

# HURRICANE FRANCES POST-STORM TRANSPORTATION ANALYSIS

## September 2005

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# **HURRICANE FRANCES TRANSPORTATION ASSESSMENT**

## **TRANSPORTATION AND EVACUATION**

The primary objective of the FEMA / USACE comprehensive hurricane evacuation studies (HES) is the calculation of clearance times. They are the amount of time needed to clear the entire evacuation road network of all evacuation traffic and convey those vehicles and their occupants to a point of relative safety. Clearance times are calculated for a variety of evacuation scenarios based on hurricane intensity, tourist occupancy and response timing, and are used by emergency managers to determine when to issue evacuation orders.

The transportation analysis combines variables from the vulnerability analysis (evacuation zones, vulnerable population and evacuating vehicles); behavioral analysis (response rates, participation percentages, intended destinations per evacuation zone); and shelter analysis (shelter use percentages and locations) into a hurricane evacuation transportation model. This transportation model emulates the characteristics of the evacuation roadway network during various hurricane evacuation scenarios to determine the most congested segments.

The most recent Transportation Analysis for the Treasure Coast Region, namely Palm Beach, Martin, St. Lucie, and Indian River Counties, was completed in 2004, while the hurricane evacuation transportation work for Broward and Dade Counties was finished in 2003.

The East Central Florida HES prepared in 1999 and the Northeast Florida HES, dated 1998 provided the clearance times used for evacuation planning purposes. The counties in the interior of north Florida and down the spine of central Florida were covered by the Cedar Key and Central Florida HESs respectively, both conducted in 1995.

Table 1 below provides the observations of local and state government representatives regarding evacuation and transportation related issues during Hurricane Frances. Transportation and clearance time issues discussed by the study teams with local and state officials for the Hurricane Frances event included the following:

- The perception of the roadway network's ability to meet evacuation traffic demand;
- The traffic control measures emplaced to improve flow or reduce congestion;
- The perceptions regarding how quickly the public responded to evacuation orders;
- The apparent volume of traffic during the evacuation;

- The duration of the evacuation event relative to clearance times; and
- Any traffic problems experienced during the evacuation.

## **COUNTY POST-STORM SURVEY RESPONSES REGARDING EVACUATIONS AND TRAFFIC CONDITIONS**

Below are the results collected from the emergency managers in counties impacted by Hurricane Frances. The responses below relate specifically to evacuations, protective action decision making and traffic control measures. The decision-making information specifically focuses on when evacuation orders were given and what areas or zones their decisions pertained to. Unfortunately, it is the decision making data that is frequently the least complete. This information is also very important in performing the types of analysis required for this document.

Twenty two of the 28 counties that were surveyed regarding their response operations during Hurricane Frances indicated that heavy traffic, congestion, traffic jams or gridlock characterized the road conditions during the evacuation. Two county emergency management offices indicated that traffic gridlock characterized the roadways in or near their jurisdictions for Hurricane Frances. The other predominant problem, irrespective of region, was the availability of fuel, and the lack of adequate signage and construction were also common issues during the Frances evacuations. Only one county that used the clearance times included in their HES indicated that they were insufficient for the magnitude of the storm. Interestingly, the county that indicated some degree of contention with their clearance times for this event had been updated the previous year.

Table 2 provides evacuation route information collected from officials of local governments surveyed during this effort. The data details what roadways are considered primary and secondary evacuation routes for residents and visitors within their communities. Where it was reported by local officials, Table 2 includes any anecdotal information regarding the observed traffic conditions in their areas. The table also indicates which roadways specifically referenced by local officials in their surveys are covered by a traffic counter or included in ETIS as an evacuation route.

## **ANALYSIS OF THE TRAFFIC COUNTER DATA**

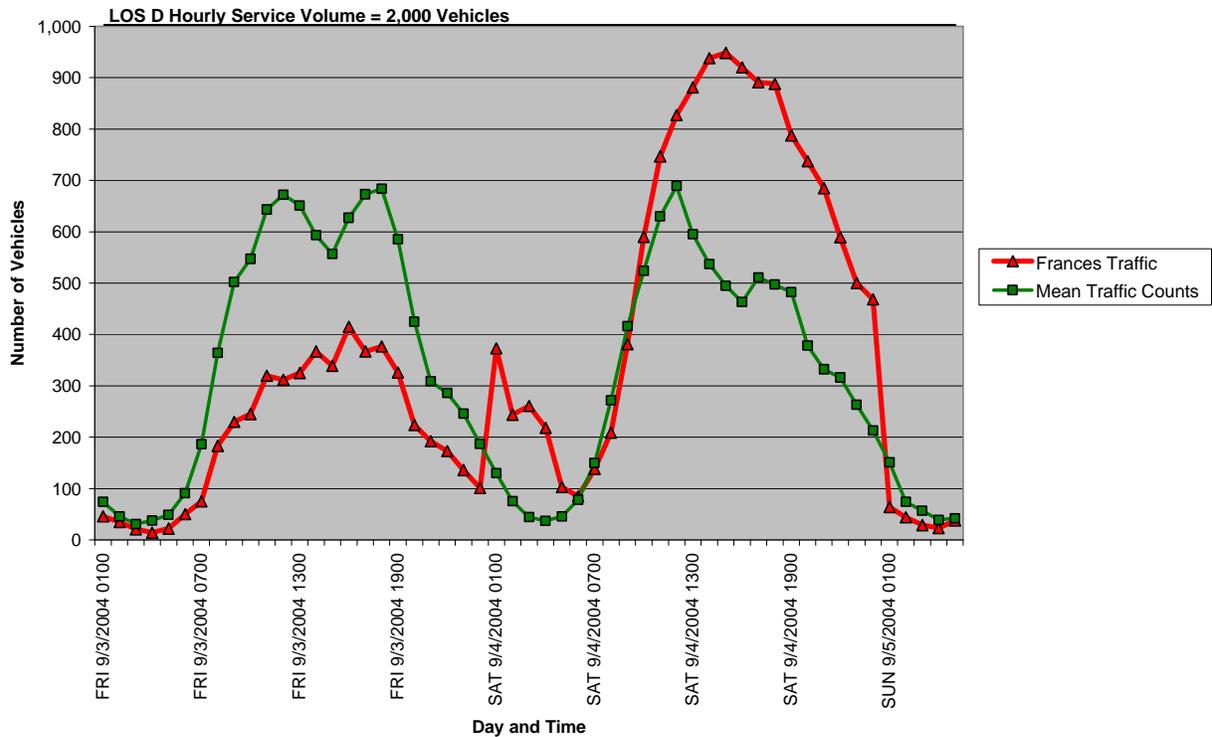
Florida has the benefit of strategically located traffic counters that record hourly counts as well as average speeds and provide that data in real time to a website that can be easily accessed. This system is called the Telemetered Traffic Monitoring System (TTMS) and was created specifically to address hurricane evacuation needs for the emergency management community at the state and local level. Analysis of the traffic counter data collected during Hurricane Frances indicates that although traffic was heavy throughout the statewide network, evacuation traffic congestion was not pervasive or persistent. From the counter data there were no discernable instances of gridlock on the roadway segments that had TTMS sensors. The following pages include figures graphically depicting the data collected at these counters during the evacuations for Hurricane Frances.

Unfortunately, although the traffic counters that were switched to emergency operational mode during Hurricane Frances recorded average speeds during the event, that data was not retained because of a software problem. Therefore, no average speed data is included in Table 3a through 3d for this report, as it has been with TTMS counter data in other post-2004 reports.

### **US 1 Northbound (TTMS Counter 0227)**

- The traffic counter (See Figure 1 and Table 3a) indicate that an abnormally high volume of traffic began moving northward in Monroe County first thing Saturday, September 4<sup>th</sup>, 2004 and continued for approximately one full day ending at midnight of the same day.
- This higher than normal traffic count occurred while the rest of the evacuations in Southeast Florida region were tapering off due to the arrival of tropical storm force winds in those more northerly jurisdictions.
- Traffic Counter 0164 on US 1 in Key Largo did not show a corresponding increase in the number of vehicles using that segment. This indicates that the trips, possibly attributable to evacuations in the Lower Keys were contained in Monroe County.
- During the time of increased traffic on US 1 on the segment near Big Pine Key during the Hurricane Frances event approximately 5,200 additional vehicles were recorded by that TTMS sensor.

**Figure 1. Frances - US 1 Northbound Near Big Pine Key (0227 NB)**



**Florida Turnpike Northbound (TTMS Counter 0417, 0421 and 0429)**

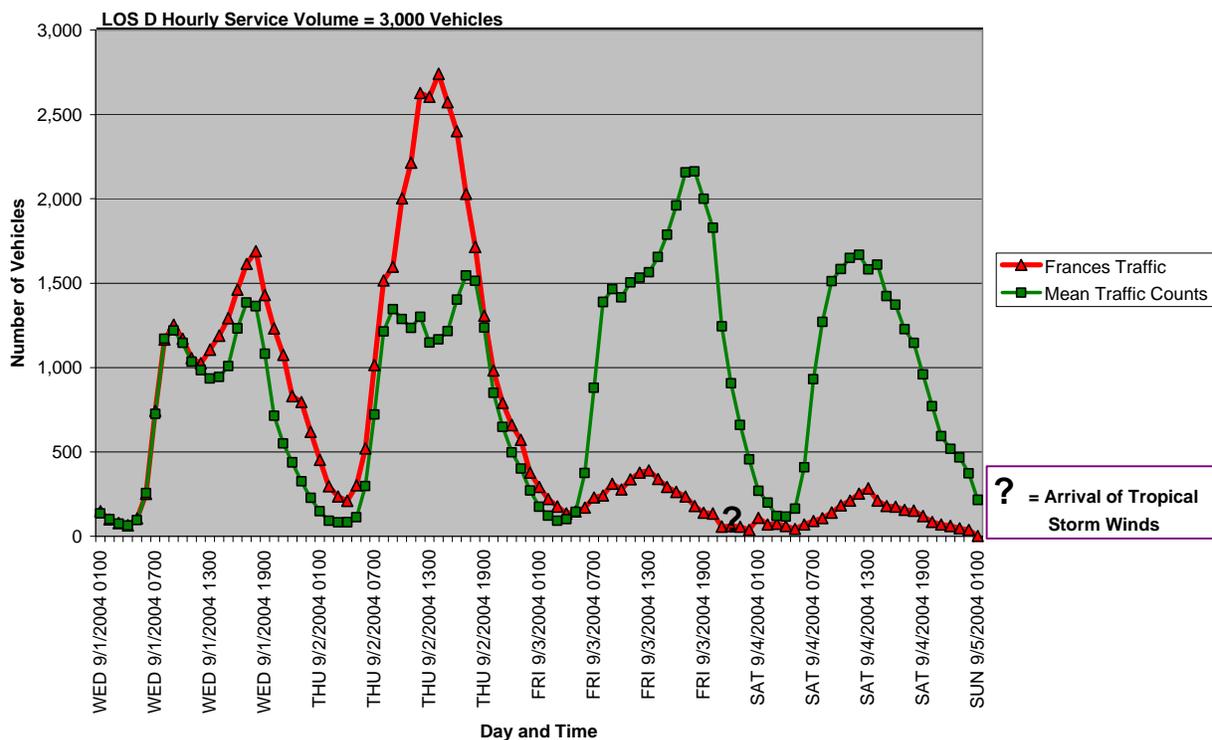
- These traffic counter (See Figures 2, 3 and 4 as well as Table 3a) in the northbound lanes of the Florida Turnpike indicated that increased hourly volumes, probably attributable to the evacuation for Hurricane Frances, began as early as 2:00 PM on Wednesday, September 1, 2004. The southernmost TTMS sensor on the Florida Turnpike near Jupiter (Figure 2) measured traffic volumes increasing 6 hours before the same sensor in the southbound direction recorded higher than normal volumes.
- The progression of the evacuation traffic can be followed up the Florida Turnpike with the next counter at Fort Pierce registering an increase in traffic volumes over ADT one hour later and the sensor at St. Cloud measuring an increase in traffic two hours after that.
- The traffic counters indicate that the evacuation probably began well in advance of the times that reportedly evacuation orders were issued by adjoining counties. In the case of Palm Beach County, the only one that provided an effective time for their evacuation orders during the post-Frances survey, the northbound traffic on the Florida Turnpike at Jupiter had already

increased to levels over ADT 24 hours beforehand. All other northbound and southbound traffic counters, even at the St. Cloud location, were measuring increased traffic volumes well before Palm Beach County's evacuation orders were issued.

