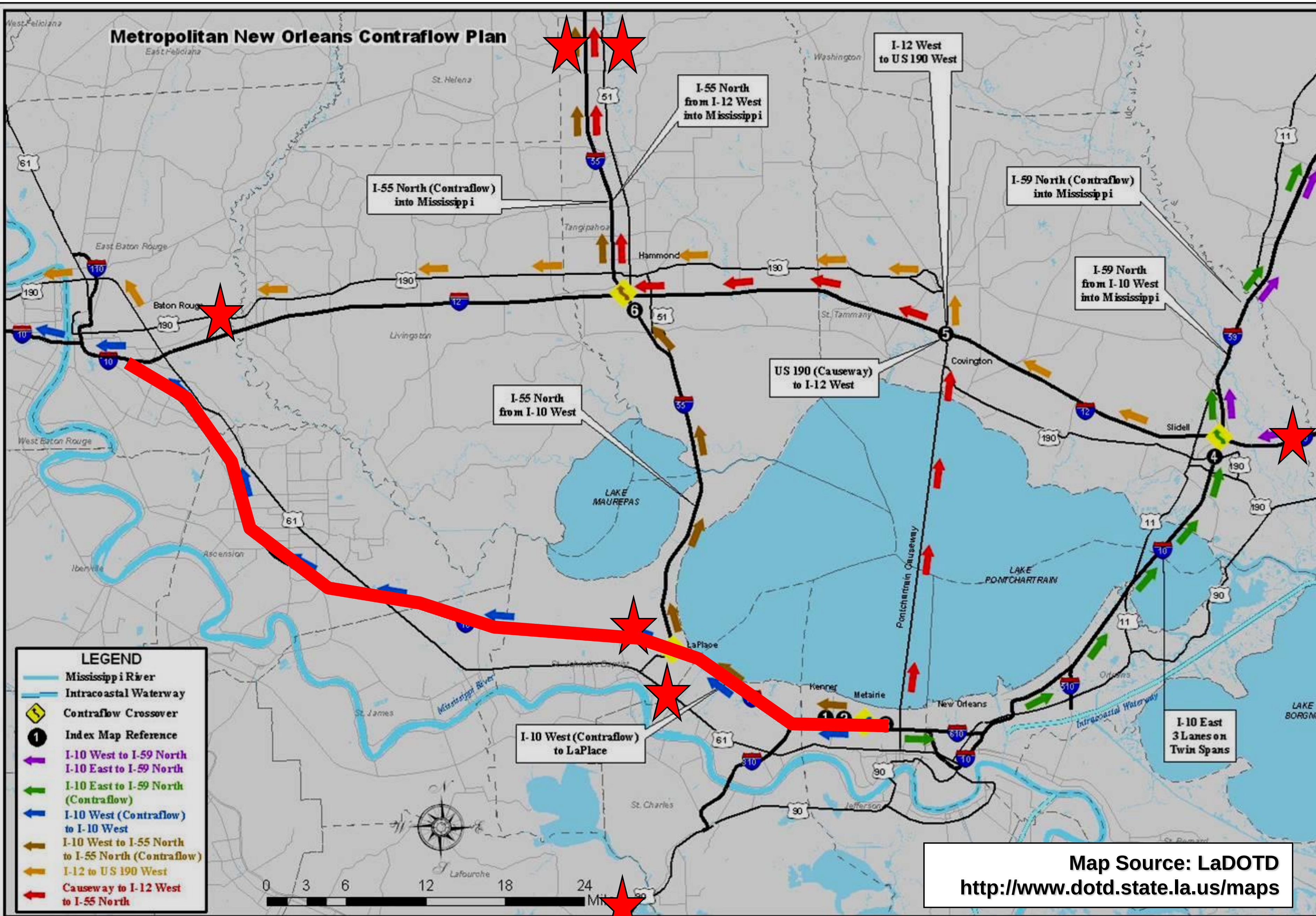
I-10 East to I-59 North
I-10 East to I-59 North (Contraflow)
I-10 West (Contraflow) to I-10 West
I-10 West to I-55 North to I-55 North (Contraflow)
I-12 to US 190 West
Causeway to I-12 West to I-55 North
0 3 6 12 18 24 Miles
Map Source: LaDOTD
http://www.dotd.state.la.us/maps




Network Link 58296 (DOTD Station 54 --2 miles W of US 51/I-55 Jct)



Metropolitan New Orleans Contraflow Plan
I-55 North (Contraflow) into Mississippi
I-55 North from I-12 West into Mississippi
I-12 West to US 190 West
I-59 North (Contraflow) into Mississippi
I-59 North from I-10 West into Mississippi
US 190 (Causeway) to I-12 West
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I-10 East 3 Lanes on Twin Spans
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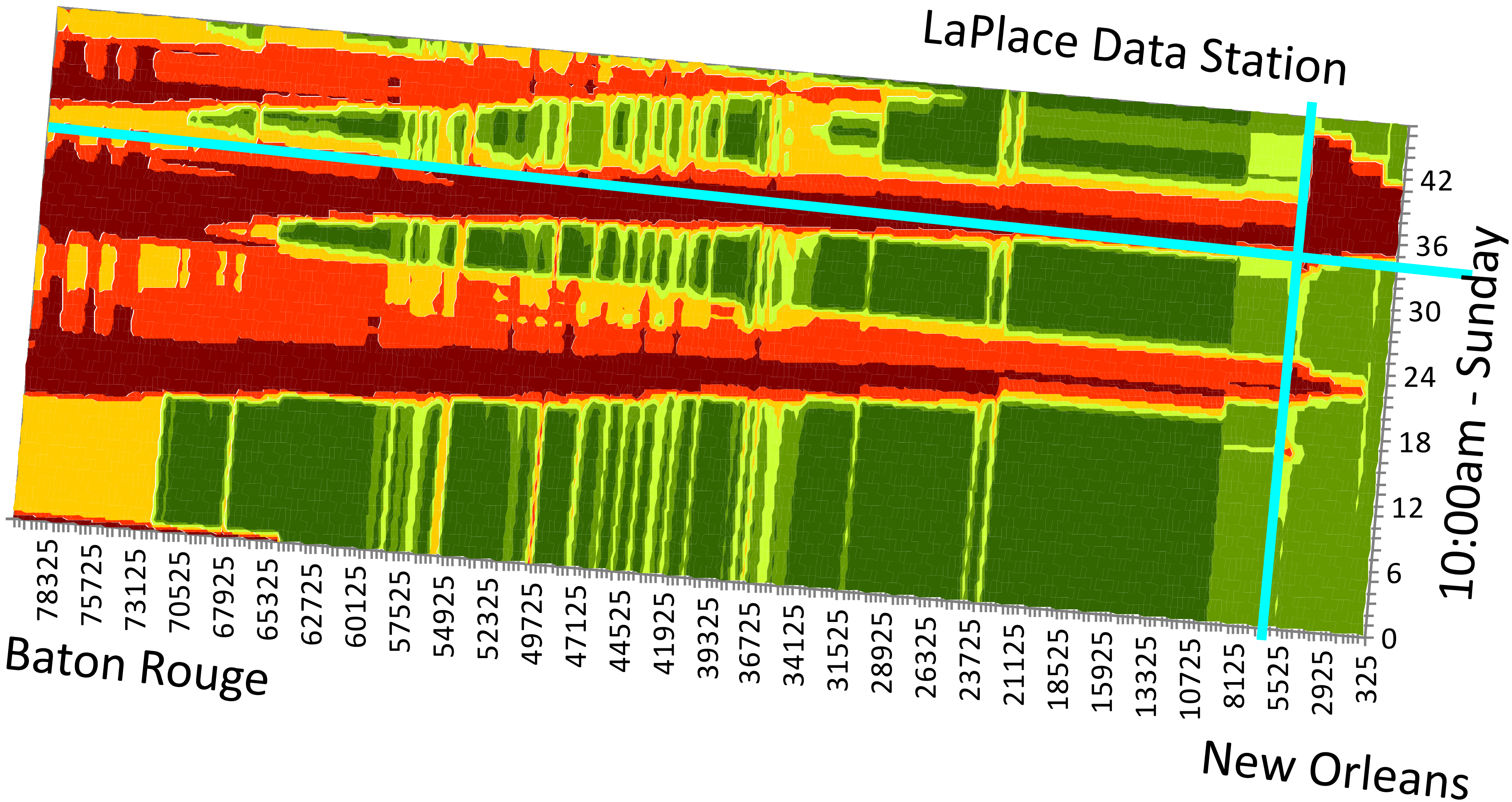
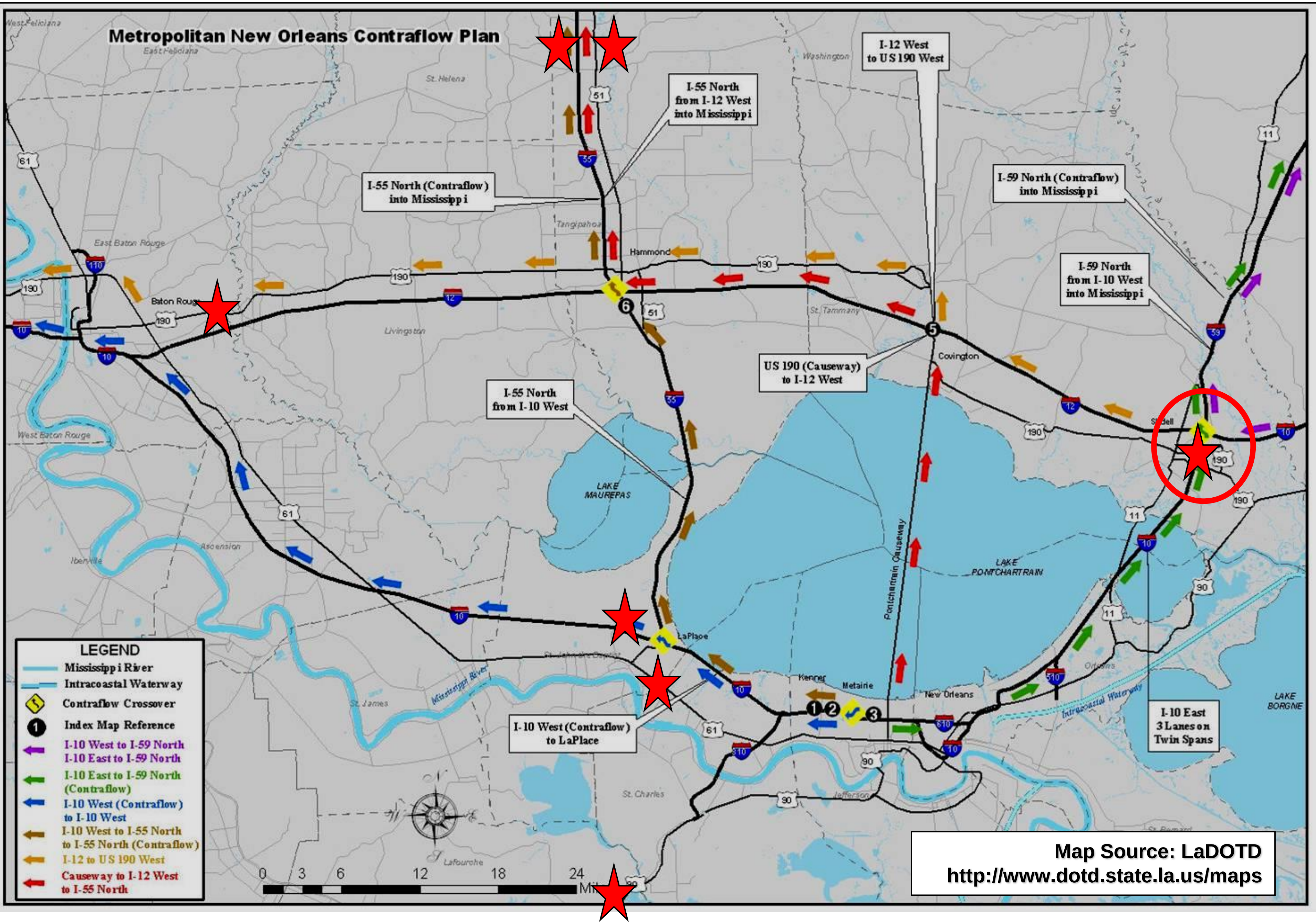
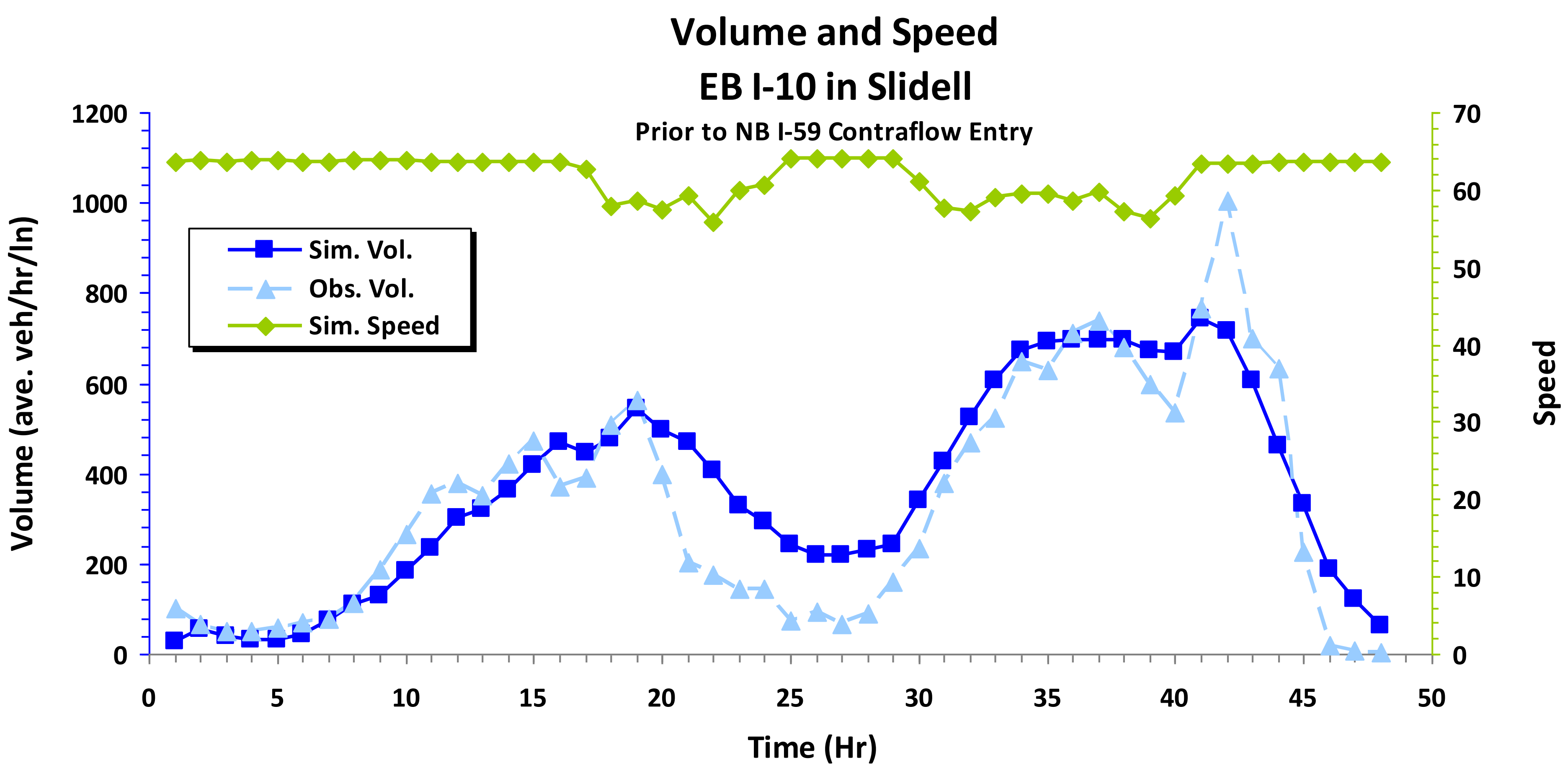
I-10 West (Contraflow) to I-10 West
I-10 West to I-55 North to I-55 North (Contraflow)
I-12 to US 190 West
Causeway to I-12 West to I-55 North
0 3 6 12 18 24 Miles
Map Source: LaDOTD
http://www.dotd.state.la.us/maps



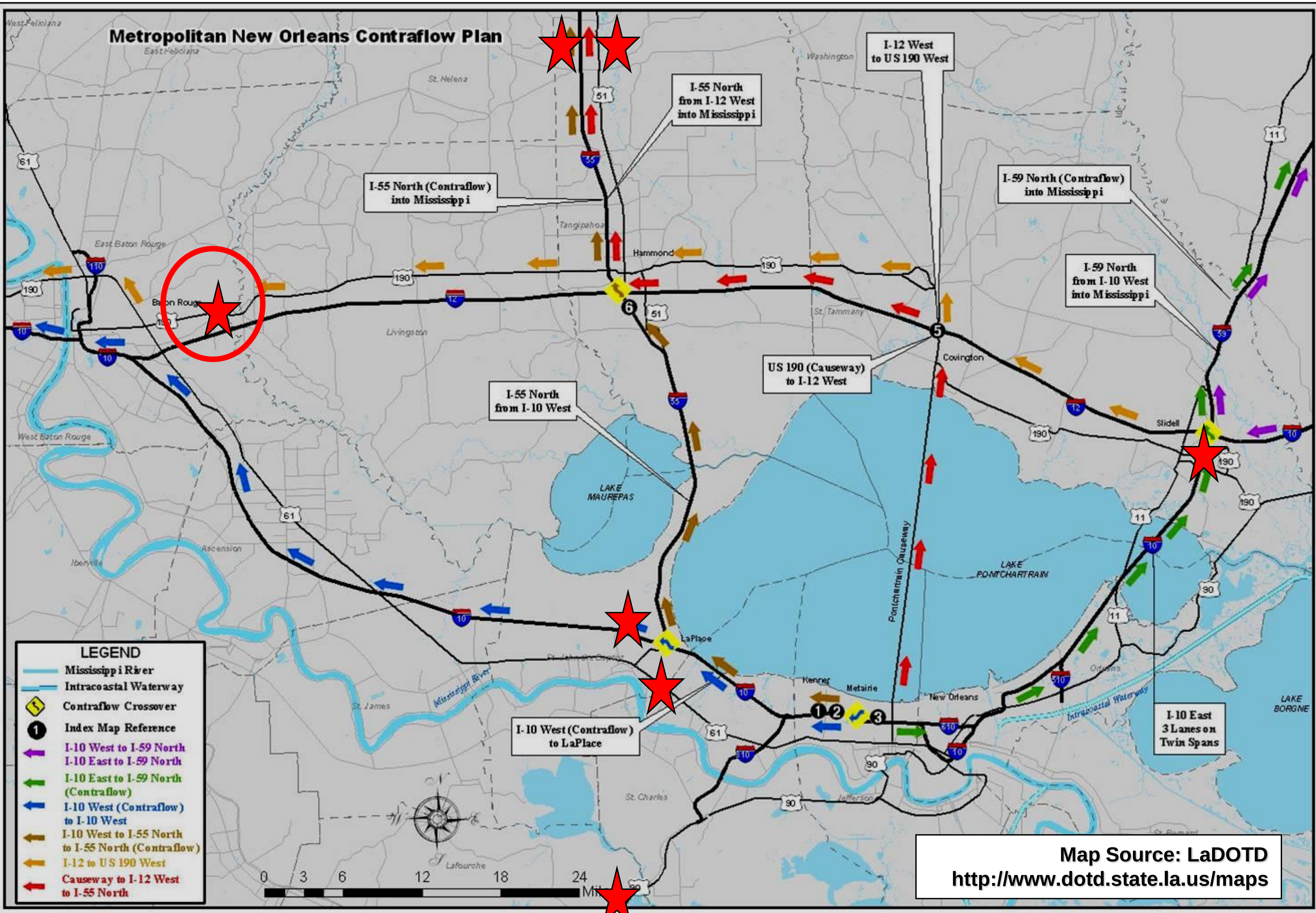

# Westbound I-10 Traffic Speed

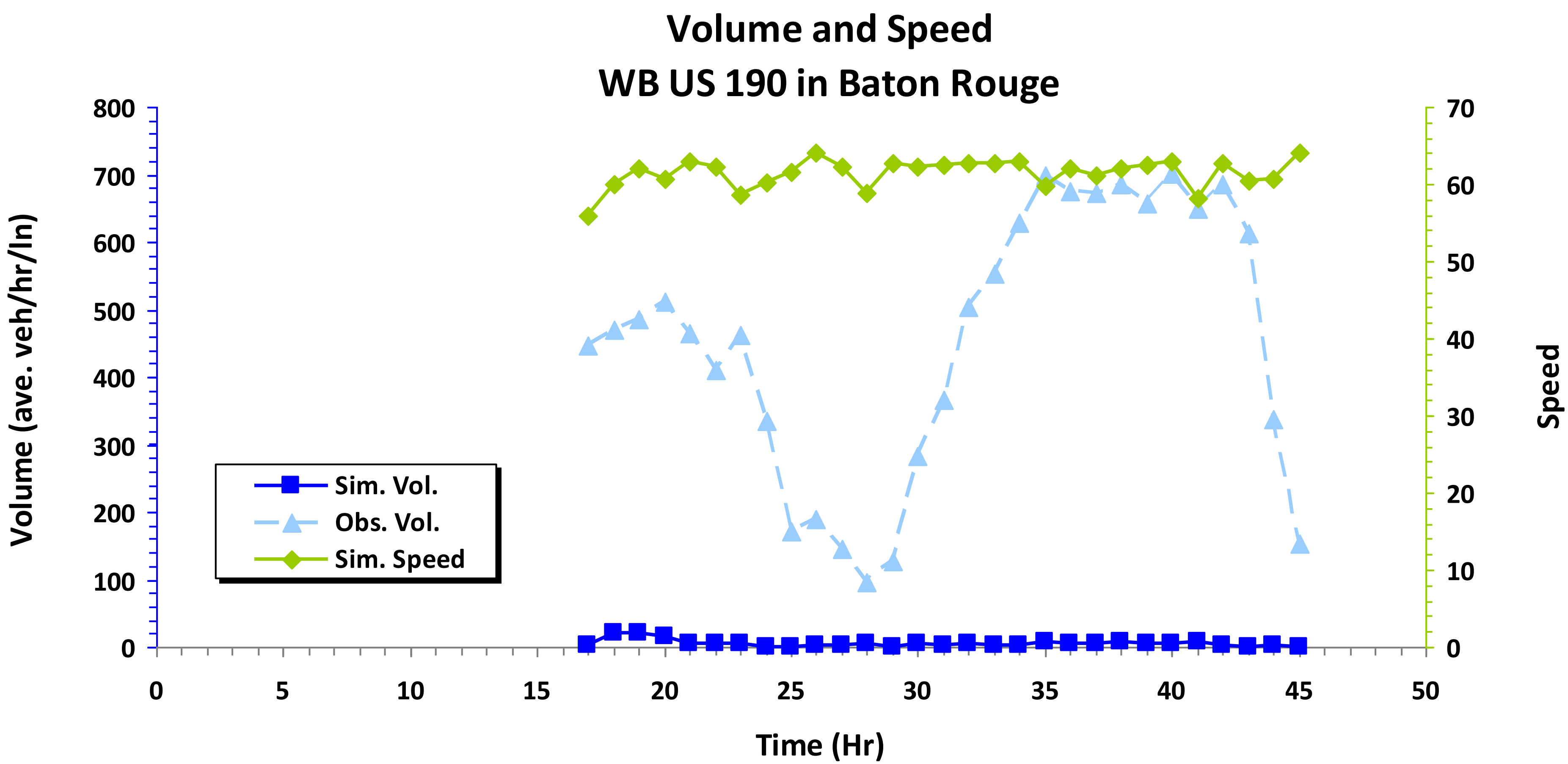


Map Source: LaDOTD
http://www.dotd.state.la.us/maps

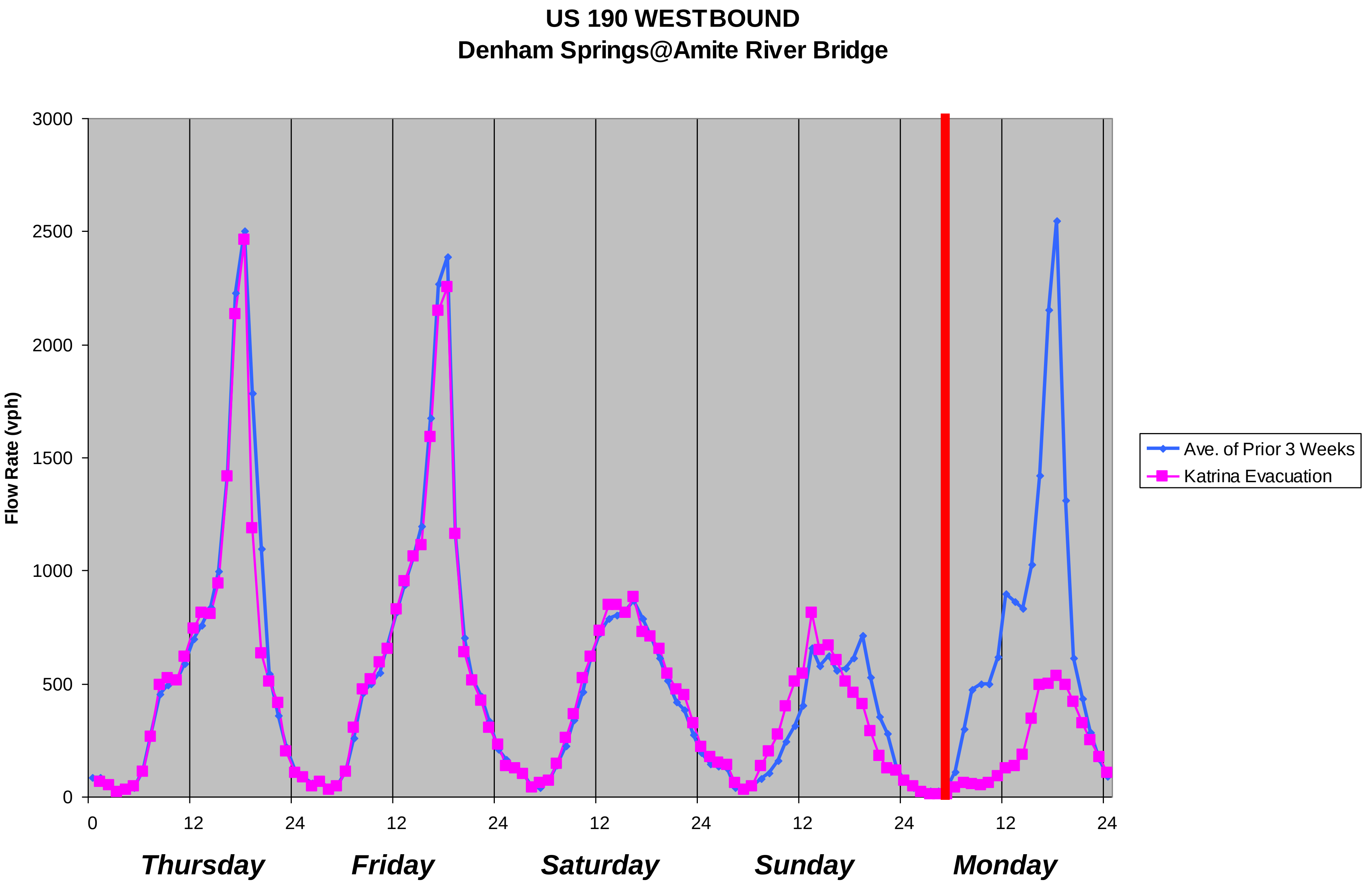



Network Link 56039 (Near DOTD Station 67 -- 1 mile S of I-12 , I-59 Jct)


Metropolitan New Orleans Contraflow Plan
I-55 North from I-12 West into Mississippi
I-12 West to US 190 West
I-55 North (Contraflow) into Mississippi
I-59 North (Contraflow) into Mississippi
I-59 North from I-10 West into Mississippi
US 190 (Causeway) to I-12 West
I-55 North from I-10 West
I-10 West (Contraflow) to LaPlace
I-10 East 3 Lanes on Twin Spans
LEGEND
Mississippi River
Intracoastal Waterway
Contraflow Crossover
Index Map Reference
I-10 West to I-59 North
I-10 East to I-59 North
I-10 East to I-59 North (Contraflow)
I-10 West (Contraflow) to I-10 West
I-10 West to I-55 North to I-55 North (Contraflow)
I-12 to US 190 West
Causeway to I-12 West to I-55 North
0 3 6 12 18 24 Miles
Baton Rouge
Hammond
Covington
Slidell
LaPlace
Kenner
Metairie
New Orleans
LAKE MAUREPAS
LAKE PONTCHARTRAIN
LAKE BORGNE
Pontchartrain Causeway
Map Source: LaDOTD
http://www.dotd.state.la.us/maps




Network Link 57784 (DOTD Station 18 -- 1.1 miles E of O'Neal Ln Jct)



US 190 WESTBOUND
Denham Springs@Amite River Bridge
Flow Rate (vph)
3000
2500
2000
1500
1000
500
0
0
12
24
12
24
12
24
12
24
12
24
Thursday
Friday
Saturday
Sunday
Monday
Ave. of Prior 3 Weeks
Katrina Evacuation