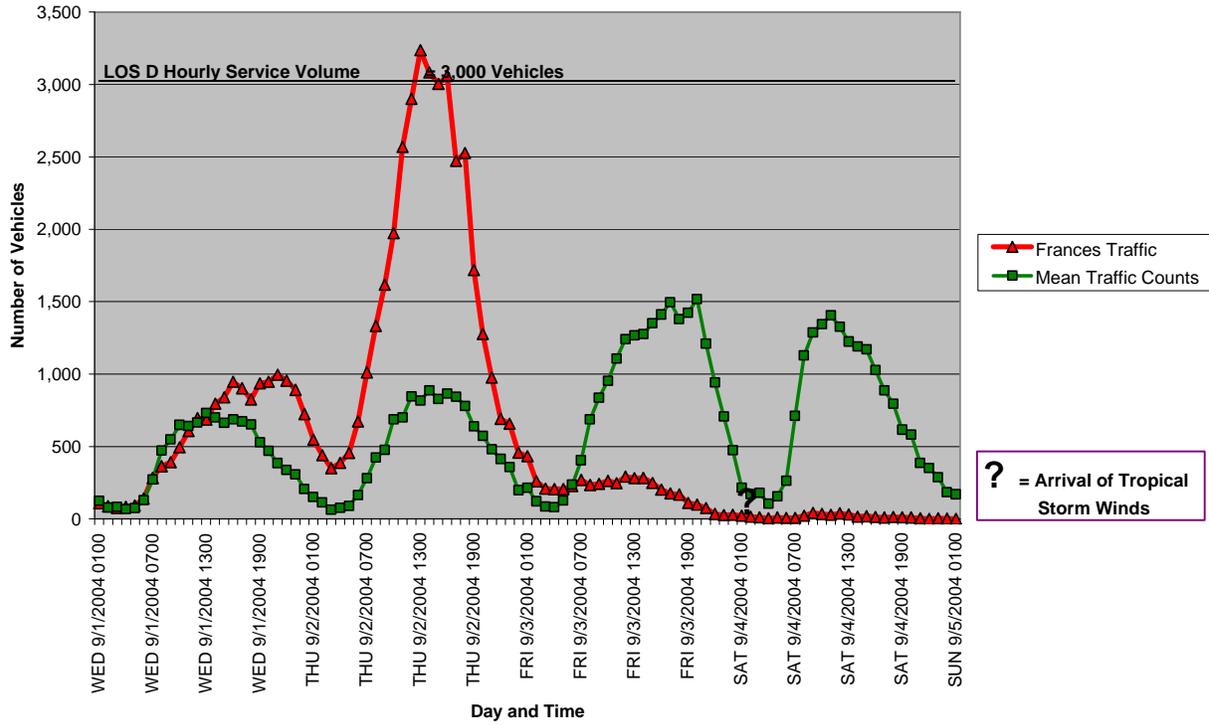
- The peak hour of traffic volumes occurred at different times for all three counters, but in reverse order from north to south with a separation of only three hours. The St. Cloud sensor reached its peak volume at 1:00 PM, September 2<sup>nd</sup>, the Ft. Pierce counter measured its peak hour at 2:00 PM followed an hour later by the Jupiter site.
- Only the TTMS counter near Ft. Pierce (Figure 3) exceeded its evacuation hourly directional service volume during the Hurricane Frances evacuation. From 1:00 to 4:00 PM, on September 2<sup>nd</sup>, the hourly volume of traffic was higher than 3,000 vehicles. Nonetheless, it does not appear that the high counts relative to capacity resulted in any restrictions to traffic flow, not only during this peak period but also at any other time during the evacuation.
- The period of higher than normal traffic ended in the same succession for all three counters as it had begun. All three counters in the northbound lane of the Florida Turnpike recorded 40 hours of higher than average traffic volumes. The number of vehicles dropped below ADT starting at the counter at Jupiter, followed an hour later at the Ft. Pierce sensor and two hours later at the St. Cloud site. By 4:00 AM on Friday, September 3<sup>rd</sup>, the traffic counts dropped precipitously to 272 vehicles from 1,403 measured just the hour before. Traffic counts at all three counters on the Florida Turnpike remained at consistently below ADT levels for the duration of the Hurricane Frances event.
- Interestingly, although the peak number of vehicles at the St. Cloud (See Figure 4) counter only attained 67% of the evacuation service volume figure, it appears that congestion or some other impediment to smooth traffic flow occurred during the Frances event. Between 12:00 PM, September 2<sup>nd</sup> and 12:00 AM September 3<sup>rd</sup>, the slightly erratic line which represents the recorded number of vehicles indicates that traffic was somewhat impeded during that time. Another indication of a possible traffic flow problem is the drop in two hours during the middle of the day of over 900 vehicles per hour. Unfortunately this speculation regarding traffic congestion or other issues at this site cannot be confirmed without the corresponding speed data.

- The traffic volumes recorded at all three sites on the Florida Turnpike had dropped off to consistently low levels by the arrived time of tropical storm force winds. All three counters measured very low traffic volumes for a significant number of hours before tropical storm force winds arrived.
- The traffic counter at Fort Pierce (Figure 3) recorded the highest number of additional vehicles over ADT during the evacuation period. The counter at Jupiter recorded 16,600 additional vehicles over ADT. The number had almost doubled to 30,400 vehicles at Ft. Pierce and then dropped off slightly to 27,300 vehicles at the counter near St. Cloud. These numbers indicate that over half the vehicles using the Florida Turnpike were probably from Palm Beach County and south. The other half of the additional vehicles counted on the Florida Turnpike probably originated in the Treasure Coast region with a majority of them continuing on to the greater Orlando metropolitan area.

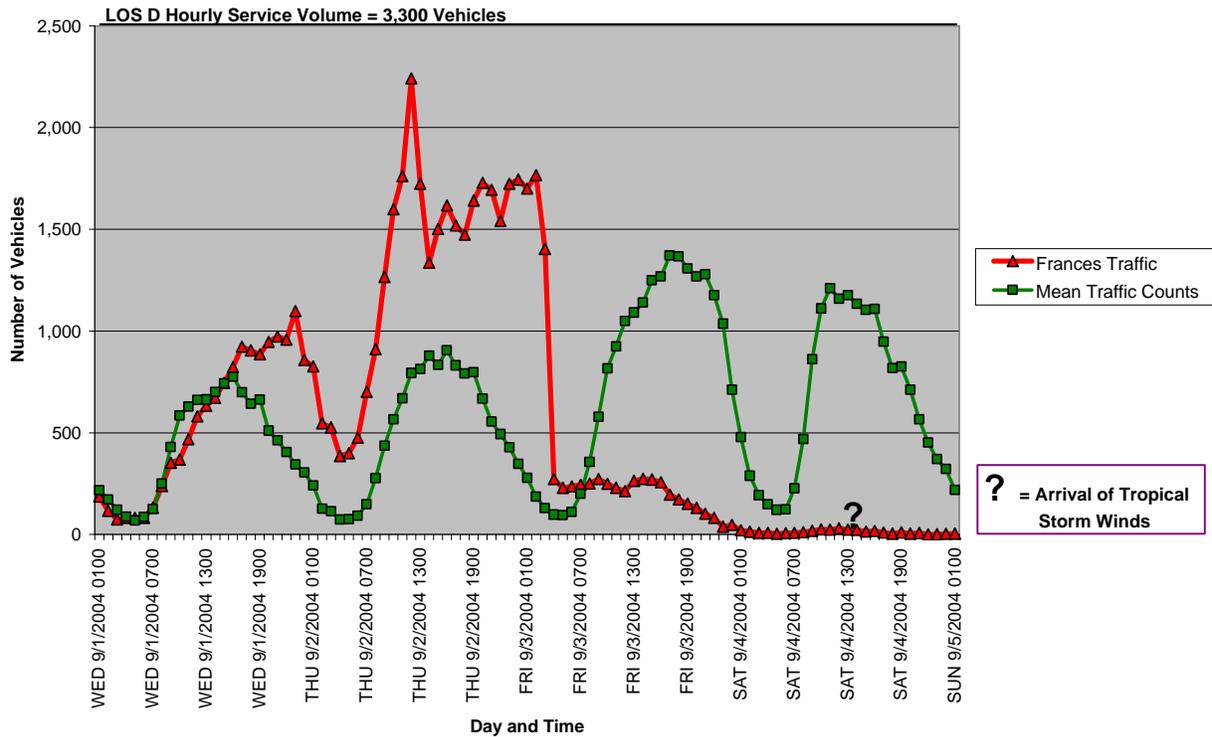
**Figure 2. Frances - Florida Turnpike Northbound Near Jupiter (0417 NB)**



**Figure 3. Frances - Florida Turnpike Northbound Near Ft. Pierce (0421 NB)**



**Figure 4. Frances - Florida Turnpike Northbound Near St. Cloud (0429 NB)**

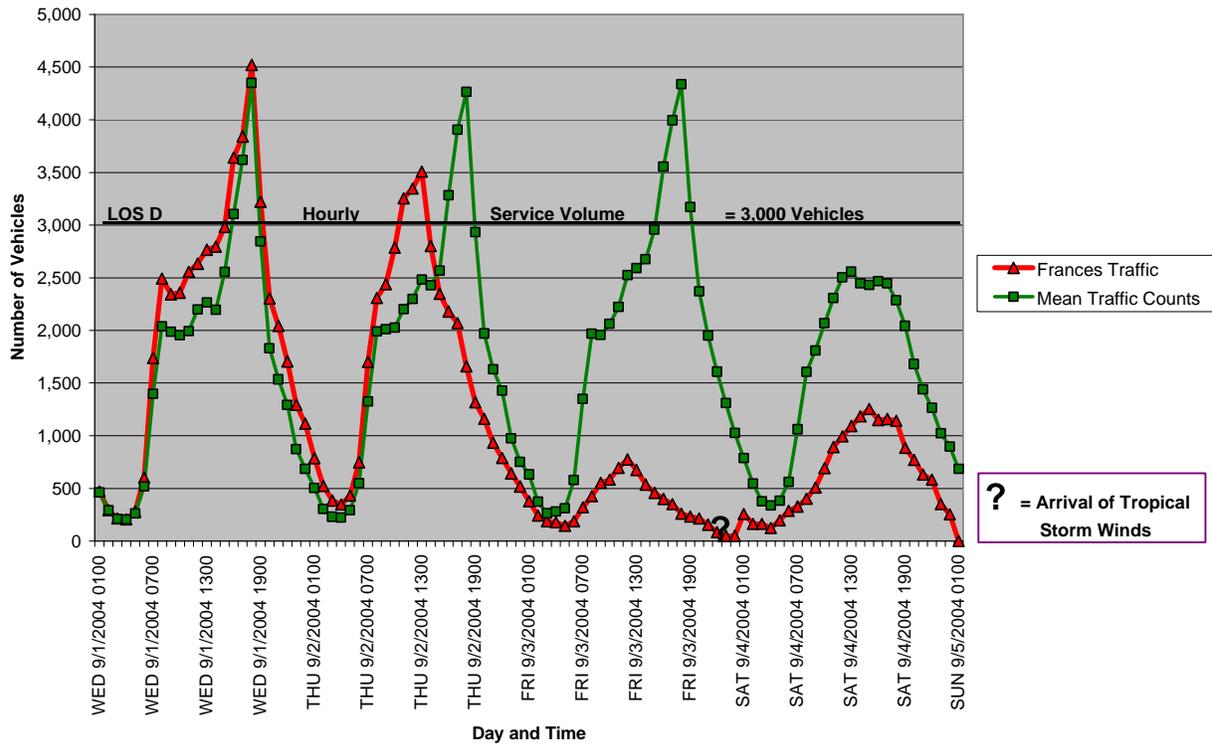


### **I-95 Northbound (TTMS Counter 0217, 0260, 0322, 0292 and 0132)**

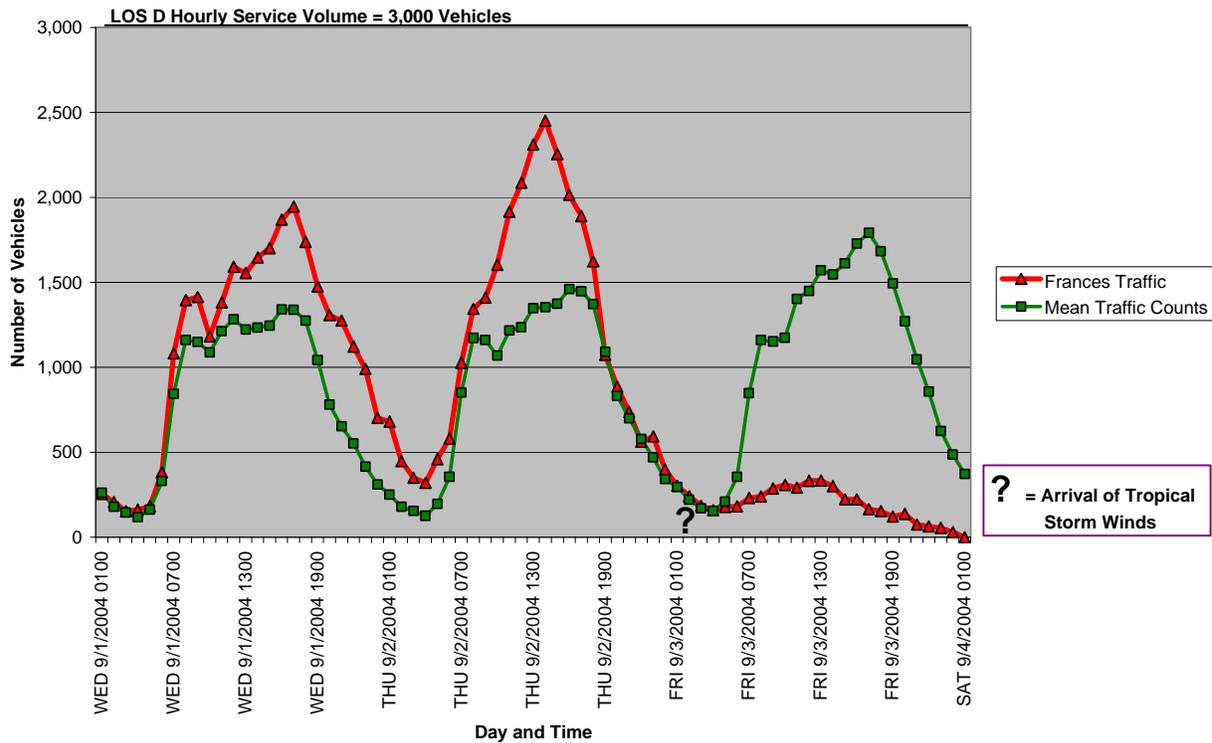
- The traffic counters on the northbound lanes of I-95 located near Jupiter in Palm Beach County (see Figure 5), near Ft. Lucie (Figure 6), near Mims in Brevard County (Figure 7), Bunnell in Flagler County (Figure 8) and the Florida-Georgia state line (Figure 9) show evacuation traffic increased with the distance north, culminating in over 50,000 additional vehicles (See Table 3a) entering Georgia before the landfall of Hurricane Frances.
- The first traffic counter to register an increase in northbound traffic on I-95 over normal volumes was site 0260 near St Lucie (Figure 6), beginning at 2:00 AM on Wednesday, September 1, 2004. The traffic counters just south and north on I-95, in Jupiter and Mims followed suit recording volumes over ADT by 6:00 AM on the same day. Four hours later, at 10:00 AM, the Bunnell site (Figure 8) was recording sporadic increases over normal traffic volumes and apparently the surge in the number of vehicles reached the northernmost counter in Florida by 2:00 PM.
- For the next day and a half traffic on I-95 the number of vehicles measured by all five sites remained consistently above the average hourly volumes. The shortest duration of increased traffic volumes, probably attributable to evacuations from Hurricane Frances, was at the southernmost counter in Jupiter with 36 hours while the longest period of additional vehicles over ADT was registered at the counter on the state line. These timeframes roughly coincide with the overall number of additional vehicles processed at each roadway segment with a TTMS counter.
- During the entire course of the evacuation event the total number of additional vehicles processed by each counter increased from south to north. The additional trips on I-95 apparently generated by the communities from Palm Beach County and below was 14,200 vehicles or 27% of the highest volume counted at the site on the state line; 1,500 vehicles more vehicles had joined the exodus at the counter near St. Lucie. The additional number of trips recorded at the Mims site indicates that another 28,700 vehicles, accounting for approximately 55% of all vehicles recorded on I-95, joined the fray on the segments from St Lucie northward to that location. The 6,300 new trips were registered between the counters at Mims and Bunnell and the communities north of Bunnell to the state line apparently contributed another 1,400 vehicles to the 52,100 additional vehicles that crossed the traffic counter heading into Georgia.

- Based on the traffic counts alone at four of the five counters on northbound I-95 relative to each of their hourly evacuation service volumes, it does not appear that any of those segments should have experienced significant congestion or other major traffic problems. All the peak hour traffic counts were well below the hourly evacuation capacity thresholds for those roadway segments.
- The saw-tooth character of the lines representing the traffic counts between 10:00 AM and 8:00 PM on September 2<sup>nd</sup> at the Mims site (Figure 7) and 11:00 AM to 11:00 PM on the same day at the Bunnell counter location provides some evidence of impediments to traffic flow, but those assertions cannot be confirmed with corresponding average speed data.
- Only the site near Jupiter (Figure 5) indicated that the hourly volumes during certain hours on September 1 and 2 actually exceeded the hourly evacuation capacity thresholds. Unfortunately, without average hourly speeds to coincide with those counts, it is not possible to definitively state whether traffic flow was impeded during that time.
- Except for the counter at the state line which was not assessed to not have received tropical storm winds, three of the four other stations on northbound I-95 were recording very low hourly volumes at the arrival time of tropical storm winds.
- Only the counter at Mims in Brevard County (counter 0322) registered a higher than average hourly count as tropical storm winds were arriving at that location on or around 2:00 PM on September 4<sup>th</sup>. Data from a counter (0223) in the eastbound lane of SR 407 near the Beeline Expressway (see Figure 18) indicates that hourly traffic volumes increased to levels above ADT starting at 1:00 AM on the morning of the 4<sup>th</sup> of September and continued until 1:00 AM on the 5<sup>th</sup>. The periods of higher than normal traffic volumes for both the SR 407 and I-95 at Mims counters coincide with one another and presumably are the result of possible evacuation orders in Orange and Seminole Counties. Unfortunately, without the effective time of any local evacuation orders, that statement cannot be confirmed. The correlation of the increase in hourly traffic volumes between the two counters would indicate that the eastbound traffic on SR 407 continued to I-95 and primarily headed north. Interestingly, none of the other activated counters on any of the other roadways heading eastbound from Orlando (on SR 520, the Beeline, and SR 50) to the coast recorded corresponding increases in traffic volumes during the 4<sup>th</sup> of September. Unfortunately it also appears that the I-95 northbound counter near Bunnell failed starting at 1:00 AM on September 4 so no data exists on how far north these additional eastbound trips on SR 407 traveled.

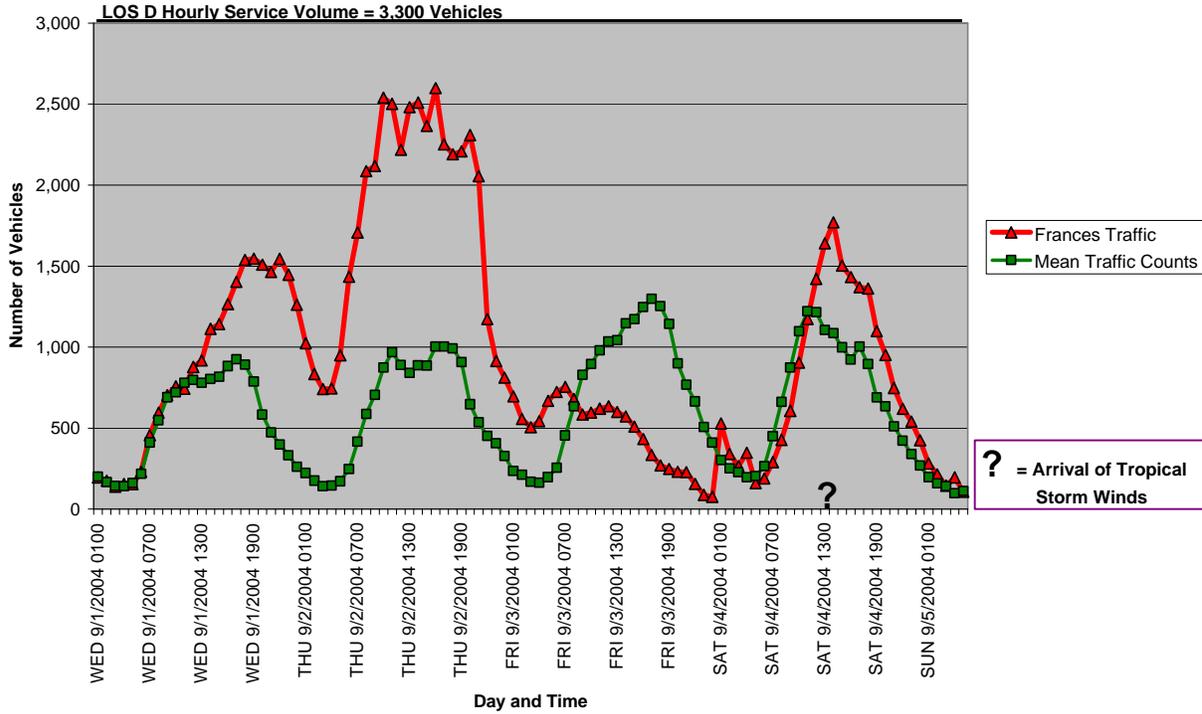
**Figure 5. Frances - I-95 Northbound Near Jupiter (0217 NB)**