# Conclusions

- ***Evidence that TRANSIMS can be an effective tool for evacuation modeling and planning***
- ***Constituent models can be useful in whole or when used separately***
- ***Development of the TRANSIMS model has added benefits beyond evacuation***
- ***User interface for coding and output results was cumbersome***

# Assisted Evacuation Modeling

# *Assisted Evacuations*

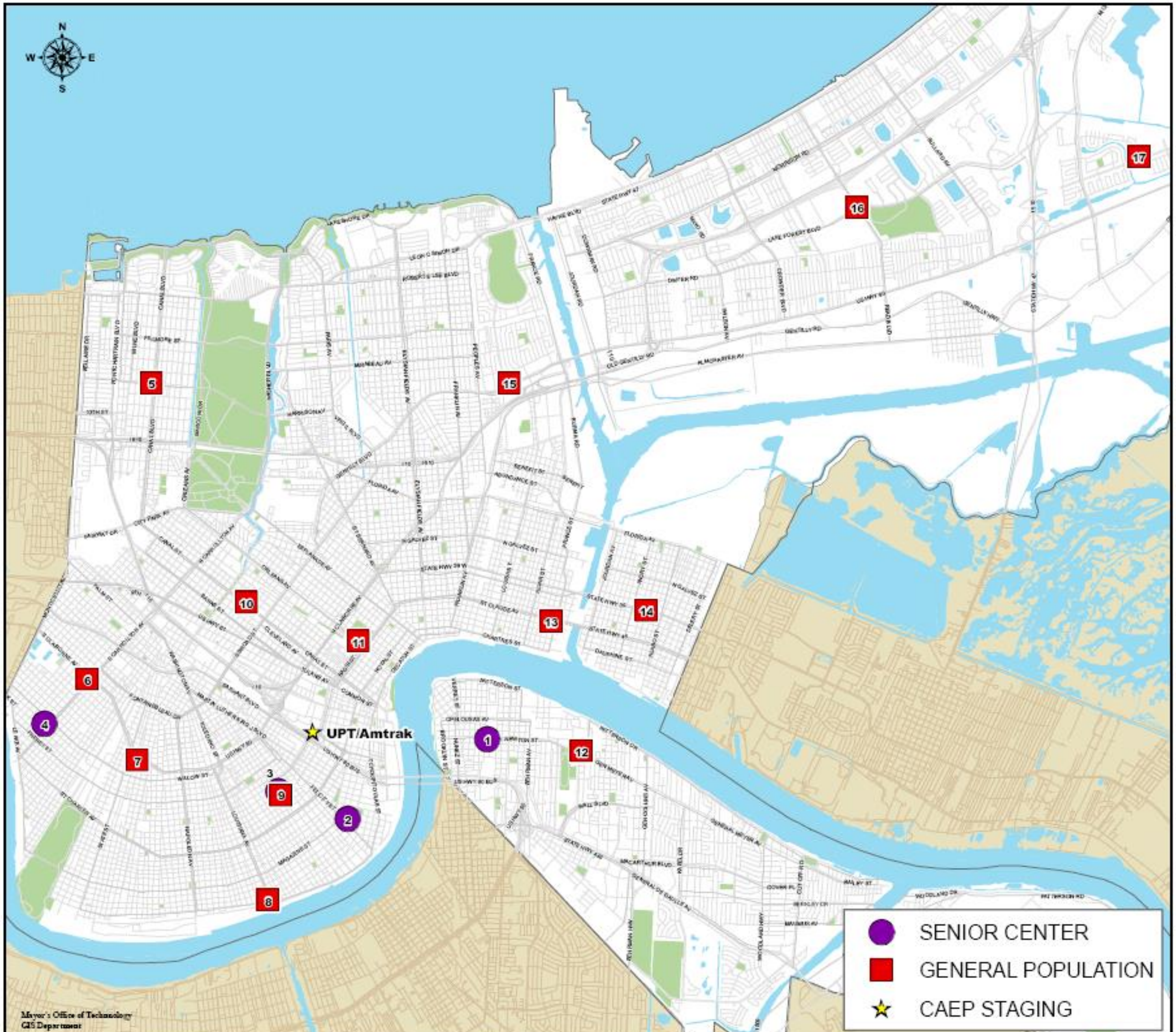
- ***Evacuation planning has historically been targeted at persons with personal vehicles***
- ***A substantial percentage of potential vulnerable populations do not have personal vehicles***
- ***Plans to evacuate "carless" populations in many locations have been created relatively recently or are currently in development***
- ***There have been few actual activations to gain knowledge and experience, nor tests, drills or simulations to evaluate potential weakness and needs***

# Study Questions

- ***Proof-of-Concept - Can TRANSIMS be used for evacuation analysis? Are its results reasonable?***
- ***Develop a variety and range of hazard-response scenarios***
- ***How many buses might be needed under various scenarios? What routes should they take?***
- ***Potential to estimate the number of location of evacuees***
- ***Examine the potential of alternate plans***

# Research Methodology

- ***Model Development***
  - ***Spatial distribution, loading, and temporal movements 40,000 assisted evacuees (including 10,000 tourists)***
- ***Scenario Development (8 cases)***
  - ***Routing: I-10 vs. US-61***
  - ***Response "Urgency": 24, 32, 36, 48 hours***
- ***MOE's***
  - ***Total evacuation time and average travel time***
- ***Develop and Evaluate Alternative Management Strategies***
  - ***"Off-peak" movements***
  - ***"Forced" routing***




# Evacuation Pick-Up Locations

**SENIOR CENTER LOCATIONS**

1. Arthur Mondy Center
1111 Newton Avenue, Algiers

2. Kingsley House
1600 Constance Street,
Lower Garden District

3. Central City Senior Center
2020 Philip Street, Central City

4. Mater Dolorosa
1226 S. Carrollton Ave, Carrollton

**GENERAL POPULATION**

5. Smith Library Bus Stop
6300 Canal Blvd., Lakeview

6. Palmer Park
S. Claiborne and S. Carrollton,
West Carrollton

7. McMain High School
5712 S. Claiborne Ave, Broadmoor

8. Lyons Community Center
624 Louisiana Ave, Irish Channel

9. Dryades YMCA
1924 Philip Street, Central City

10. Warren Easton High School
3019 Canal Street, Treme

11. Municipal Auditorium
801 N. Rampart, 7th Ward

12. O. Perry Walker High School
2832 General Meyer, Algiers

13. Stallings Community Center
4300 St. Claude, Bywater

14. Sanchez Center
Caffin & N. Claiborne, Lower 9th Ward

15. Gentilly Mall Parking Lot
Chef Menteur & Press Dr., Gentilly

16. Walgreen's
Lake Forest & Read Blvd, NO East

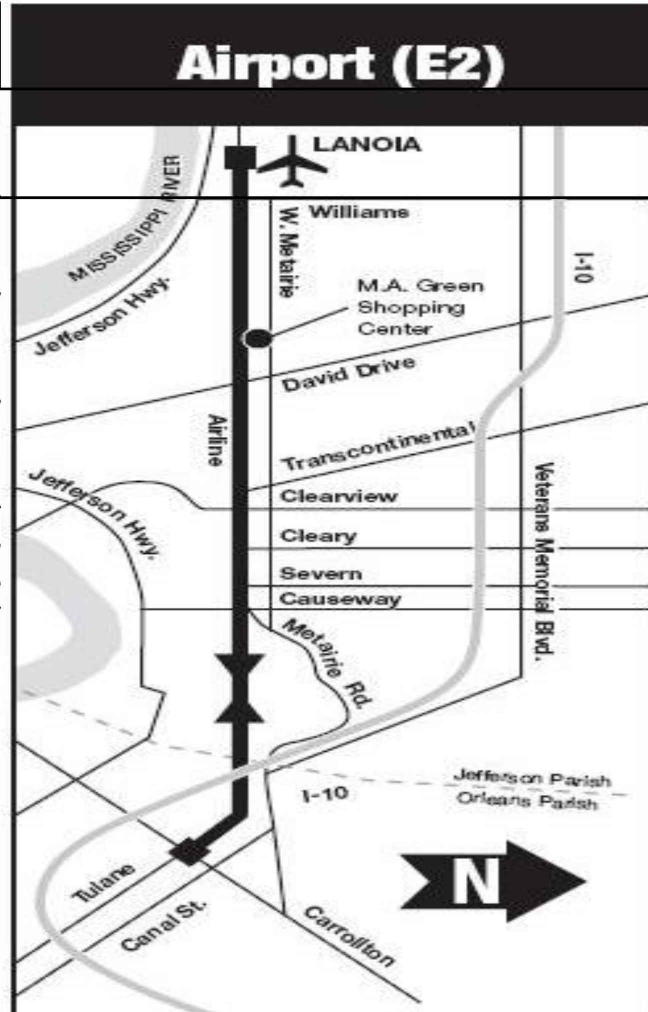
17. Mary Queen of Vietnam
14001 Dwyer, New Orleans East