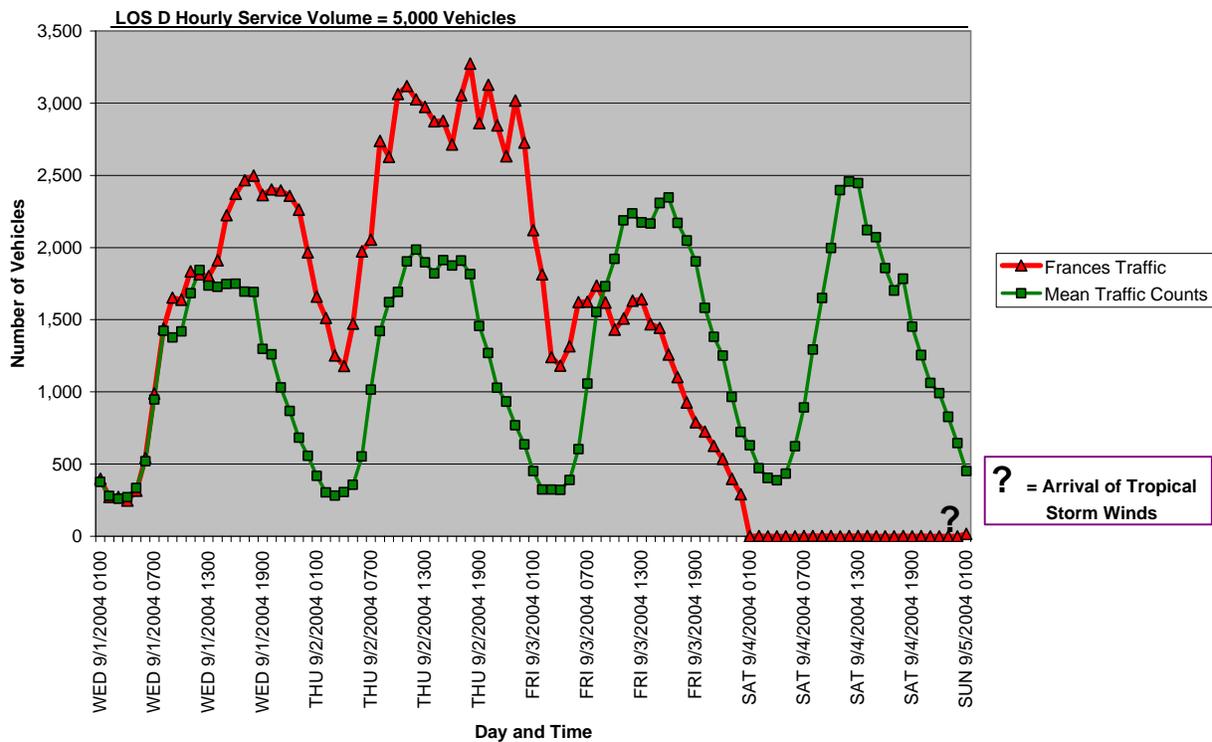
**Figure 6. Frances - I-95 Northbound Near St. Lucie (0260 NB)**



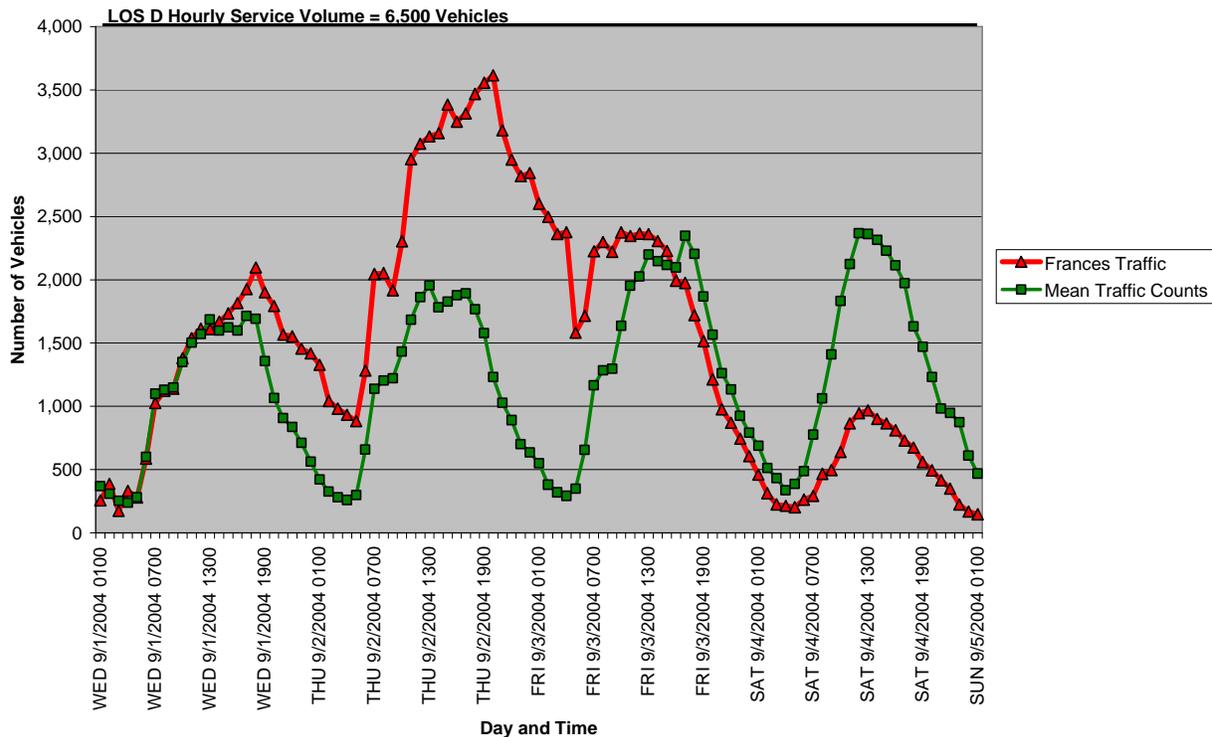
**Figure 7. Frances - I-95 Northbound Near Mims (0322 NB)**



**Figure 8. Frances - I-95 Northbound Near Bunnell (0292 NB)**



**Figure 9. Frances - I-95 Northbound Near Georgia Line (0132 NB)**

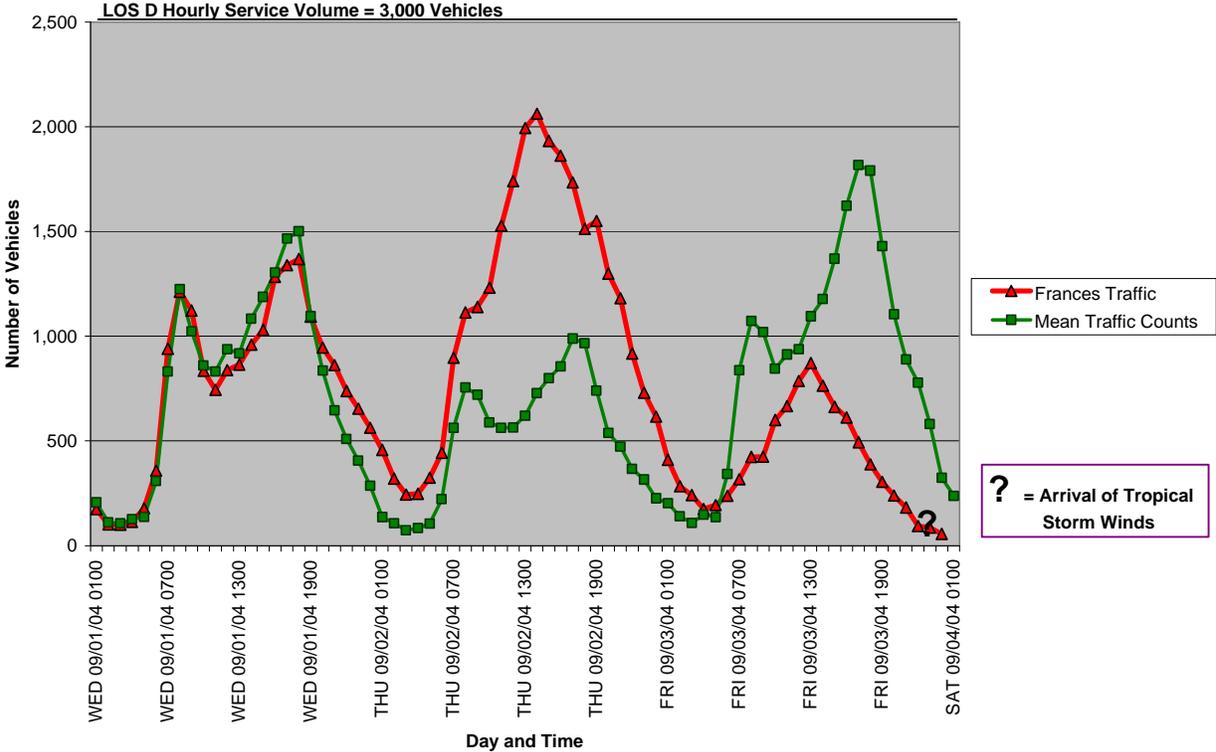


**Florida Turnpike Southbound (TTMS Counter 0417)**

- This traffic counter (See Figure 10 and Table 3b) measured traffic traveling southbound presumably from Treasure Coast region to the Southeast Florida, most likely to the greater Fort Lauderdale and Miami metropolitan areas. The increase in southbound traffic began as early 8:00 AM on September 1<sup>st</sup> and continued consistently for 35 hours ending at 5:00 AM, September 3.
- The hour of peak volume (2,062 vehicles) for the southbound movement of traffic on the Florida Turnpike occurred at 2:00 PM on Thursday, September 2. This peak in traffic volume coincided with an evacuation order for Palm Beach County and may well have occurred simultaneous with orders in other counties. Nonetheless, despite the reasonably long duration of heightened traffic flow, the recorded volume during that time constituted only 69% of the overall evacuation service volume for that segment of the roadway. Consequently, based on hourly directional volume data, there are no indications that traffic flow was at all impeded during this peak period, or at any other time during the evacuation.

- The overall additional number of vehicles recorded on the southbound lane of the Florida Turnpike near Jupiter was approximately 16,500 only 100 vehicles less than the number recorded in the northbound lane at the same counter.
- Despite a slight peak in traffic on Friday September 4<sup>th</sup>, those volumes did not approach even the normal average daily traffic (ADT). By the time tropical storm force winds arrived at the counter location, the traffic count for that hour was down to 56 vehicles.

**Figure 10. Frances - Florida Turnpike Southbound Near Jupiter (0417 SB)**

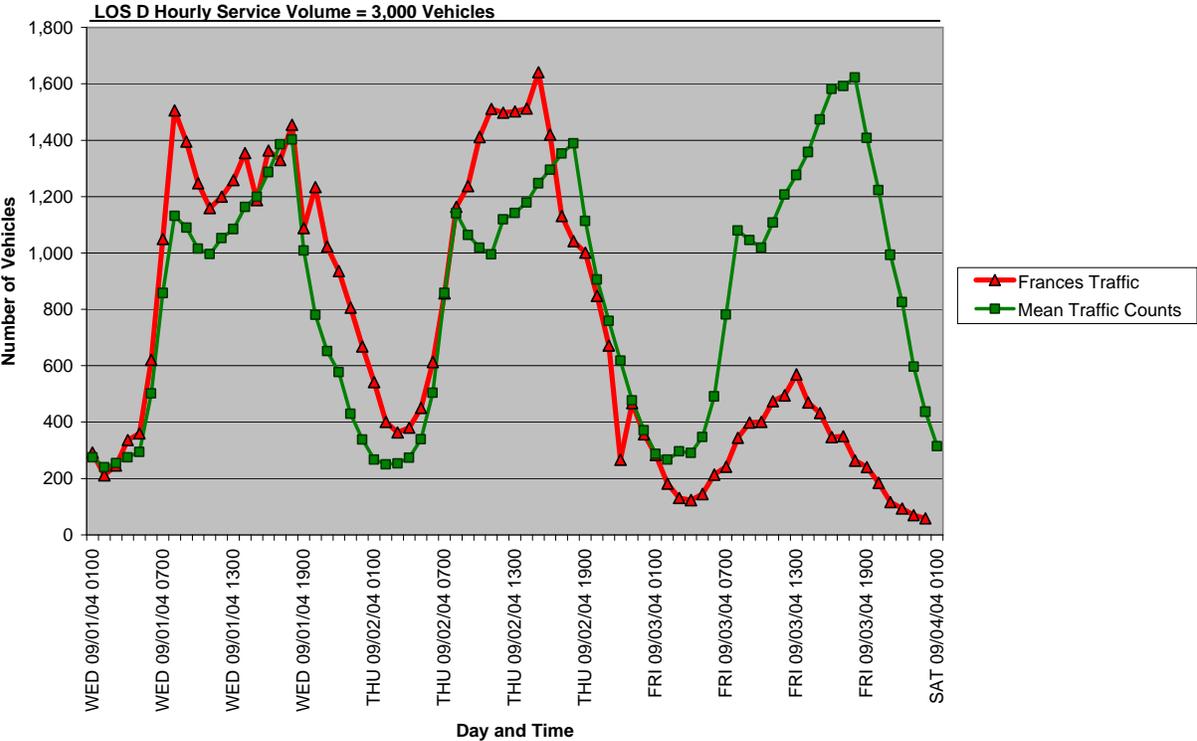


**I-95 Southbound (TTMS Counter 0260)**

- This traffic counter on I-95 near Ft. Pierce (see Figure 11) like its nearby counterpart on the Florida Turnpike (see Figure 10 above) registered a considerable amount of above normal traffic traveling southbound, most likely in response to the storm. Over 33 hours, from 5:00 AM on September 1, 2004 to 5:00 PM the next day, a consistent stream of traffic above ADT for that roadway segment used the southbound lane.