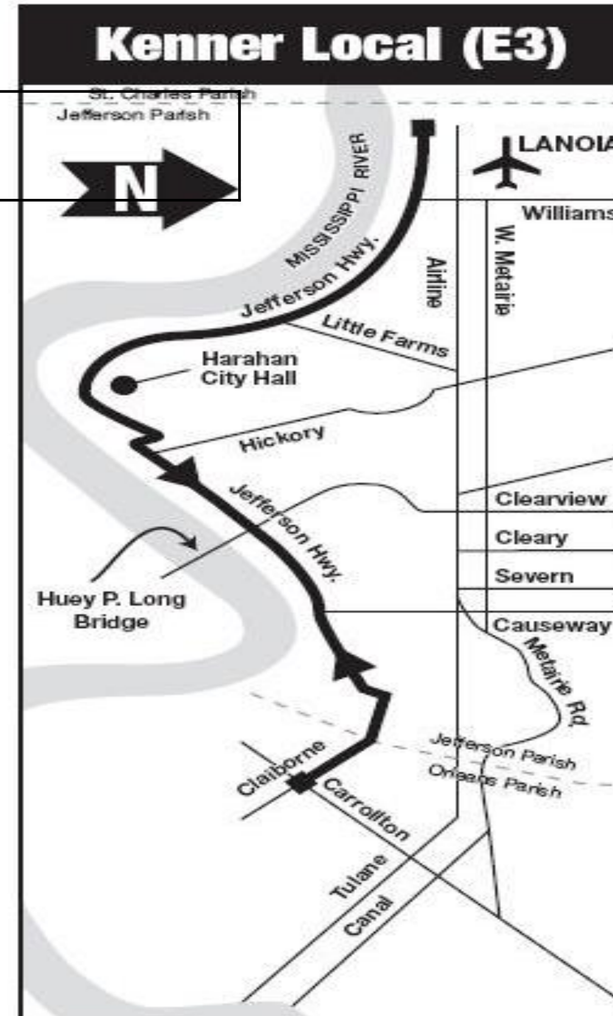
**CITY OF NEW ORLEANS**

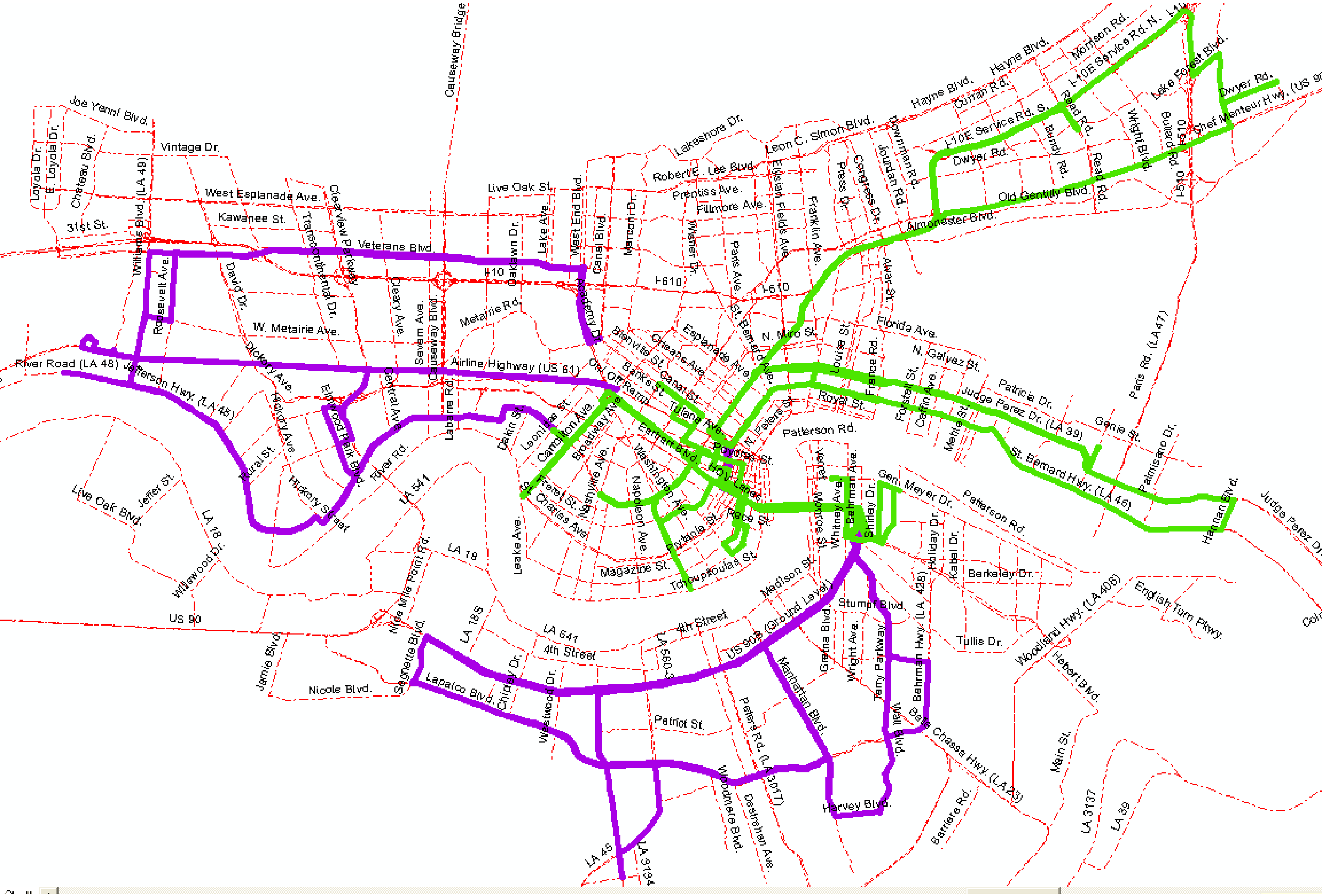
**City Assisted Evacuation Plan**

0 0.45 0.9 1.8 Miles

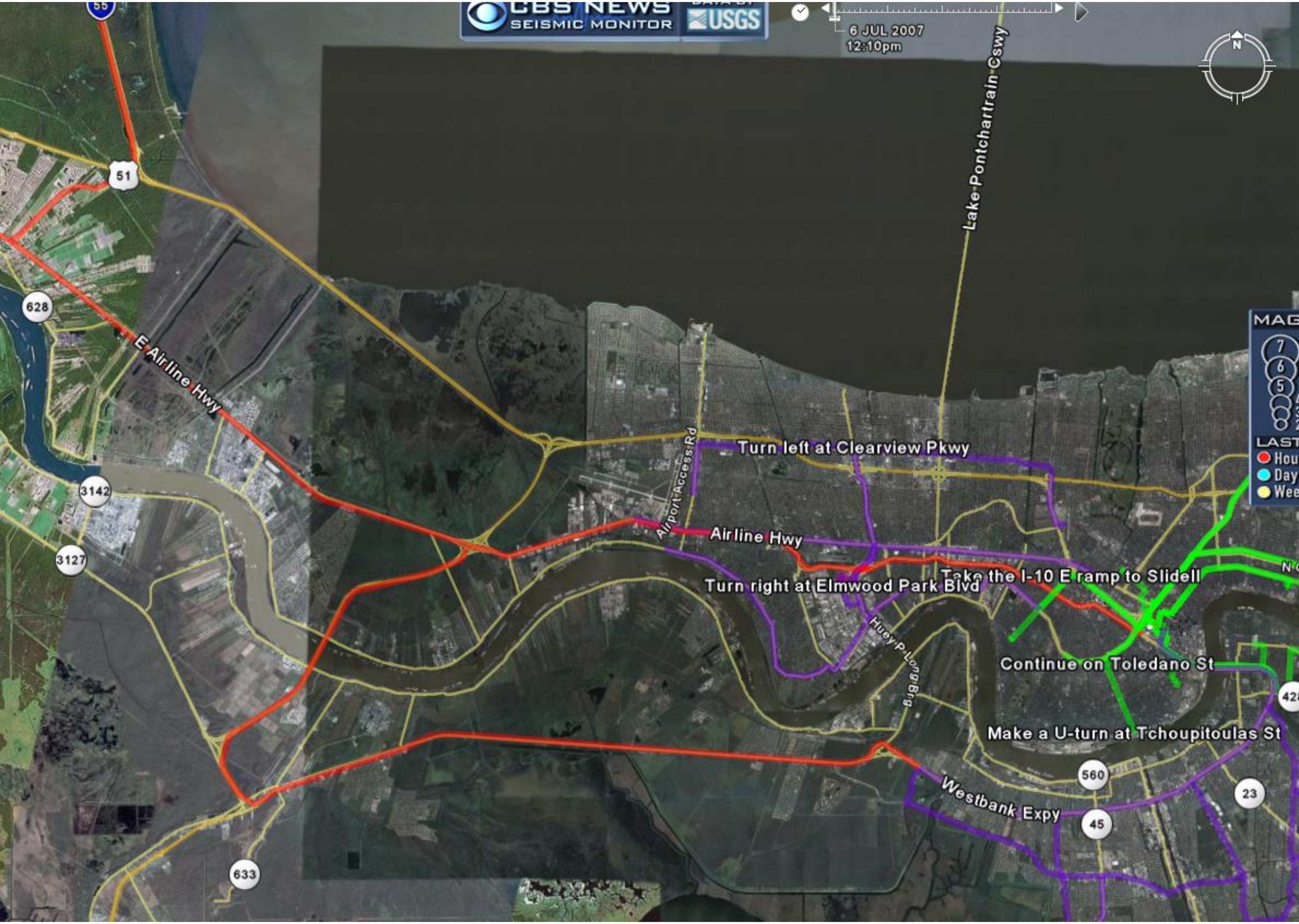
# Jefferson Parish Bus Routes



Causeway Bridge
Joe Yenni Blvd.
Vintage Dr.
Loyola Dr.
E. Loyola Dr.
Chateau Blvd.
Williams Blvd. (LA 49)
31st St.
West Esplanade Ave.
Kawanee St.
Clearview Parkway
Transcontinental Dr.
Veterans Blvd.
Live Oak St.
Lake Ave.
West End Blvd.
Canal Blvd.
Marconi Dr.
Oaklawn Dr.
I-10
Roosevelt Ave.
David Dr.
W. Metairie Ave.
Cleary Ave.
Severn Ave.
Causeway Blvd.
Metairie Rd.
Airline Highway (US 61)
River Road (LA 48)
Jefferson Hwy. (LA 48)
Dickory Ave.
Hickory Ave.
Elmwood Park Blvd.
Central Ave.
Labarre Rd.
Oakin St.
Leonidas St.
Carrollton Ave.
Broadway Ave.
Pontchartrain Expy.
Rural St.
Hickory St.
River Rd.
LA 541
Live Oak Blvd.
Jeffer St.
LA 18
Willswood Dr.
US 90
Jamie Blvd.
Nicole Blvd.
Segnette Blvd.
Nine Mile Point Rd.
LA 18
LA 18S
Lapalco Blvd.
Chidaw Dr.
Westwood Dr.
LA 541
4th Street
LA 45
LA 3134
Patriot St.
Woodmere Blvd.
Destrehan Ave.
Peters Rd. (LA 3017)
Manhattan Blvd.
Harvey Blvd.
US 90B (Ground Level)
4th Street
Madison St.
Tchoupitoulas St.
Magazine St.
Prytania St.
Napoleon Ave.
Nashville Ave.
Washington Ave.
Charles Ave.
Earhart Blvd.
Tulane Ave.
Canal St.
Banks St.
Bienville St.
Orleans Ave.
Esplanade Ave.
St. Bernard Ave.
N. Miro St.
HOV Lanes
Poydras St.
Lakeshore Dr.
Robert E. Lee Blvd.
Prentiss Ave.
Fillmore Ave.
Leon C. Simon Blvd.
Elysian Fields Ave.
Franklin Ave.
Paris Ave.
Wisner Dr.
I-610
Press Dr.
Congress Dr.
Jourdan Rd.
Downman Rd.
Almonaster Blvd.
Hayne Blvd.
Haynes Blvd.
Dwyer Rd.
I-10E Service Rd. S.
I-10E Service Rd. N.
Read Rd.
Morrison Rd.
Lake Forest Blvd.
Dwyer Rd.
Chef Menteur Hwy. (US 90)
Bundy Rd.
Wright Blvd.
Bullard Rd.
I-510
Old Gentilly Blvd.
Florida Ave.
N. Galvez St.
Louisa St.
France Rd.
Royal St.
Patterson Rd.
Forstall St.
Caffin Ave.
Patricia Dr.
Judge Perez Dr. (LA 39)
Genie St.
Paris Rd. (LA 47)
Palmisano Dr.
St. Bernard Hwy. (LA 46)
Hannan Blvd.
Judge Perez Dr.
Gen. Meyer Dr.
Patterson Rd.
Behrman Ave.
Shirley Dr.
Whitney Ave.
Monroe St.
Holiday Dr.
Kabel Dr.
Berkeley Dr.
LA 428
Stumpf Blvd.
Gretna Blvd.
Wright Ave.
Terry Parkway
Behrman Hwy.
Tullis Dr.
Woodland Hwy. (LA 406)
English Turn Pkwy.
Hebert Blvd.
Belle Chasse Hwy. (LA 23)
Wall Blvd.
Barriere Rd.
Main St.
LA 3137
LA 39


CBS NEWS
SEISMIC MONITOR
USGS
6 JUL 2007
12:10pm
N
Lake Pontchartrain Cswy
E Airline Hwy
Airport Access Rd
Turn left at Clearview Pkwy
Airline Hwy
Turn right at Elmwood Park Blvd
Take the I-10 E ramp to Slidell
Huey P Long Brg
Continue on Toledano St
Make a U-turn at Tchoupitoulas St
Westbank Expy
55
51
628
3142
3127
633
560
45
23

# Quantitative Results

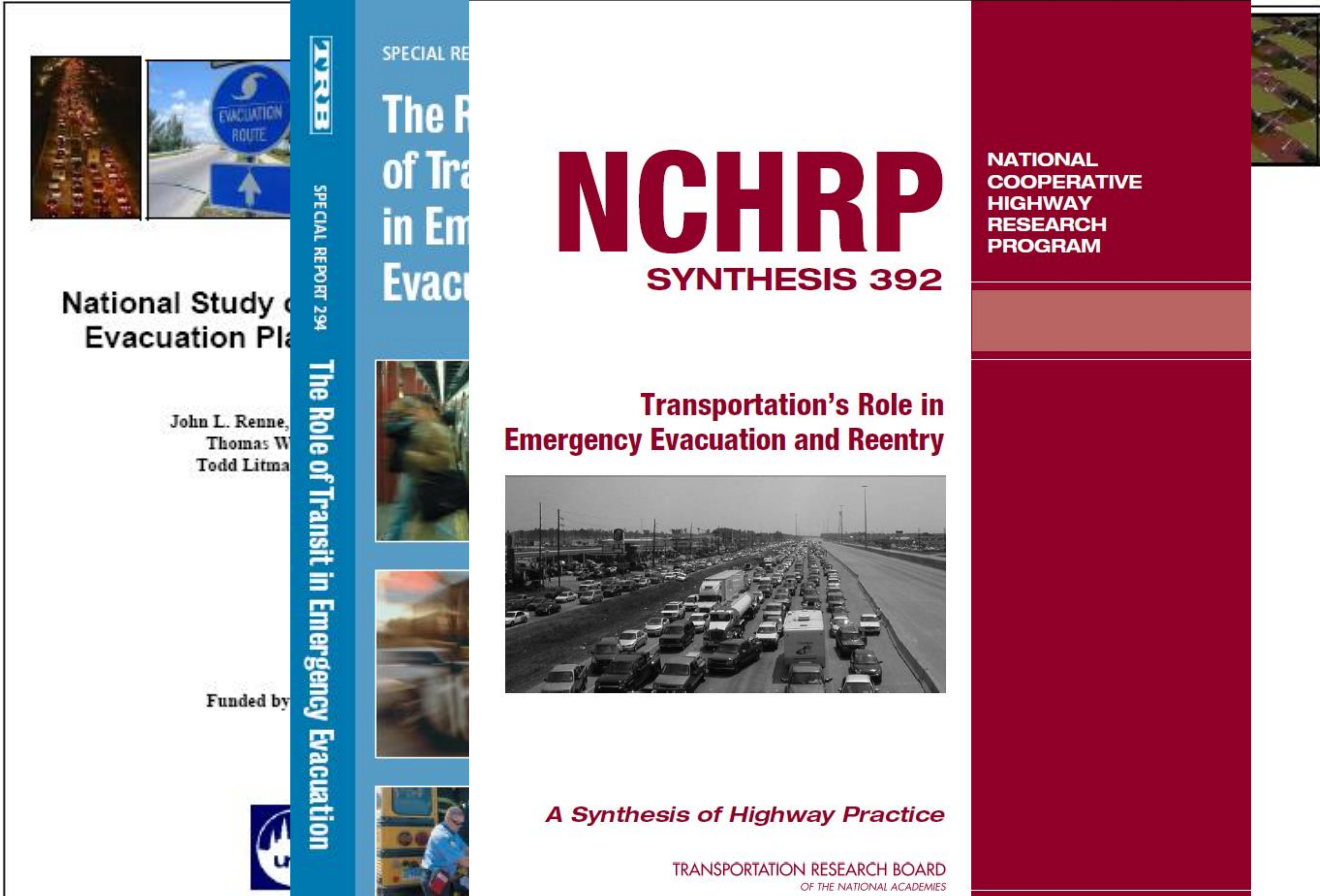
| Evacuation Scenario | Total Evacuation Time (hr) | | Percent Reduction |
|---|---|---|---|
| | I-10 | US-61 | |
| A | 34.95 | 32.79 | **6.2 %** |
| B | 47.27 | 46.44 | **1.8 %** |
| C | 29.89 | 25.76 | **13.8 %** |
| D | 41.35 | 36.49 | **11.8 %** |

| Evacuation Scenario | Average Travel Time (hr) | | Percent Reduction |
|---|---|---|---|
| | I-10 | US-61 | |
| A | 4.81 | 2.55 | **47.0 %** |
| B | 5.03 | 2.84 | **43.5 %** |
| C | 4.54 | 2.20 | **51.5 %** |
| D | 4.80 | 2.61 | **45.6 %** |

# Conclusions

- ***Evidence that TRANSIMS is an effective tool for multimodal evacuation modeling and planning***
- ***Constituent models can be useful in whole or when used separately***
- ***Quantify Process and Evaluate Alternatives***

| *Management Strategy* | *Total Evacuation Time* | *Average Travel Time* |
|---|---|---|
| *Off Peak Evacuation* | *45%* | *10%* |
| *Alternative Routing* | *14%* | *52%* |




**http://www.trb.org/**

# Florida Keys Evacuation Planning

# *Evacuation Planning in The Florida Keys: Unique Challenges and Emerging Knowledge*

***Brian Wolshon, Ph.D., P.E.***
***Louisiana State University***

***Gulf Coast Center for Evacuation and Transportation Resiliency***

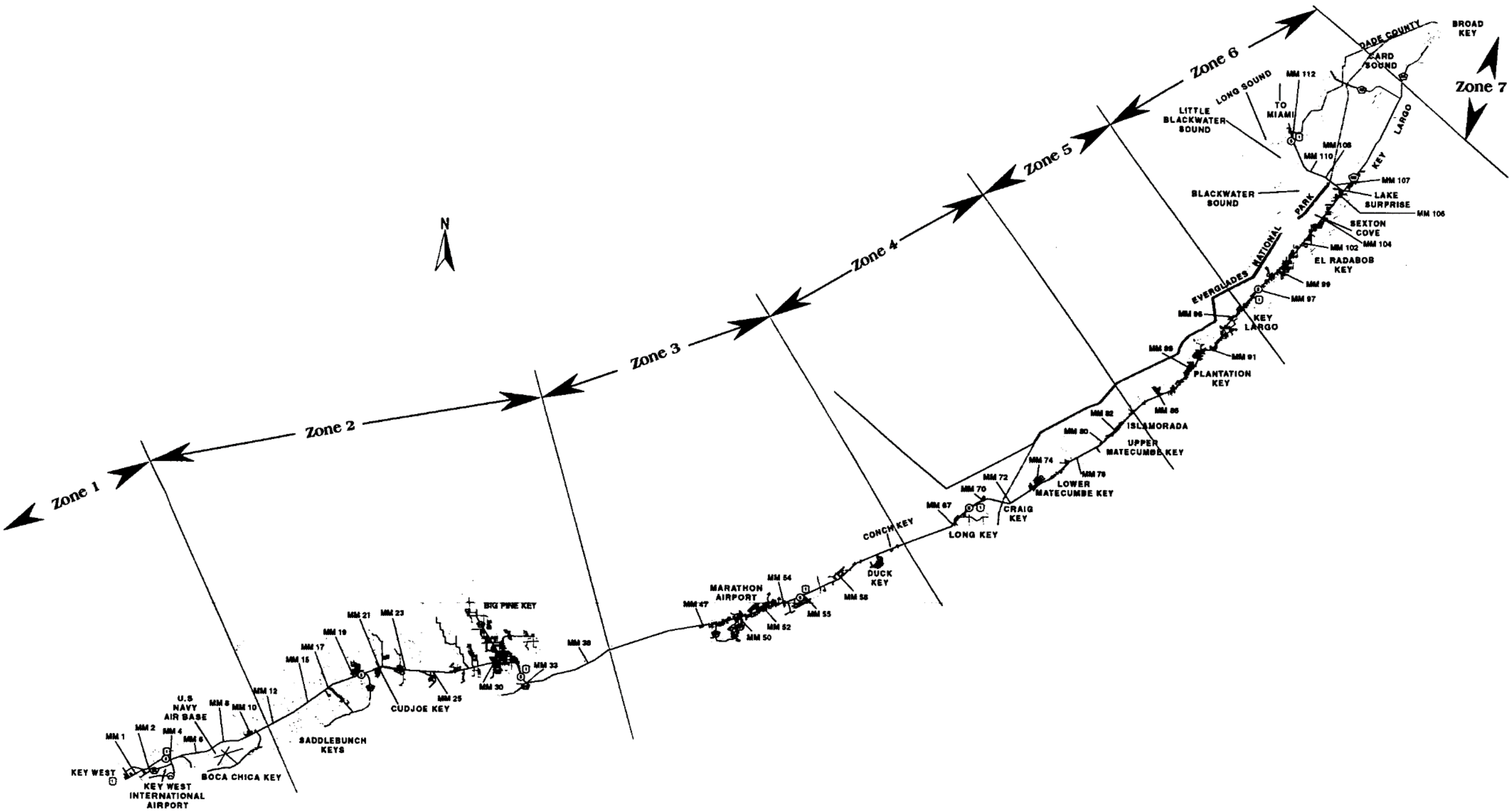
***2012 National Evacuation Conference*** ***March 29, 2012***

# Discussion Topics

- *Background on the unique nature of The Florida Keys and the challenges they present to evacuation*
- *Transportation network in The Keys*
- *Social and political concerns influencing evacuation*
- *Transportation analyses and emerging knowledge*
- *Applicability to other locations*

# *Unique Nature of The Florida Keys*

- ***High risk potential***
- ***Effectively one route out***
  - ***Susceptible to traffic and roadway incidents***
  - ***Use of contraflow is problematic***
- ***Approximately 80,000 resident and tourists evacuees***
  - ***Highest concentration  in the Lower Keys***
- ***Long travel distance***
- ***Potential effects of “mainland” traffic***




*(Map source: 2001 Florida Keys Hurricane Evacuation Study)*

# Unique Nature of The Florida Keys

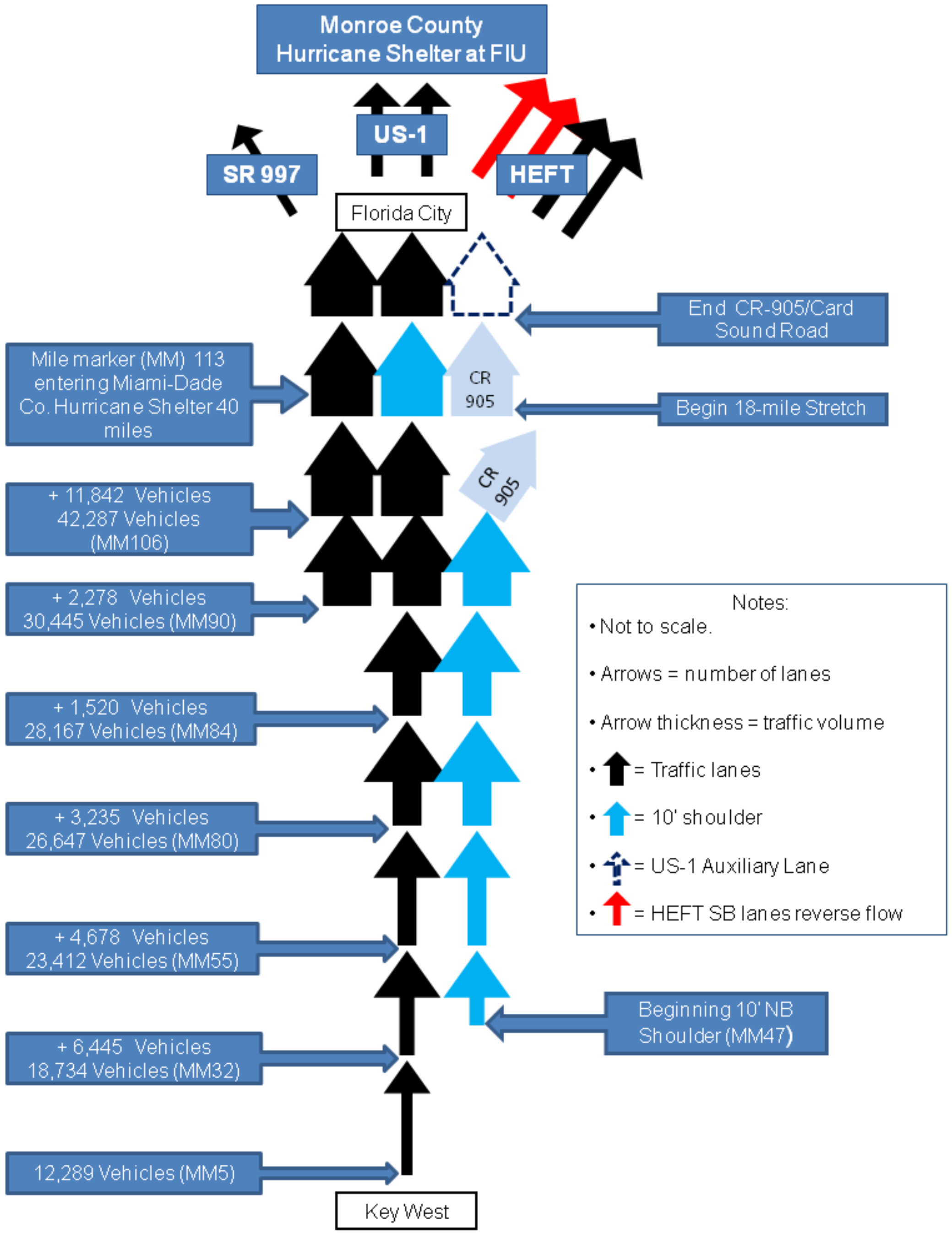
- *Designated as a Florida "Area of Critical State Concern"*
  - *Unique nature and value of the area makes The Keys important to the State as a whole*
  - *State, rather than local government, has authority over many key civil issues*
- *Evacuation*
  - *Must be able to undertake a full evacuation in 24 hours*
- *Growth and Development*
  - *New construction is limited by the ability to serve water, sewer, evacuation, etc.*

# Transportation Analysis History

- *Long history of traffic analysis and modeling in The Keys*
- *2001 Florida Keys Hurricane Evacuation Study (aka "The Miller Model")*
  - *Linear model of link flows*
- *More complex models as part of the Florida Statewide Study*
- *The models rely on estimates of roadway capacity*

# General Modeling Process

- *Spatial and temporal generation of travel demand*
  - *Who leaves, when do they leave, where do they come from, where do the go, what route(s) do they take?*
- *What is the carrying capacity of the road network?*
- *What are the travel conditions?*
  - *Speed, travel time, delay, congestion*
- *Convert to a clearance time*


Monroe County
Hurricane Shelter at FIU
SR 997
US-1
HEFT
Florida City
End CR-905/Card Sound Road
Mile marker (MM) 113 entering Miami-Dade Co. Hurricane Shelter 40 miles
CR 905
Begin 18-mile Stretch
CR 905
+ 11,842 Vehicles
42,287 Vehicles (MM106)
+ 2,278 Vehicles
30,445 Vehicles (MM90)
+ 1,520 Vehicles
28,167 Vehicles (MM84)
+ 3,235 Vehicles
26,647 Vehicles (MM80)
+ 4,678 Vehicles
23,412 Vehicles (MM55)
+ 6,445 Vehicles
18,734 Vehicles (MM32)
12,289 Vehicles (MM5)
Beginning 10' NB Shoulder (MM47)
Key West
Notes:
• Not to scale.
• Arrows = number of lanes
• Arrow thickness = traffic volume
• = Traffic lanes
• = 10' shoulder
• = US-1 Auxiliary Lane
• = HEFT SB lanes reverse flow

# Model Findings 2001

- *2001 Florida Keys Hurricane Evacuation Study*
  - *Examined clearance time under numerous scenarios including existing road configuration and various lane and intersection capacity improvements*
- *Existing (no-build) condition would result in an clearance time of 25hr 58min*
- *Through various improvements, it was suggested that this could be lowered to just under 19 hours*
  - *Lane additions where expected flow were highest – Upper Keys*
- *FDOT implementing these improvements since*

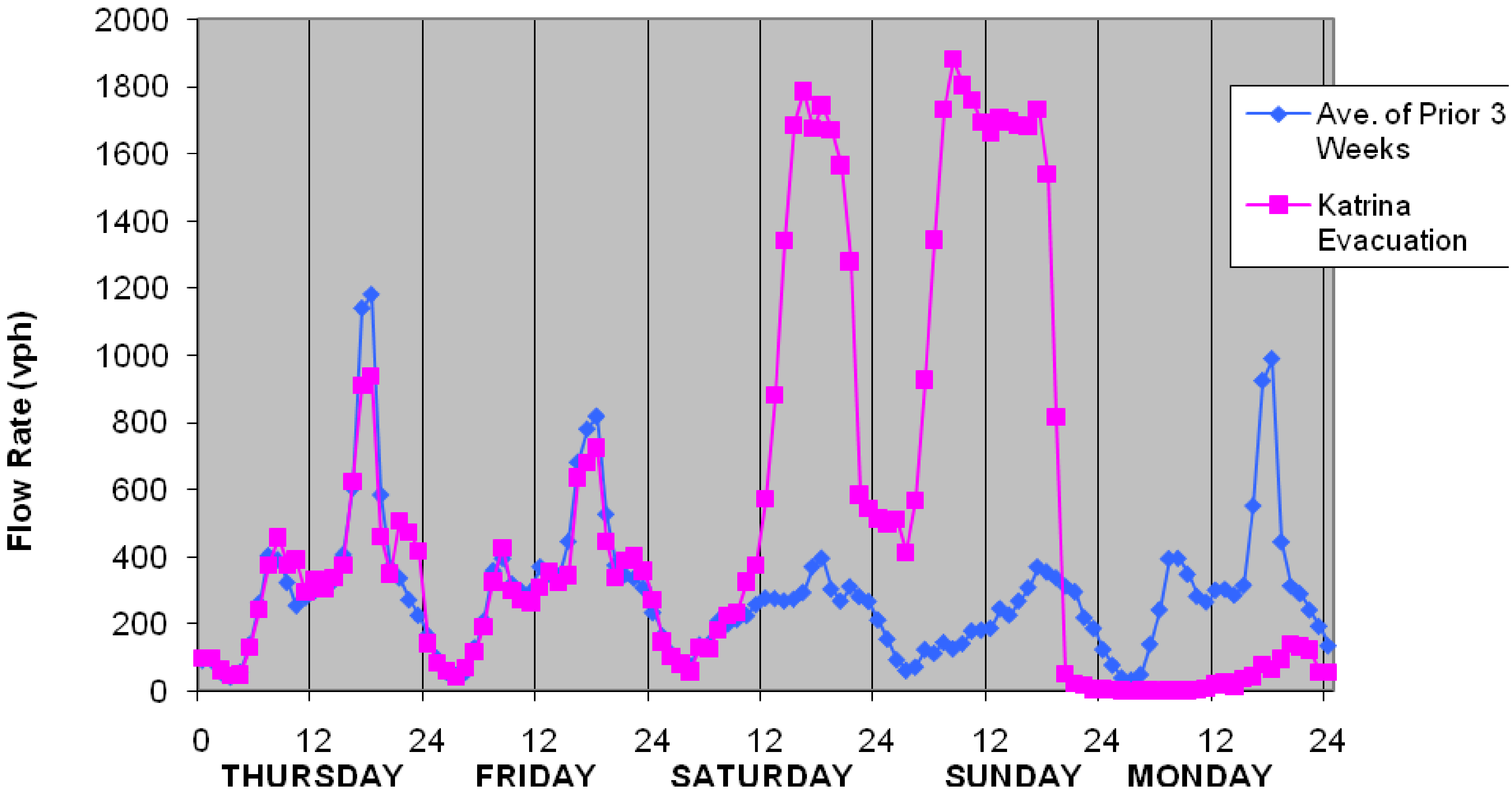
# Research Findings

- *Numerous major evacuations (1999 – 2008) afforded the opportunity to collect and analyze flow patterns and characteristics*
- *The observed data showed consistent patterns that actual flow during events were not consistent with prior assumptions*
  - *They also vary at different times*
- *Research suggests the use of "Maximum Sustainable Evacuation Traffic Flow Rates" for modeling and analysis*