- Ultimately this southbound roadway segment processed over 7,600 vehicles (see Table 3b) before the traffic tapered off well in advance of the arrival of tropical storm force winds. The other southbound lane traffic counters on I-95 further south (0217 near Jupiter and 0163 near Ft. Lauderdale) indicate that approximately 80% of that traffic continued on to Palm Beach County with less than a quarter proceeding on to Broward County.
- The peak hour of traffic recorded by this traffic counter at 4:00 PM on September 2<sup>nd</sup>, occurred just before the traffic tapered off to less than ADT for the duration of the Hurricane Frances event. Even at its peak however, there are no indications that the recorded volume caused any significant congestion. The highest hourly volume processed by this roadway segment prior to the storm's arrival was 1,641 vehicles, barely more than 50% of its hourly evacuation service volume.

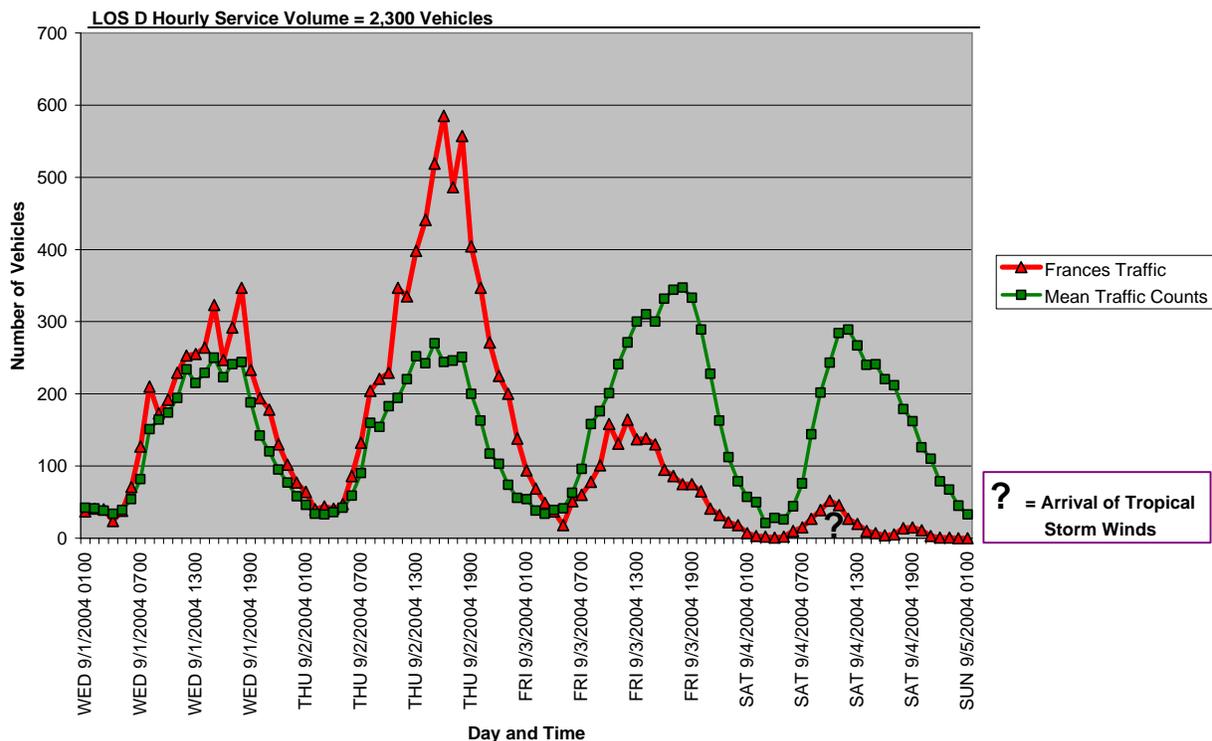
**Figure 11. Frances - I-95 Southbound Near St. Lucie (0260 SB)**



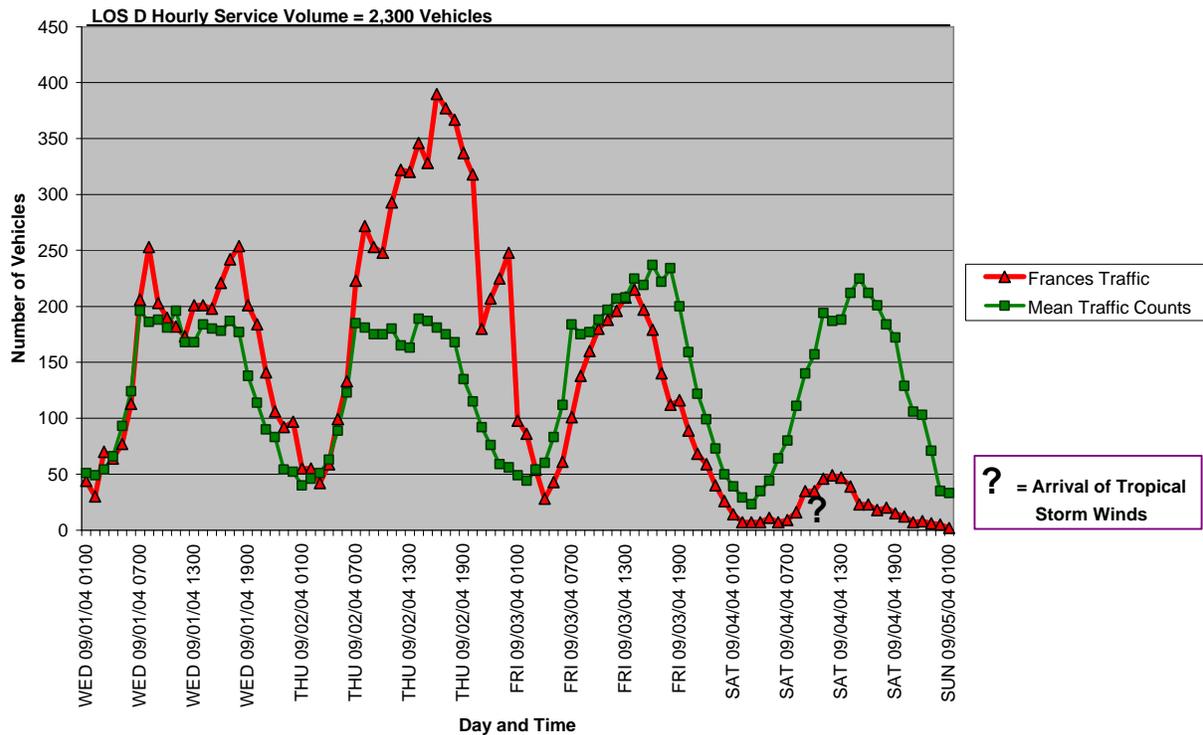
### US 27 Near Venus Both Directions (TTMS counter 0327)

- The traffic counters in both directions on US 27 (Figures 12 and 13) indicated that higher than normal traffic volumes traveled north and south on this roadway segment during the days preceding the arrival of Hurricane Frances.
- The northbound direction (see Table 3b) had the longest duration of higher than ADT traffic counts, 42 to 38 hours in the southbound lanes. Furthermore, slightly more traffic headed north past this particular segment of US 27 than the south. The northbound lane tallied approximately 3,700 additional vehicles prior to Hurricane Frances, while the vehicles traveling southbound totaled about 3,300.
- There are no indications that traffic flow in either direction became impeded during the period before the arrival of Hurricane Frances. In both cases the peak hourly volumes were one quarter or less of the hourly evacuation service volume. Additionally, the hourly traffic counts in both directions had dropped to negligible levels well before the arrival time of tropical storm force winds.

**Figure 12. Frances - US 27 Northbound Near Venus (0327 NB)**



**Figure 13. Frances - US 27 Southbound Near Venus (0327 SB)**

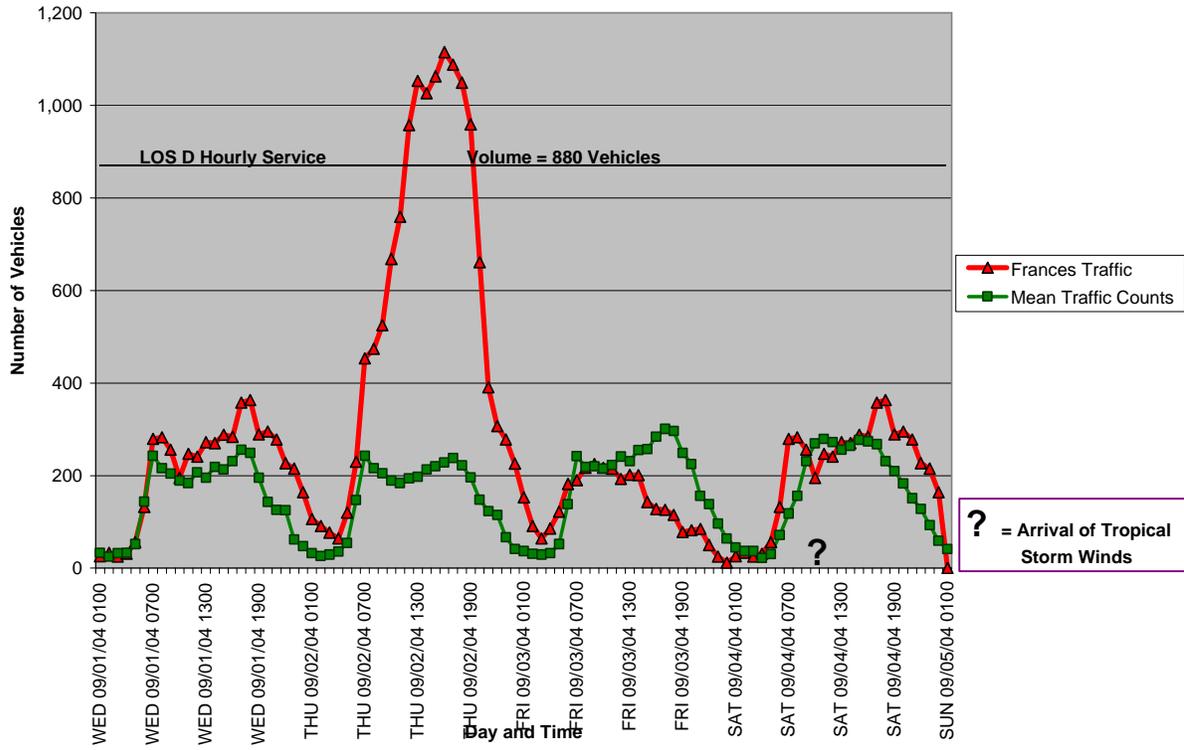


**Westbound Roadways (US 192, SR 520, SR 528, SR 407 and SR 50) from Brevard to Orange County (TTMS Counters 0065, 0113, 0336, 0223 and 104)**