# *Maximum Sustainable Evacuation Traffic Flow Rates*

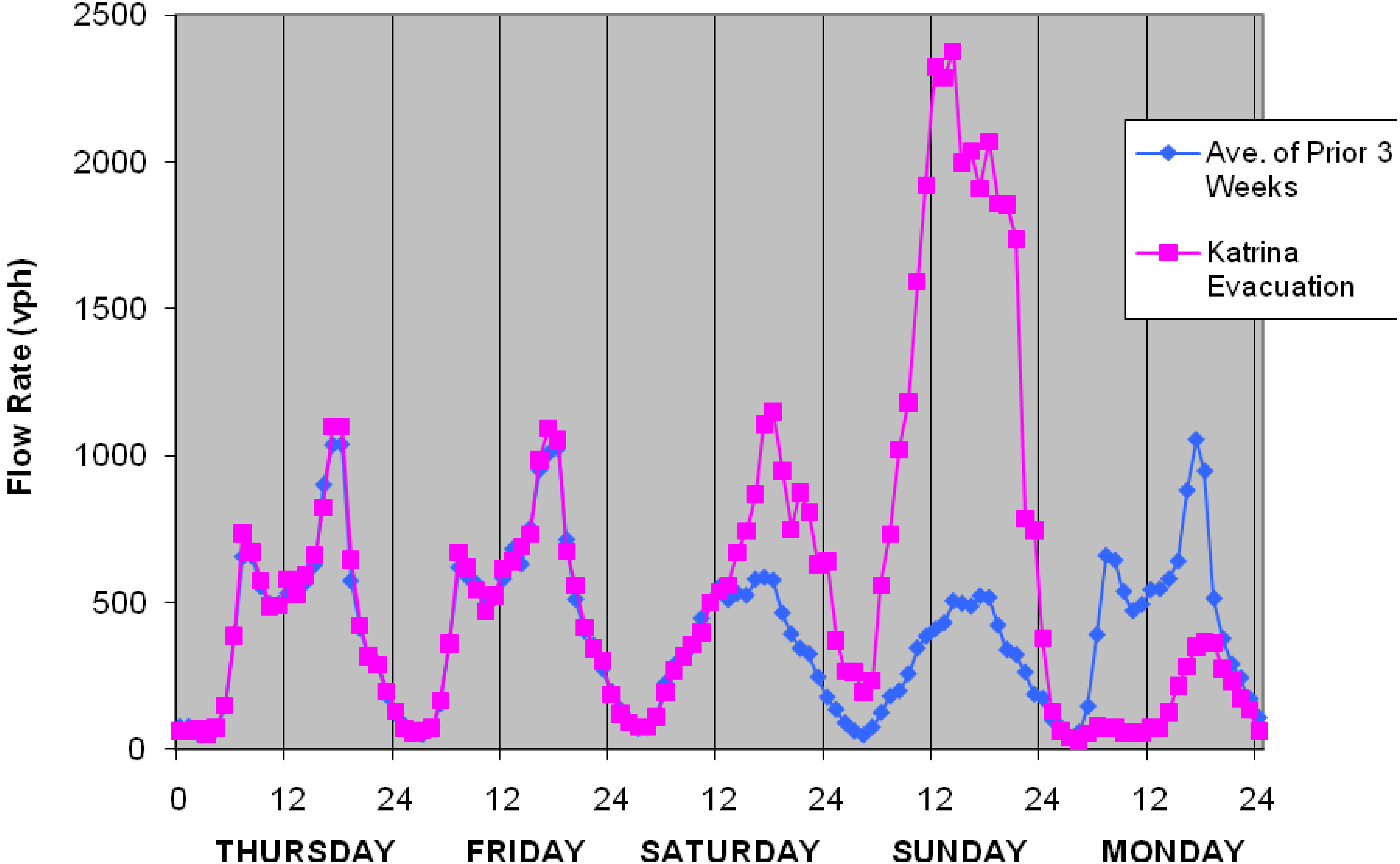
- ***The anticipated highest vehicle flow rates that can be <u>practically</u> sustained over an extended period of time during an evacuation***
- ***Although Maximum Sustainable Evacuation Traffic Flow Rates are similar to the "capacity" of the road segment, they are quite different***
- ***They vary by segment – and will also vary based on specific conditions that exist at the time of the event***

# Louisiana Observations



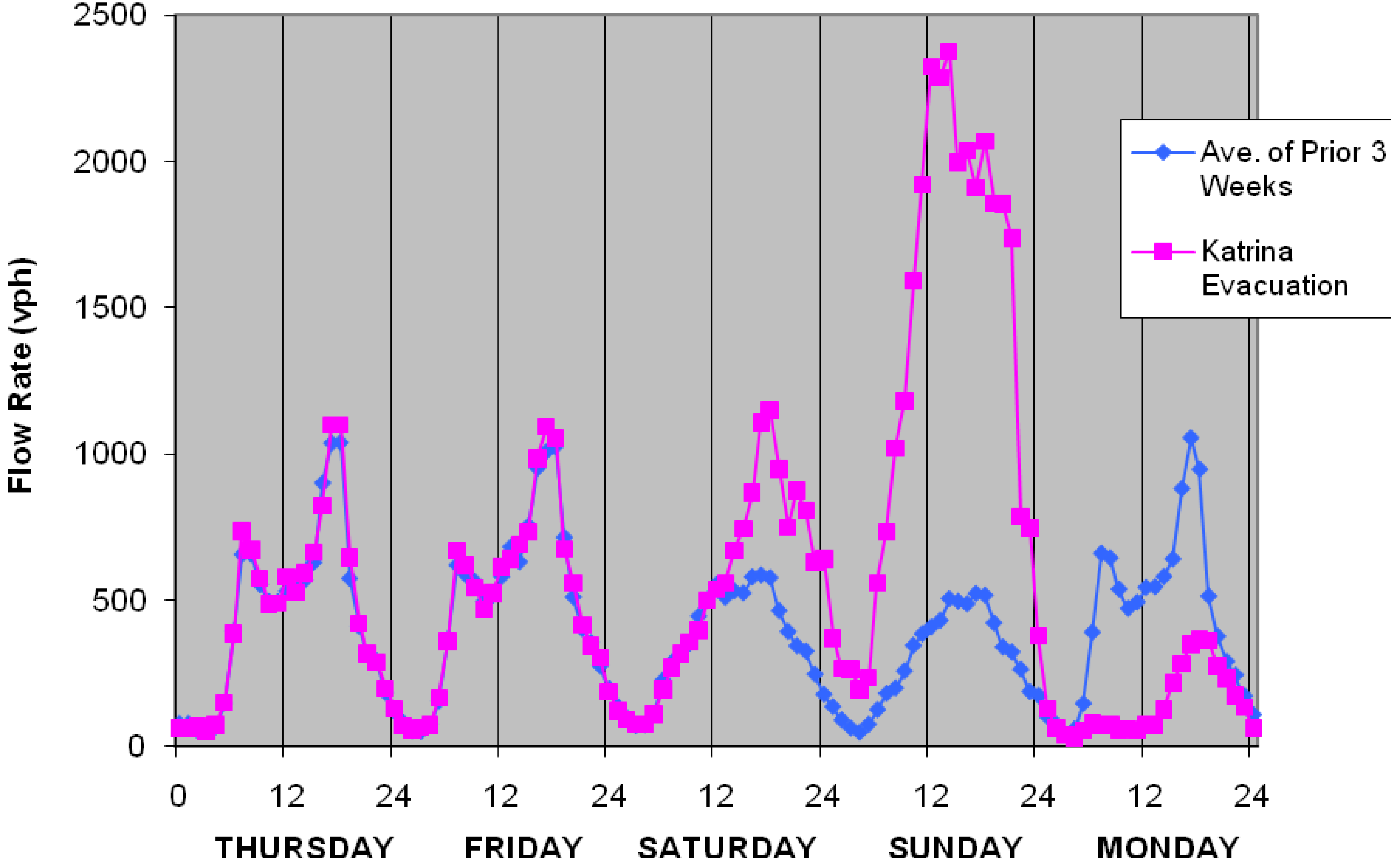

*Northbound Evacuation (2-lane) Traffic Volume - US-61 LaPlace Louisiana*

# Louisiana Observations



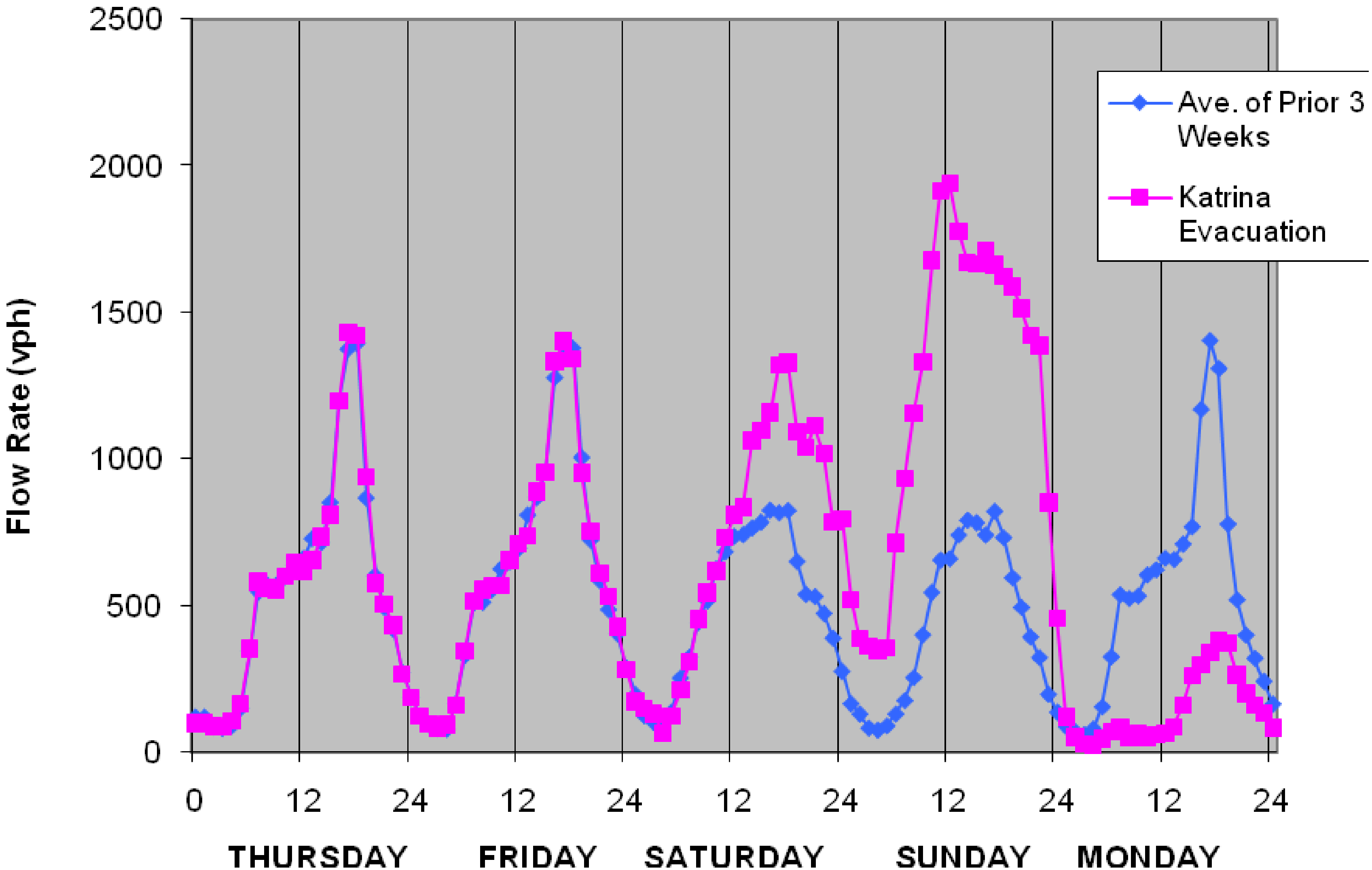

*Westbound Evacuation (2-lane) Traffic Volume - US-190 (Mississippi River Bridge departure) Port Allen, Louisiana*

# Louisiana Observations



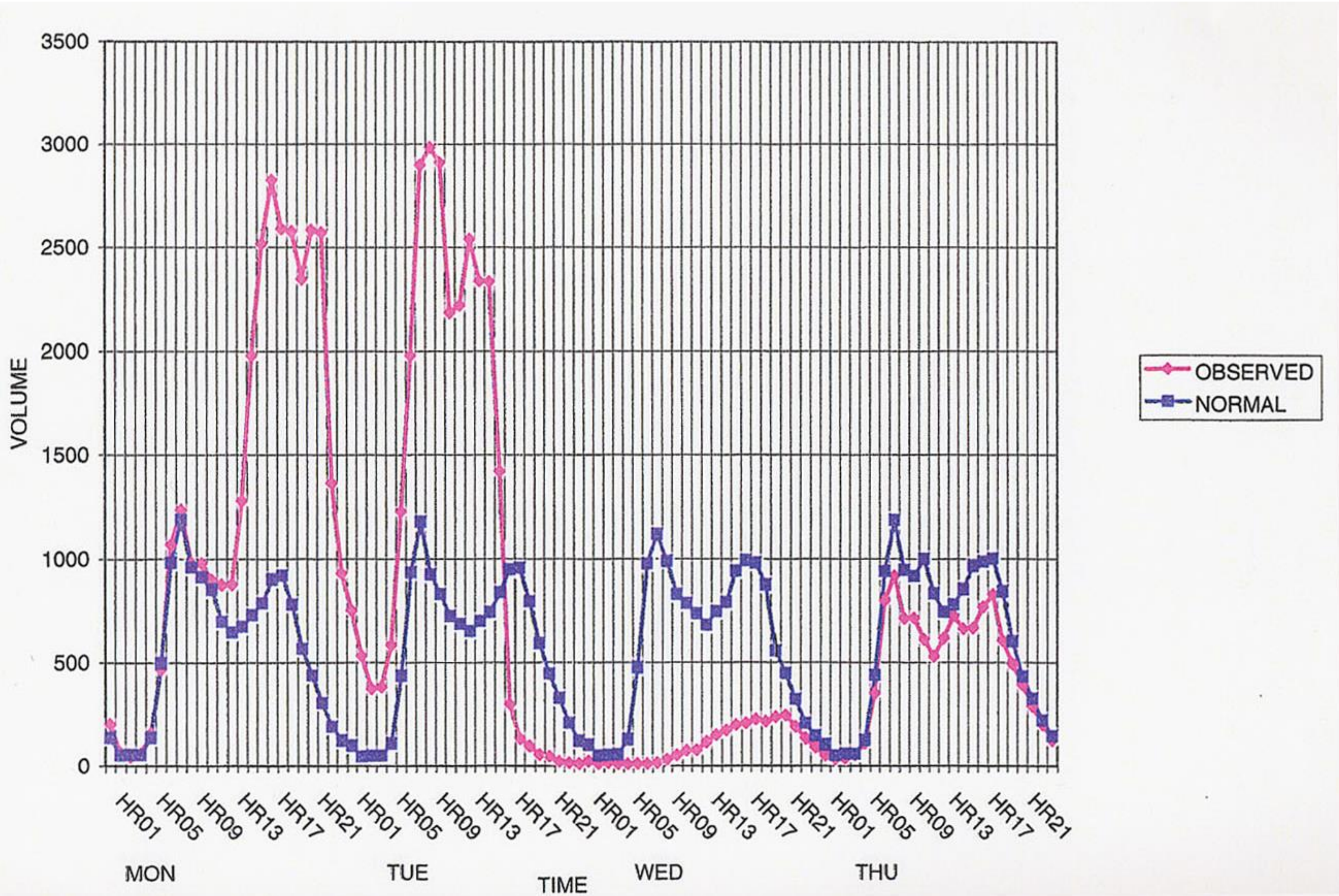

*Westbound Evacuation (2-lane) Traffic Volume - US-190 (Mississippi River Bridge departure) Port Allen, Louisiana*