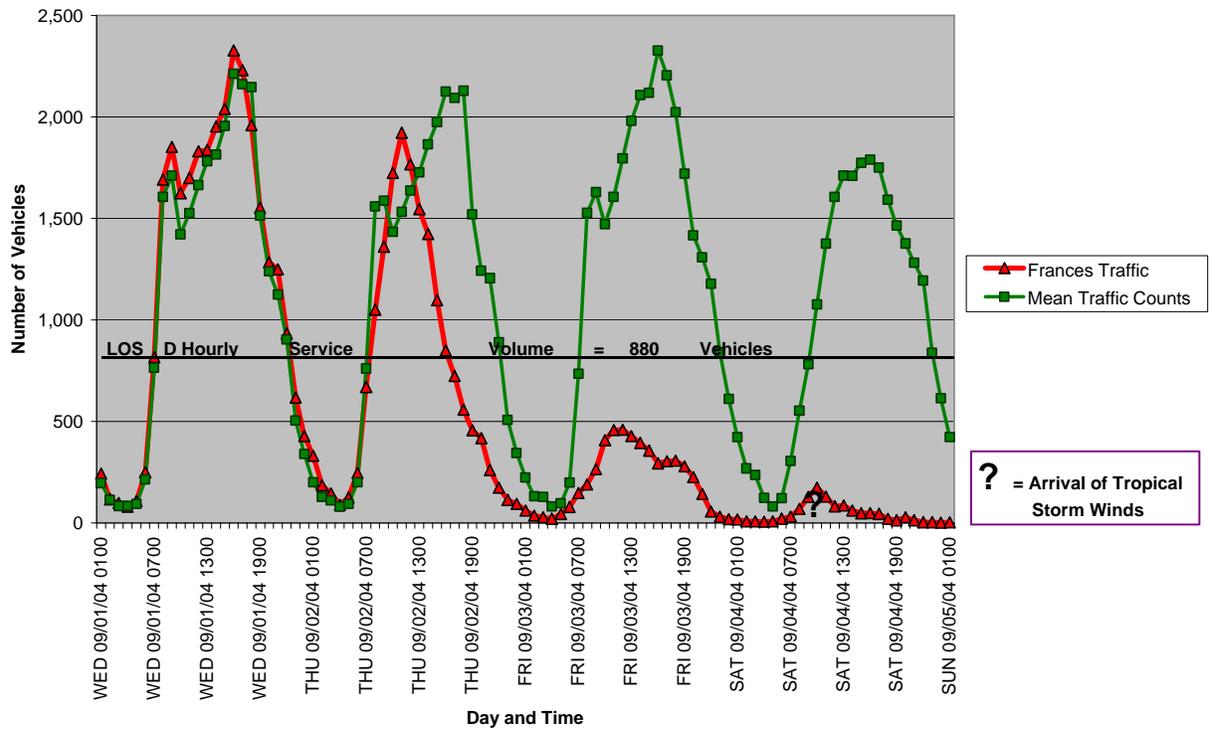
- The traffic counters on the westbound roadways that lead from the coast in Brevard County to the greater Orlando metropolitan area are located at US 192 near Holopaw (0065), SR 520 near Merritt Island (0113), SR 528 also known as the Beeline Expressway near Titusville (0336), SR 407 just east of its interchange with I-95 and SR 50 near Bithlo. Figures 14 through 17 provide the hourly counts and average daily traffic (ADT) figures for US 192, SR 520, SR 528, SR 407 respectively and Figure 19 details the same data for the counter at SR 50. The order of roadways in this report is south to north probably conveying mostly evacuation traffic originating in Brevard County. SR 407 eastbound (Figure 18) is discussed in the I-95 portion above.
- Beginning at 1:00 AM on September 1, 2004, the traffic counter on SR 407 (Figure 17) was the first to register an increase in westbound traffic on any of the roadways in this group. US 192 (See Figure 14) began recording higher than normal traffic counts at 9:00 AM on the same morning with the other counters following suit no more than two hours later.

- All of the counters registered hourly volumes only slightly above normal daily traffic all day September 1<sup>st</sup>. The amount of additional traffic at each counter was only slightly greater than the standard deviation for the ADT at each site. These figures indicate that a small portion of the population was spontaneously evacuating, leaving before an official order was possibly issued by Brevard County.
- A dramatic increase in hourly westbound traffic around 5:00 AM on the 2<sup>nd</sup> of September on most of the above roadways fixes the time that Brevard County likely issued its mandatory evacuation order for its coastal and mobile home residents. The increase in westbound traffic is most evident on US 192 which is the primary westward evacuation route for Melbourne and the southern portions of the county. It is not likely that evacuees from other jurisdictions would use that route for evacuations purposes.
- Most of the counters on this group of roadways measured higher than average hourly traffic counts for significantly more than one day. US 192 had the longest duration of higher than ADT counts at 46 hours while SR 520 (Figure 15) a less popular evacuation route only conveyed increased traffic counts for 23 hours.
- Based on the assumption that most trips heading westbound on these roadways originated in Brevard County, the additional vehicle totals for the likely Hurricane Frances evacuation period provide a good indication of the distribution for most out-of-county evacuation traffic. The evacuation roadway with the highest total number of vehicles over ADT was the Beeline Expressway (See Figure 16) with 17,300 or 49% of all out of county trips; US 192 with 33% or 11,700 vehicles; SR 50 with 4,600 or 13% and SR 520 with 5% at 1,700 vehicles.
- Only US 192 (Figure 14) and SR 520 (Figure 15) experienced peak hourly flows that exceeded the hourly evacuation service volume. Both roads have limited hourly capacity, so both routes suffered an extended number of hours with higher than evacuation threshold counts. Unfortunately, without the average speed data for these counters it is not possible to definitively gauge the amount of congestion or other impediments to traffic flow. The same statement applies to the other routes; however none of them experienced peak traffic counts that surpassed their hourly evacuation service volume.
- All the roadways in the group of evacuation routes were reasonably clear of vehicles by the time tropical storm force winds arrived at each counter location. Only US 192 was conveying near normal hourly traffic numbers when those winds supposedly arrived in South Brevard County. Nonetheless, the normal traffic counts on this roadway do not appear to be due to any vehicle processing backlog caused by congestion or road closure in previous hours.

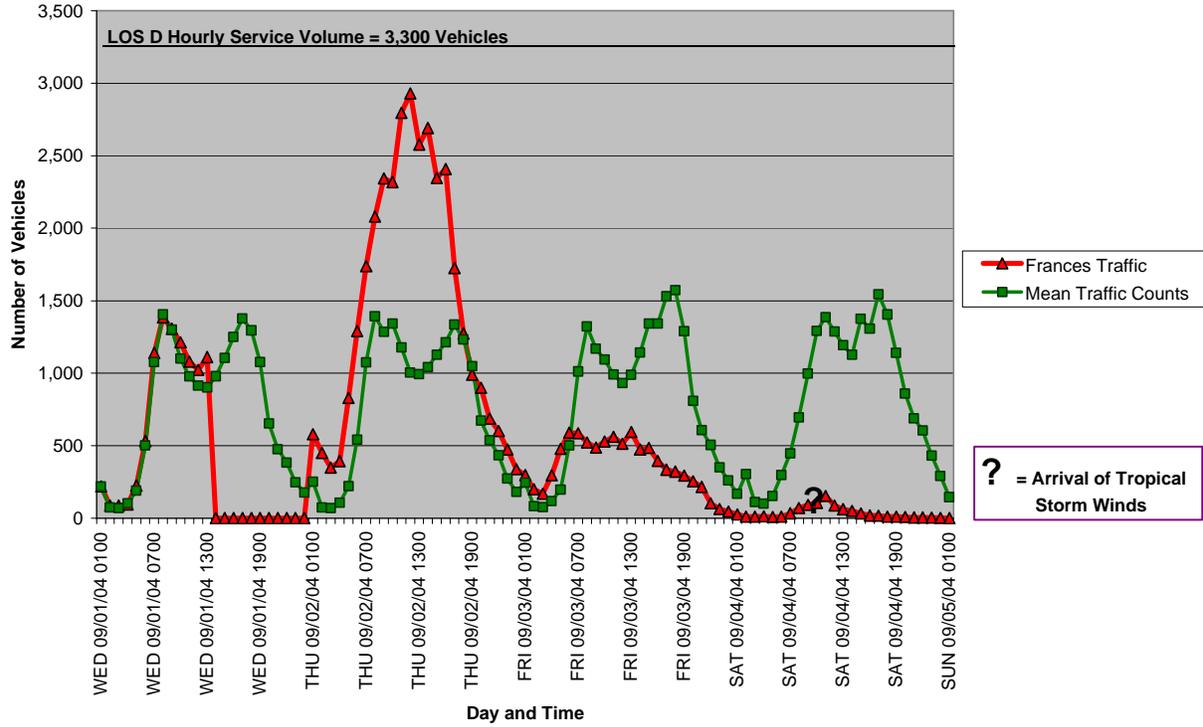
**Figure 14. Frances - US 192 Westbound Near Holopaw (0065 WB)**



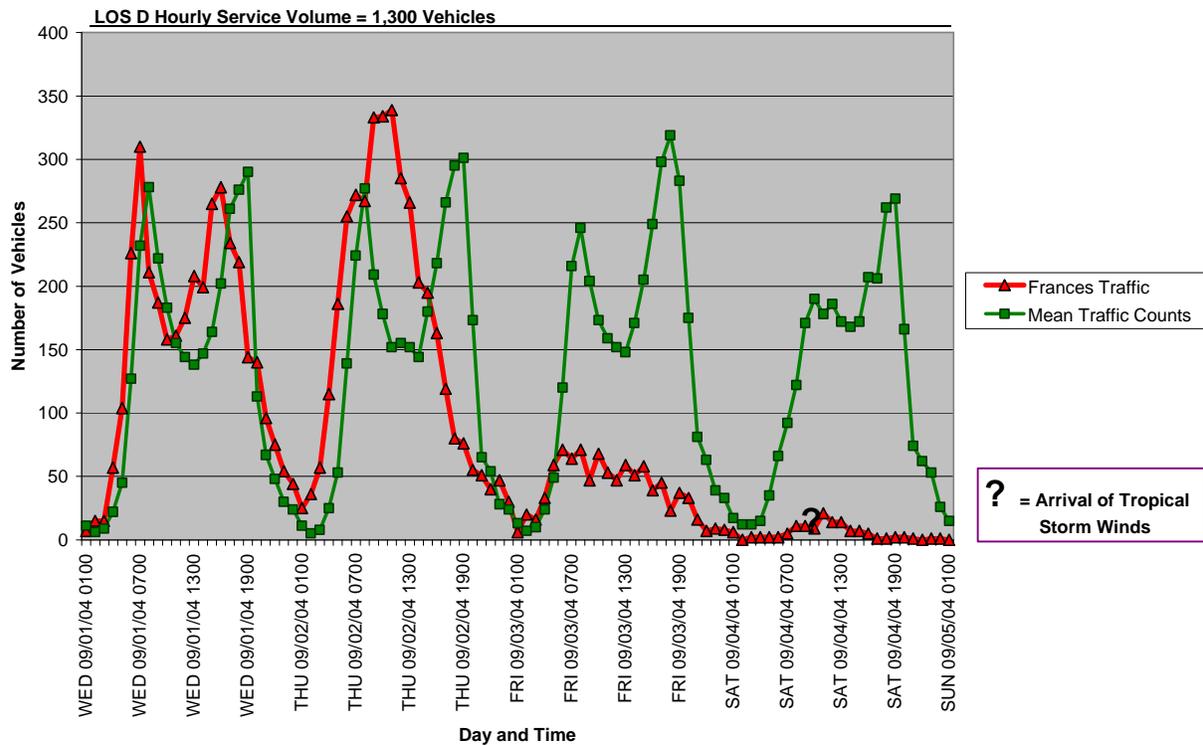
**Figure 15. Frances - SR 520 Westbound Near Merritt Island (0113 WB)**



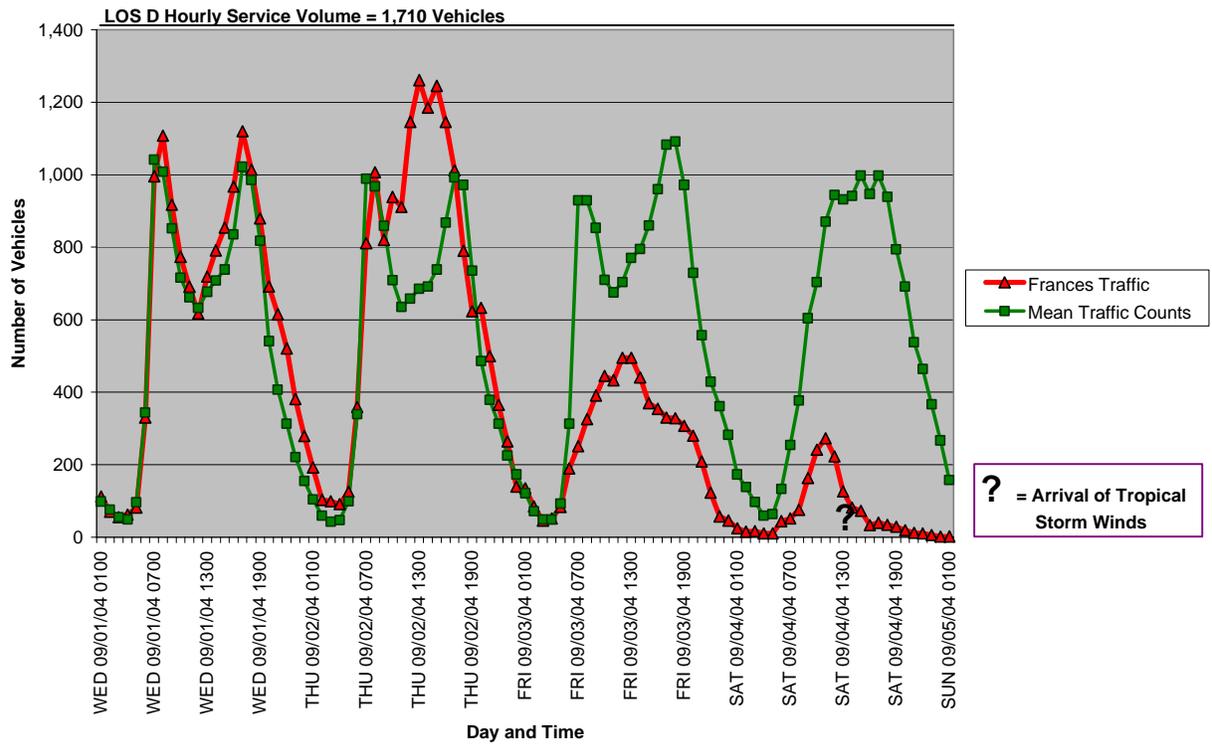
**Figure 16. Frances - SR 528 Westbound Near Titusville (0336 WB)**



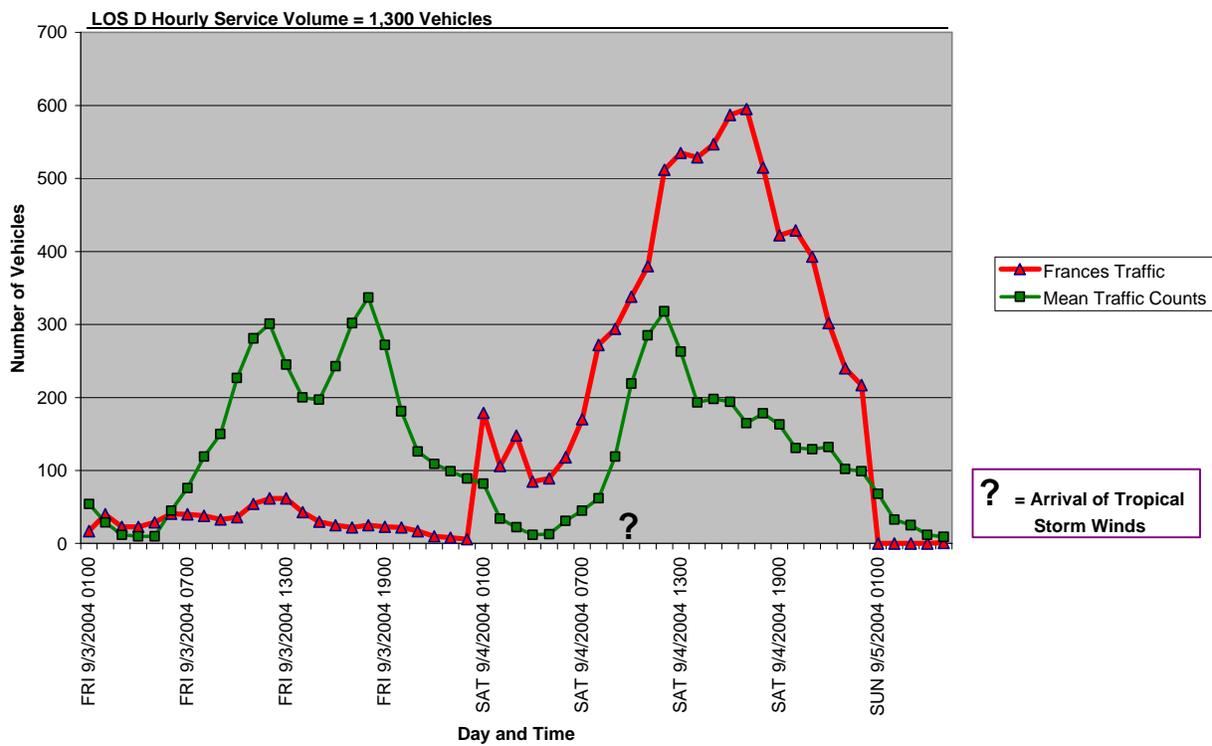
**Figure 17. Frances - SR 407 Westbound Near Beeline (0223 WB)**



**Figure 18. Frances - SR 50 Westbound Near Bithlo (0104 WB)**



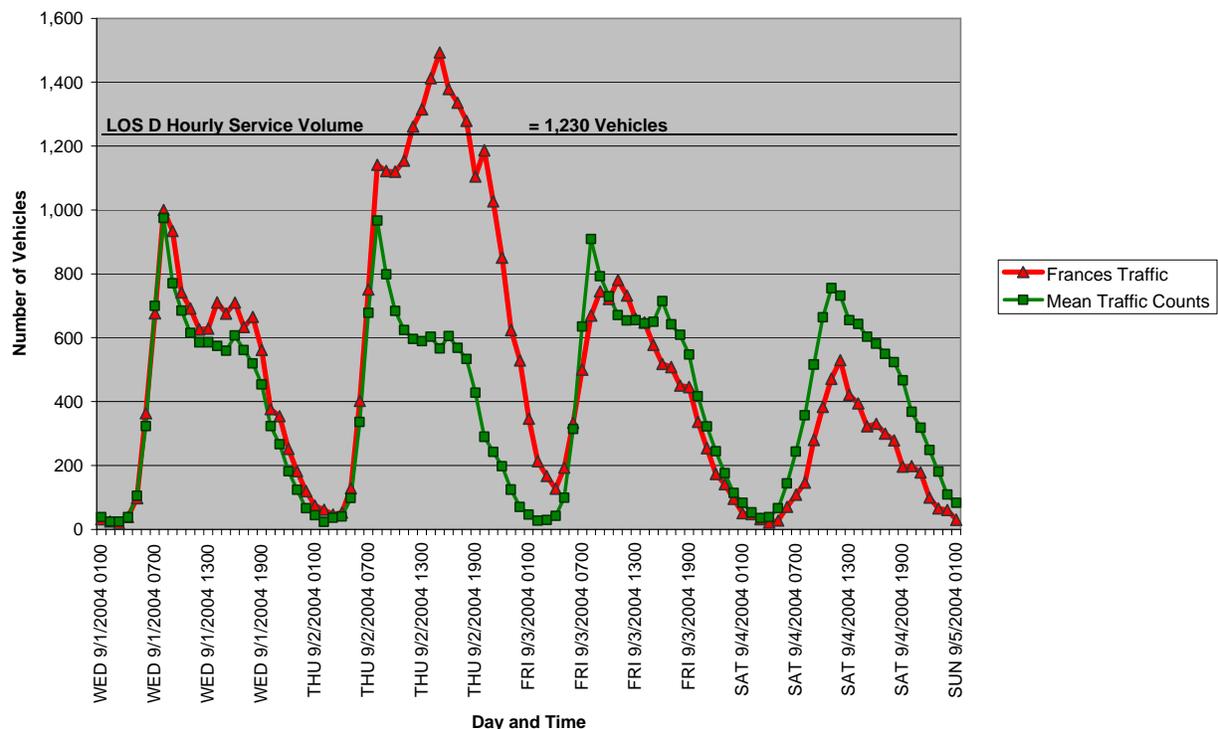
**Figure 19. Frances - SR 407 Eastbound Near Beeline (0223 EB)**



## US 17 Northbound (TTMS Counter 0105)

- This traffic counter (see Figure 20) is located near San Mateo in Putnam County and is noteworthy for the relatively large number of vehicles over ADT were recorded using this route during the days before the arrival of Hurricane Frances. In the 48 hours that this segment on US 17 processed above average traffic prior to the hurricane, approximately 14,500 vehicles traveled in the northbound direction away from the coast to more inland locations, probably in Florida.
- Interestingly, the increase in traffic above normal daily figures at 9:00 AM on September 1<sup>st</sup>, 2004, began on this roadway before the closest segment with a TTMS counter on I-95 (0292 near Bunnell-see Figure 8) started to register higher than normal traffic volumes.
- This counter indicated that between 12:00 PM and 6:00 PM on Thursday, September 2<sup>nd</sup> the hourly traffic volumes increased to above the hourly evacuation service volume for this roadway. The peak hour registered 1,493 vehicles, 263 vehicles over the hourly directional capacity of that segment during evacuations. Nonetheless, without average speed data from the counter any statements about congestion or other traffic issues on this roadway are conjecture.

**Figure 20. Frances - US 17 Northbound Near San Mateo (0105 NB)**



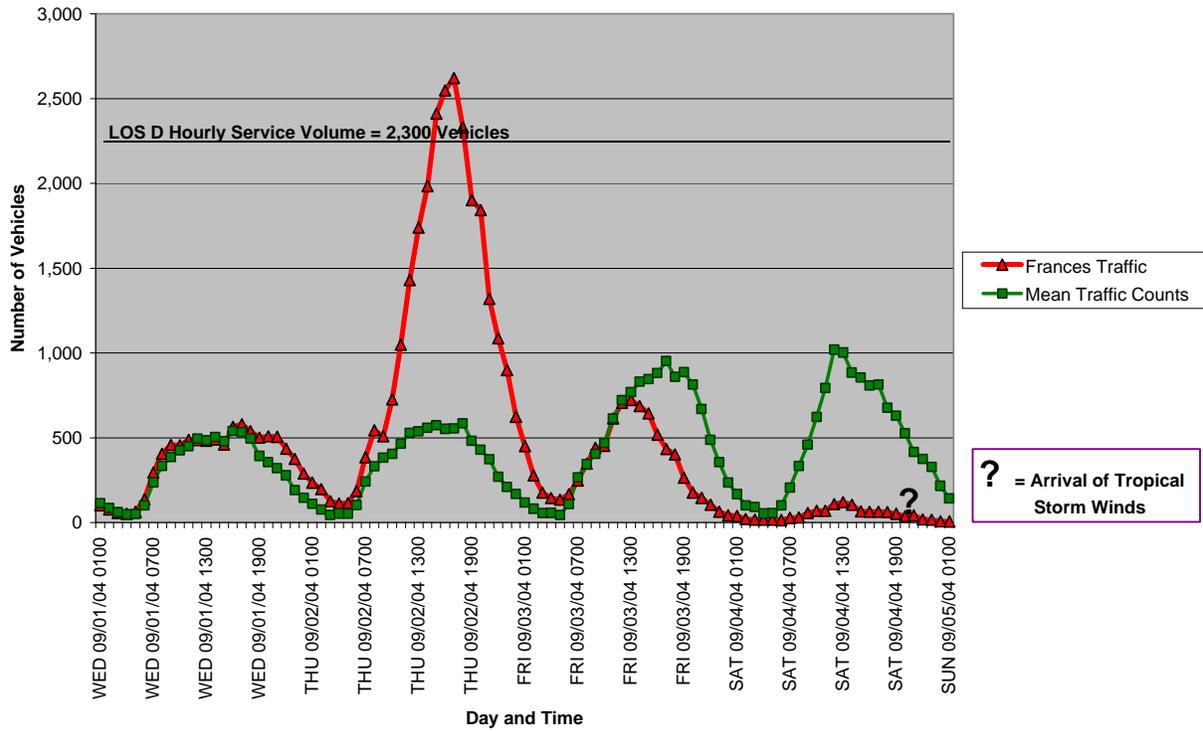
### **I-75 Northbound (TTMS Counters 0351, 0350, 0225, 0190, 0358, 0317 and 0112)**