# Louisiana Observations



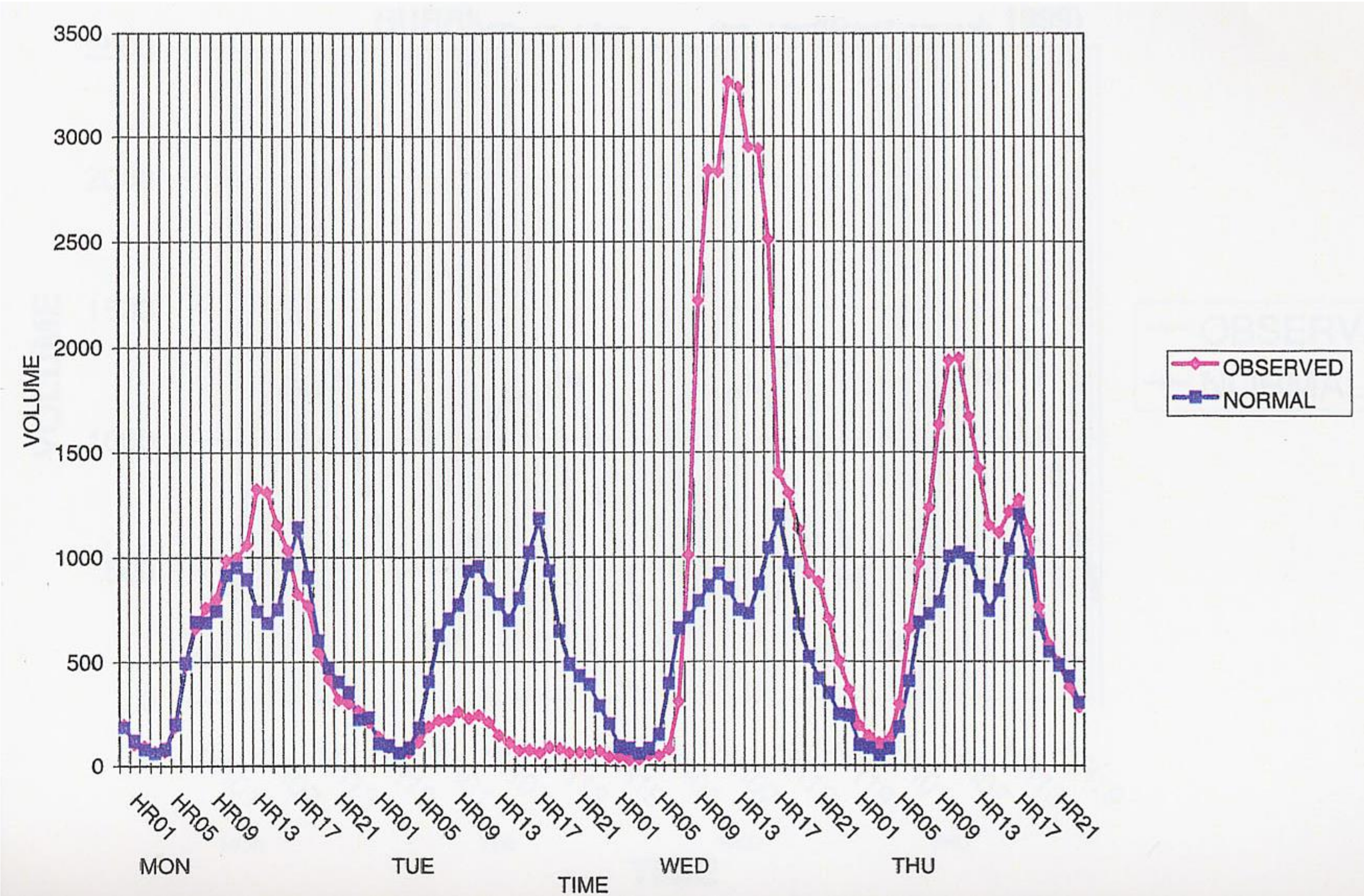

*Westbound Evacuation (2-lane) Traffic Volume - US-190 Port Allen Louisiana*

# Florida Observations



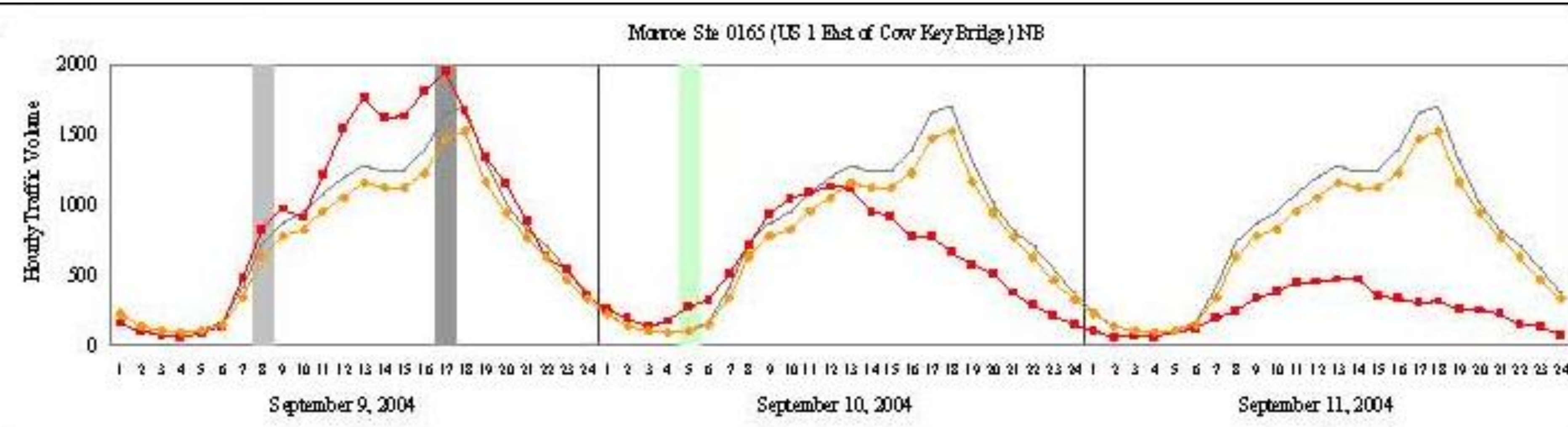

*Westbound SR-528 Traffic Volume Data*

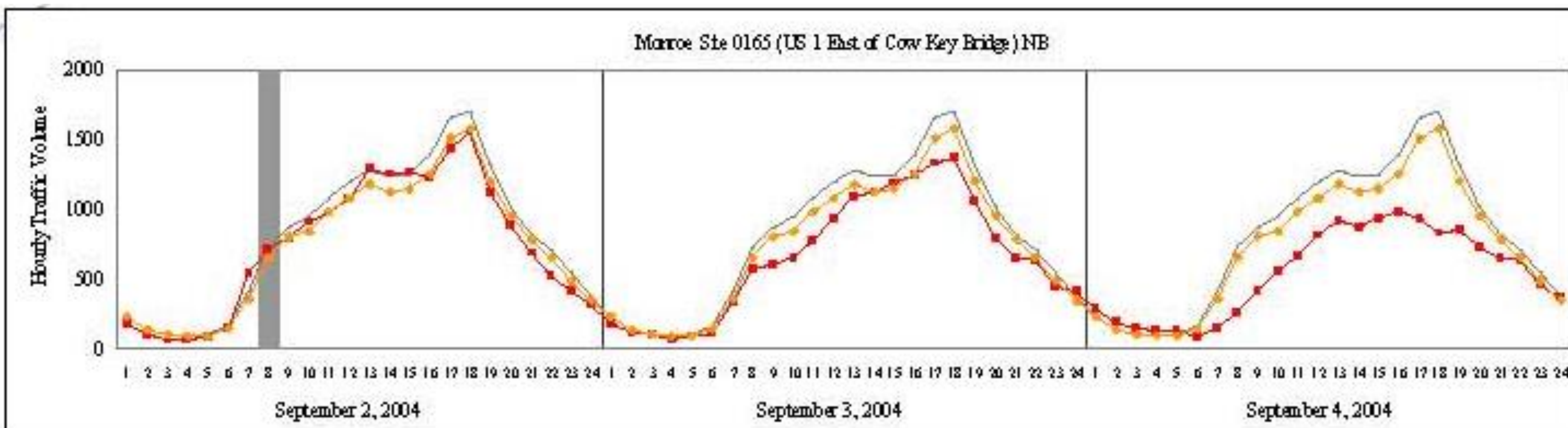
# Florida Observations




***Eastbound SR-528 Traffic Volume Data***

# Florida Keys Observations




***Northbound US-1 Traffic Volume Data at Cow Key Bridge***
***Hurricane Ivan (top) and Hurricane Frances (bottom)***

# Maximum Observed Flows

| Event | Cow Key Bridge MM 4 (vphpl) | Big Pine Key MM 28 (vphpl) | Key Largo MM 106 (vphpl) |
|---|---|---|---|
| Hurricane Charley | 1,125* | 1,100* | 725* |
| Hurricane Francis | 800* | 595* | 450* |
| Hurricane Ivan | 600* | 810* | 625* |
| Hurricane Wilma | 650* | 590* | 650* |
| Hurricane Dennis | 650* | 1,180* | 748* |
| Trop. Storm Fay | 855 | 1,030 | 874 |
| Trop. Storm Ike | 584 | 680 | 502 |
| Highest Hrly Vol. of 2010 | 1,092 | 1,066 | 903 |
| 2nd Highest Hrly Vol. 2010 | 1,061 | 1,065 | 869 |
| 3rd Highest Hrly Vol. 2010 | 1,058 | 1,063 | 849 |
| 4th Highest Hrly Vol. 2010 | 1,055 | 1,059 | 824 |
| Maximum Sustainable Evacuation Traffic Flow Rates | 900 – 1,100 | 1,050 - 1,100 | 900 - 1,200 |

** Denotes approximate value based on graphical data*

| Maximum Sustainable Evacuation Traffic Flow Rates for Hurricane Evacuation Purposes<br>US Highway 1 (Overseas Highway) and CR 905/Card Sound Road in the Florida Keys, Monroe County, Florida | | | | | |
|---|---|---|---|---|---|
| Area | Milemarkers | | Location/Description | Year 2,010 Configuration | Suggested Maximum Sustainable Evacuation Flow Rate per Hour per Lane |
| | From | To | | | |
| Lower Keys | 2.0 | 4.0 | Key West to Stock Island | 4L | 900 |
| Lower Keys | 4.0 | 9.0 | Stock Island to Big Coppitt Key | 4LD | 900 |
| Lower Keys | 9.0 | 17.0 | Big Coppitt Key to Sugarloaf Key | 2L | 1,100 |
| Lower Keys | 17.0 | 22.0 | Sugarloaf Key to Cudjoe Key | 2L | 1,100 |
| Lower Keys | 22.0 | 24.0 | Cudjoe Key to Summerland Key Cove Airport | 2L | 1,100 |
| Lower Keys | 24.0 | 25.0 | Summerland Key Cove Airport to Summerland Key | 3L | 1,100 |
| Lower Keys | 25.0 | 30.0 | Summerland Key to Big Pine Key | 2L | 1,100 |
| Lower Keys | 30.0 | 34.0 | Big Pine Key to West Summerland Keys | 2L | 1,050 |
| Lower Keys | 34.0 | 35.2 | West Summerland Keys to Spanish Harbor Keys | 2L | 1,100 |
| Lower Keys | 35.2 | 36.5 | Spanish Harbor Keys to Bahia Honda Bridge | 4LD | 1,100 |
| Lower Keys | 36.5 | 37.5 | Bahia Honda Bridge to Bahia Honda Key | 2L | 1,100 |
| Middle Keys | 37.5 | 47.0 | Bahia Honda Key to Hog Key | 2L | 1,200 |
| Middle Keys | 47.0 | 48.0 | Hog Key to Boot Key | 2L | 1,100 |
| Middle Keys | 48.0 | 50.2 | Boot Key to Marathon | 4L | 900 |
| Middle Keys | 50.2 | 50.8 | Marathon to Marathon Shores | 5L | 900 |
| Middle Keys | 50.8 | 54.0 | Marathon Shores to Key Colonial Beach | 4LD | 900 |
| Middle Keys | 54.0 | 54.5 | Key Colonial Beach to Deer Key | 4LD | 900 |
| Middle Keys | 54.5 | 58.0 | Deer Key to Grassy Key | 2L | 1,100 |
| Upper Keys | 58.0 | 74.0 | Grassy Key to Matecumbe Harbor | 2L | 1,100 |
| Upper Keys | 74.0 | 80.0 | Matecumbe Harbor to Teatable Key | 2L | 1,100 |
| Upper Keys | 80.0 | 83.5 | Teatable Key to Islamorada | 3L | 1,100 |
| Upper Keys | 83.5 | 85.6 | Islamorada to Windley Key | 2L | 1,100 |
| Upper Keys | 85.6 | 90.0 | Windley Key to Plantation Key | 2L | 1,100 |
| Upper Keys | 90.0 | 100.0 | Tavernier Key to Newport Key | 4LD | 900 |
| Upper Keys | 100.0 | 105.0 | Newport Key to Sexton Cove | 4LD | 900 |
| Upper Keys | 105.0 | 106.3 | Sexton Cove to Rattlesnake Key | 4LD | 900 |
| Upper Keys | 106.3 | 126.5 | Rattlesnake Key to Card Sound Rd | 2L/4L | 1,200 |
| South Dade | 126.5 | HEFT | Card Sound Rd to HEFT | 4LD | 900 |
| Upper Keys | 106.3 | Int CR 905 / CR 905 A | Lake Surprise to Crocodile Lake | 2L | 1,100 |
| Upper Keys | Ocean Reef | Int CR 905 / CR 905 A | Tanglefish Key to Crocodile Lake | 2L | 1,100 |
| Upper Keys | Int CR 905 / CR 905 A | US 1 | Crocodile Lake to South Miami-Dade | 2L | 1,100 |

**LEGEND**

| | |
|---|---|
| 2L | Two-lane facility |
| 2L/4L | Two lanes with short four-lane sections for passing purposes |
| 3L | Three-lane facility (center lane is a two-way left-turn lane) |
| 4L | Four-lane undivided facility |
| 4LD | Four-lane divided facility |
| 5L | Five-lane facility (center lane is a two-way left-turn lane) |

# *Model Findings - 2010*

- ***2010 Statewide Regional Evacuation Study Program Models***
  - ***More than 30 scenarios***
  - ***Using FDOT recommended MSETFR’s***
- ***Will be used by the State of Florida to set policy***
- ***Enormous range of clearance times from 12 - 47 hours, based on amount of population, behavioral response, downstream traffic, etc., etc., etc.***
  - ***Comparable assumptions to 2001 (using MSETFR’s is now about 26 hours)***

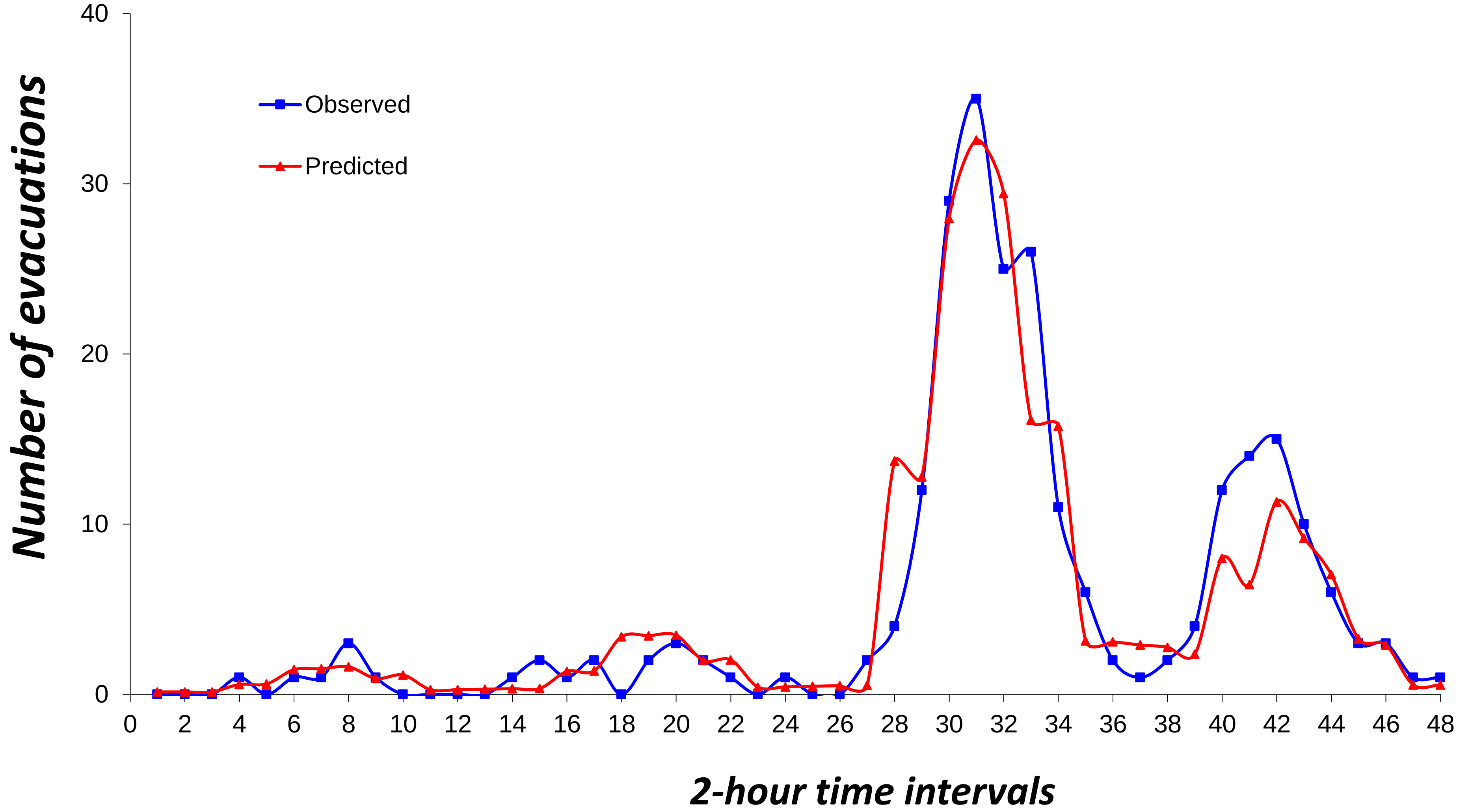
# Conflicting Concerns and Needs

- *Improvements would be needed most in Upper Keys to serve Lower/Middle Keys populations*
- *Additional road capacity would bring more traffic, diminishing the quality of life and the existing nature of The Keys*
- *Building prohibitions would amount to government "takes" of private property, involving of hundreds of millions*
- *Compromise?*

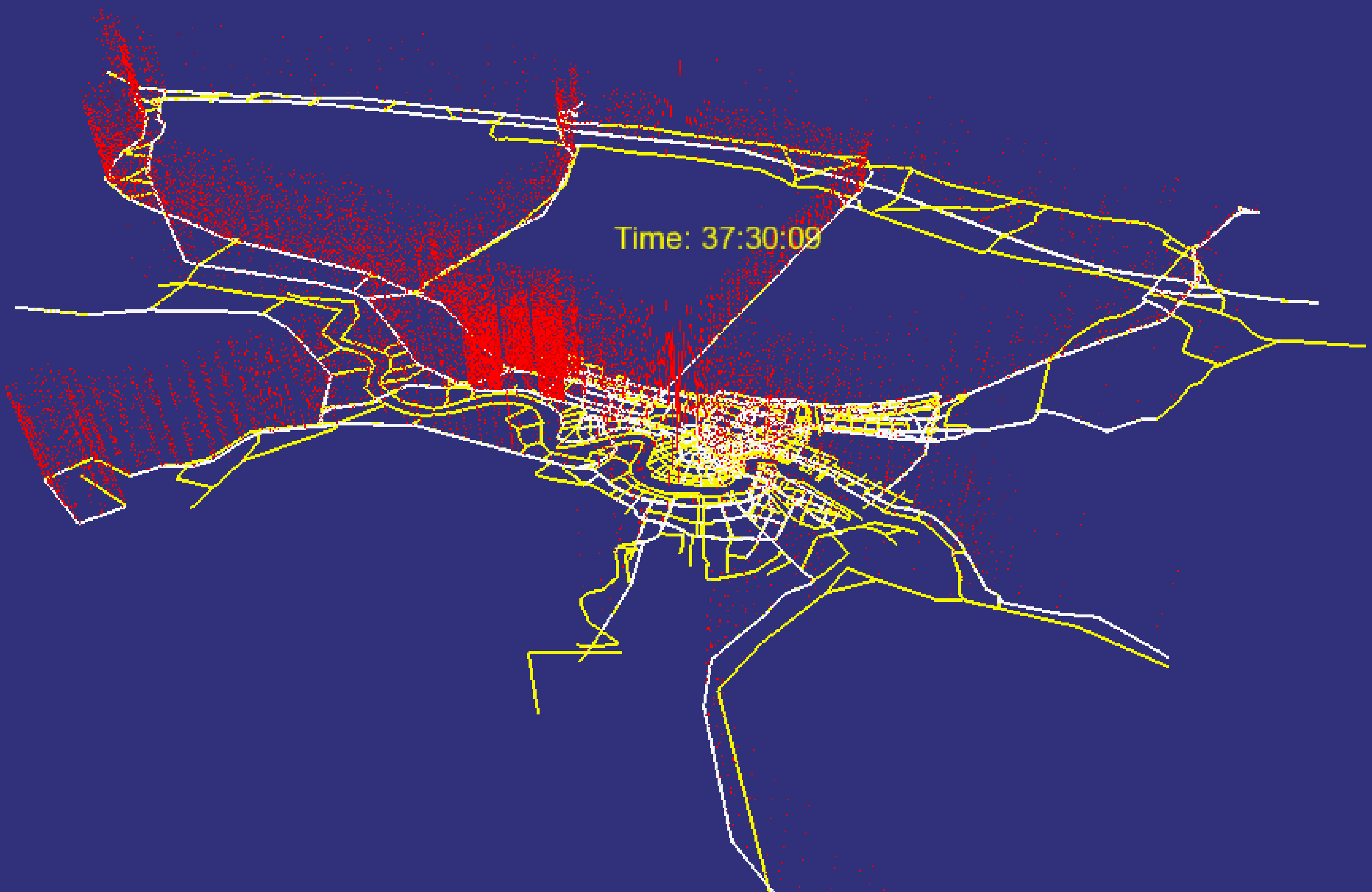
# *Current Research*

# Behavioral Modeling

## *Forecast time-dependent evacuation demand*

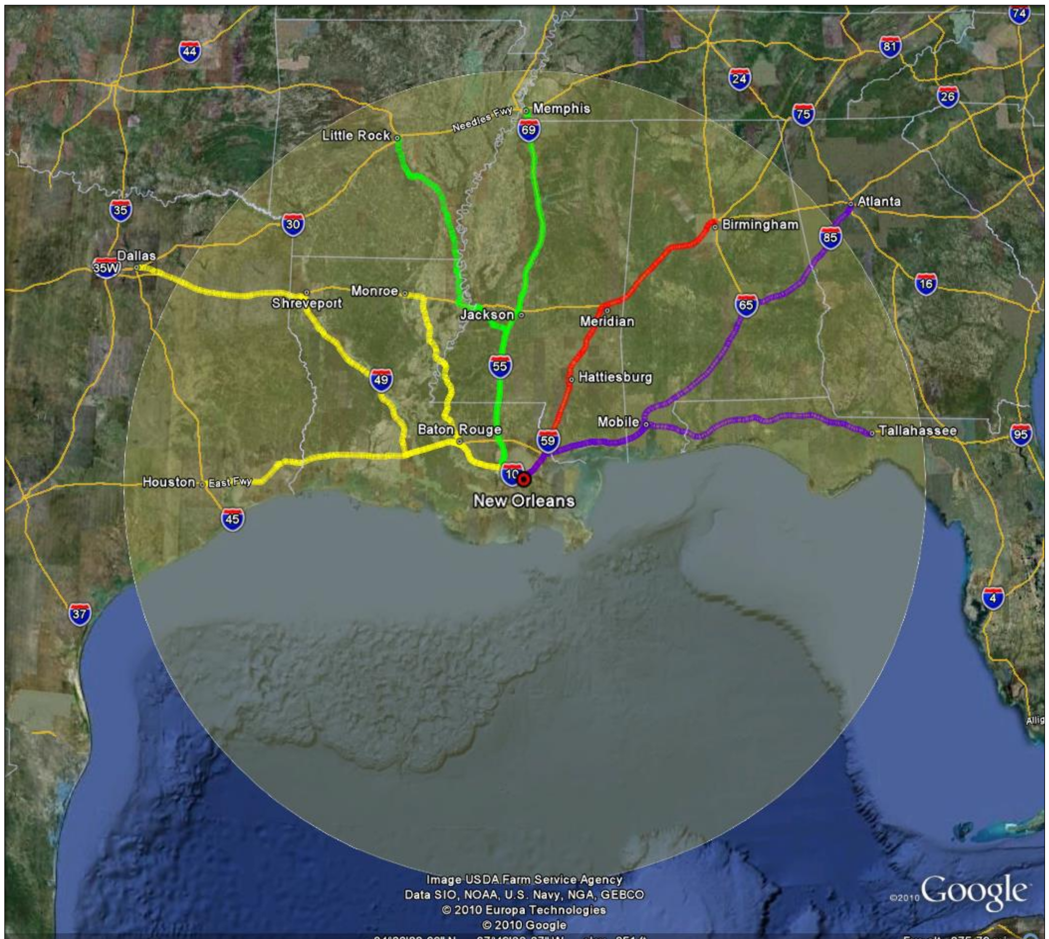


# *Regional-Level Modeling and Visualization*



# Scenario Testing and Evaluation

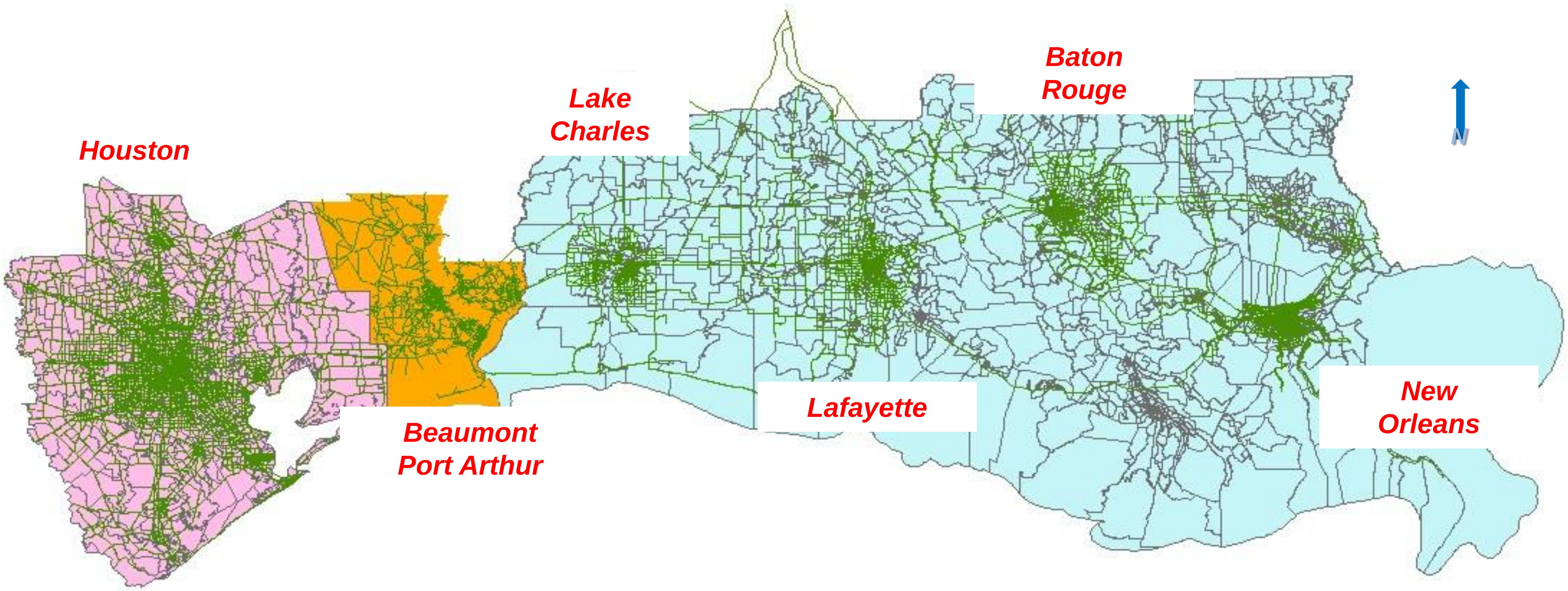
## *Analysis of "variable" hazards and responses*




- ***Temporal –***
  - ***More/less time to evacuate***
  - ***implementation of phasing strategies***
- ***Spatial –***
  - ***Storm size and direction of approach***
  - ***network management***

# Future Modeling

- *Police enforcement control*
- *MegaRegion evacuation network analysis*



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