- During the Hurricane Frances event, I-75 was well served by an extensive array of operational TTMS counters that extended from Goldengate in Collier County to the Florida-Georgia border. The operational traffic sensors on I-75 were 0351 (Figure 21) at the western end of Alligator Alley; 0350 (Figure 22) near Punta Gorda in Charlotte County; 0225 near Sarasota (Figure 23); 0190 in the vicinity of Zephyrhills in Pasco County (Figure 24); 0358 in the area around Bushnell in Sumter County (Figure 25); 0317 just south of Ocala (Figure 26); and 0112 close to the state line with Georgia (Figure 27).
- Like a majority of the traffic counters on other major evacuation routes, almost all of the stations on I-75 began recorded higher than normal daily average volumes early on the morning of Wednesday, September 1<sup>st</sup>, well before any official evacuation orders were reportedly issued by the counties on either coast.
- As a consequence to this apparent early mobilization by the citizens and visitors of Florida, all of the traffic counters observed volumes above ADT for approximately two full days, between 44 and 67 hours. The number of hours above average hourly volumes measured at each site (See Table 3c) coincides well with the number of additional cars processed during the hours preceding the arrival of Hurricane Frances and the hourly evacuation service volume for that roadway. The segment on I-75 near Bushnell (Figure 25) had the highest number of hours over ADT at 67, even though the portion of that roadway near the state line processed more than double the number of additional vehicles. The Bushnell segment only has an hourly evacuation service volume of 2,300 vehicles while the state line roadway can process a total of 4,500 vehicles an hour.
- During the more than two days of consistent above average traffic on I-75 a total of nearly 70,000 vehicles were conveyed from south to north up the “spine” of Florida and ultimately into Georgia.
  - The counters south of Tampa Bay recorded between 21,000 and 30,000 vehicles over ADT during the approach of Frances. It then appears based on the number of additional vehicles recorded during the evacuation event that approximately 8,500 vehicles either found refuge in Tampa Bay or chose other roadways, such as I-4 to travel into the interior of Florida.

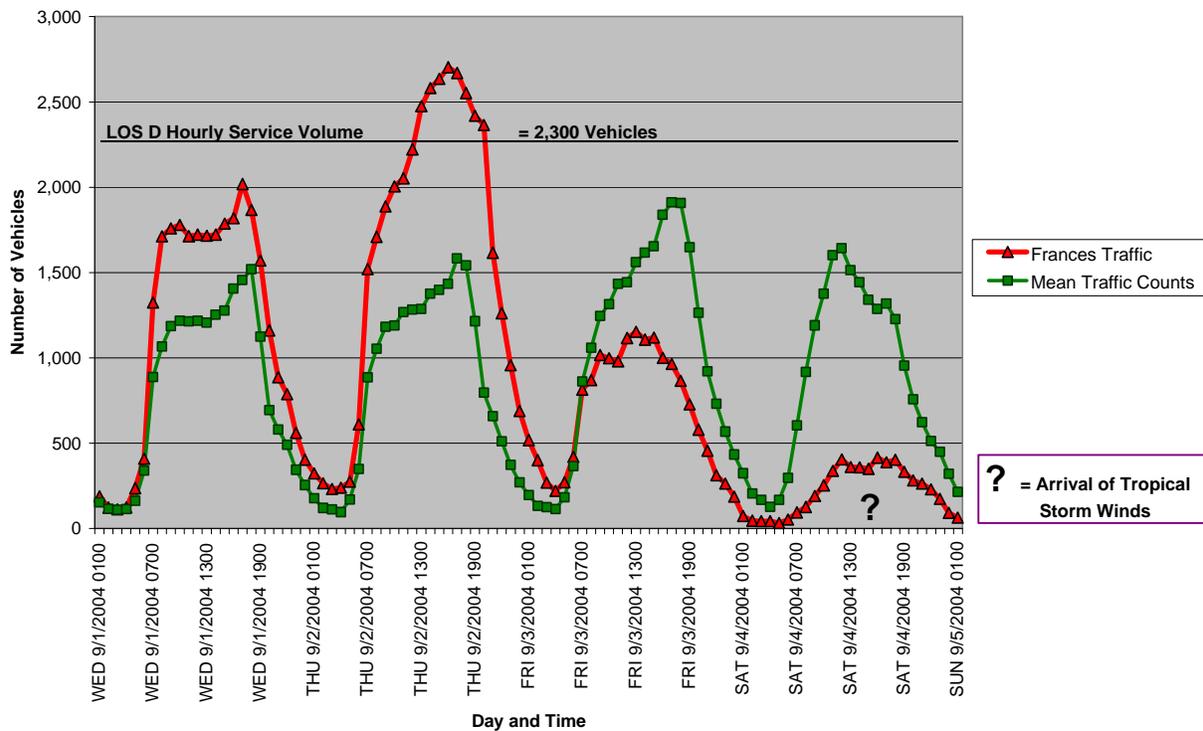
- The TTMS counters between Tampa Bay and the Florida Turnpike on I-75 reflect the reduction in the total number of additional vehicles in the area around Hillsborough County. However at the site in Bushnell, it appears that many new vehicles were introduced into I-75 traffic stream by the counties or the east-to west evacuation routes in the Tampa Bay region.
  - The traffic volume traveling north out of the Tampa Bay region on I-75 toward its junction with the Florida Turnpike required the most amount of roadway processing time, 67 hours of higher than normal hourly traffic volumes. This long duration of higher than normal traffic was attributable not only to the volume of additional vehicles over normal daily trips, but also to the limited capacity (2,300 vehicles / hour) of that 2-lane portion of the interstate highway.
  - Additionally, a large number of additional vehicles were apparently introduced onto I-75 by the Florida Turnpike. The traffic counter in Ocala on I-75 recorded 30,000 additional trips were processed by that segment of roadway over the next TTMS station south in Bushnell.
  - Finally, between Ocala and the Florida Georgia State Line apparently an additional 9,700 trips were further added to the overall number of vehicles processed by I-75 in the days before Hurricane Frances. The counter on near the state line indicated that almost 77,000 vehicles traveled into Georgia between September 1<sup>st</sup> and September 3<sup>rd</sup>, 2004.
- Five of the seven operational traffic counters on I-75 registered peak hourly volumes that exceeded the hourly evacuation service volumes of their particular segments. Interestingly the only two sites that did not measure hourly volumes higher than the theoretical hurricane evacuation roadway capacity did have the longest duration of higher than ADT volumes, i.e. Bushnell and the Florida - Georgia state line.
- Most of the peak hour incidences at all of the I-75 counters with higher than the hourly evacuation service volumes occurred roughly the same times in mid-afternoon of September 2<sup>nd</sup>. This is consistent with reports that Palm Beach County and presumably other counties in the Treasure Coast region issued their evacuation orders early in the afternoon of the same day. It is not likely that the increase in traffic counts would be primarily attributable to evacuations from the west coast counties since none were ordered there until the 4<sup>th</sup> of September.

- The counters above the Florida Turnpike on I-75 indicate that rather than a peak hour, those segments conveyed a steady and high volume of traffic from the morning of September 2<sup>nd</sup> until mid-morning on September the 3<sup>rd</sup>. The many peaks and valleys during this consistently high period of traffic volume on those roadway segments provide an indication that the amount of traffic was causing some problems with the smooth flow of vehicles. The data from the traffic counters supports anecdotal information that the volume of traffic coming into their state on I-75 concerned officials in Georgia enough that they were willing to implement a one way plan on I-75 to address it.
- Based on the traffic counter data at the Bushnell station, the traffic coming up I-75 through Southwest Florida did not impact the roadway south of the interchange with the Florida Turnpike as much as the evacuation orders in the Tampa Bay region. The peak hour of traffic for that segment of I-75 did not occur until 3:00 PM on September 4<sup>th</sup> which coincided with evacuation orders issued in the Tampa Bay region. Interestingly, those evacuation high September 4<sup>th</sup> volumes measured at the Bushnell site apparently did not continue on to Ocala since the recorded hourly volumes at that station were almost flat; the highest hourly count on I-75 near Ocala was 117 vehicles.
- Despite indications of some traffic issues at various points along I-75, all but the Bushnell segment was clear of the high volumes of traffic by the arrival time of tropical storm force winds. The situation at the Bushnell site was caused by the late spike in traffic beginning on the September 4<sup>th</sup>, but the last hour of higher than normal traffic at that site coincided with the hour that tropical storm force winds reached that location at midnight on September 4. By 1:00 AM on September 5<sup>th</sup> the traffic counts at that station dropped from 1,133 the hour before to 90 vehicles.

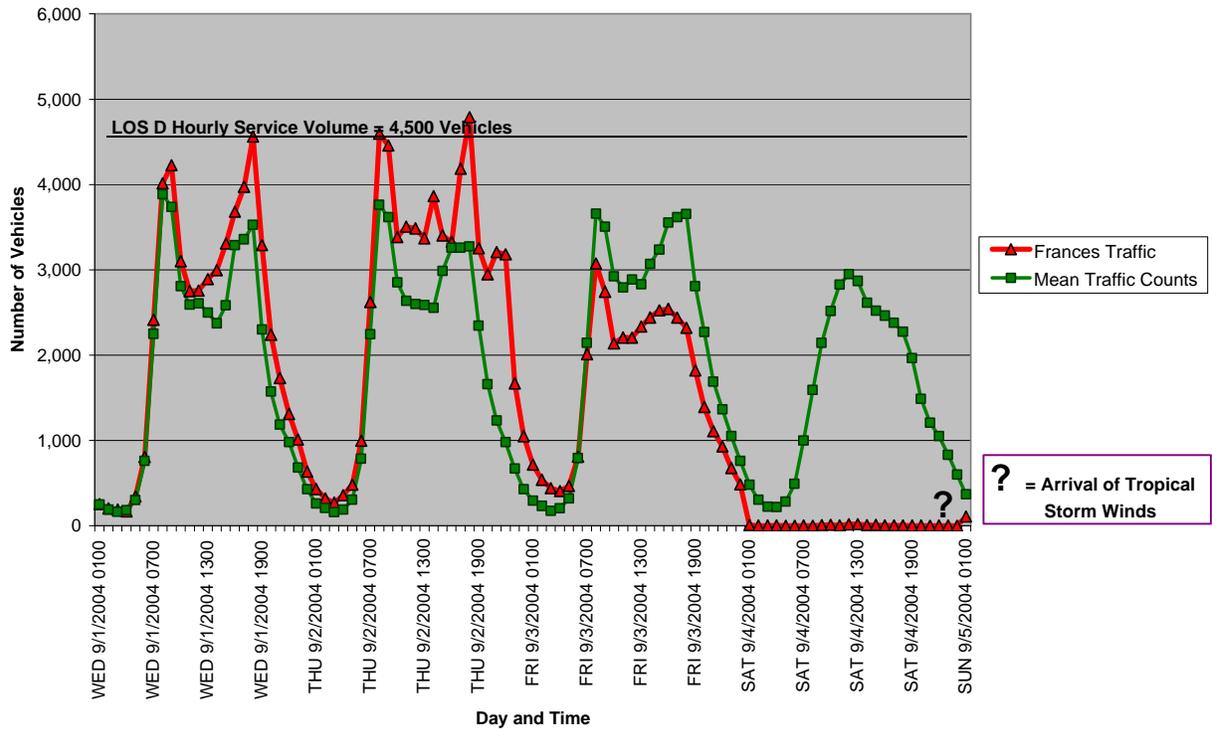
**Figure 21. Frances - I-75 (Alligator Alley) Northbound Near Goldengate (0351 WB)**



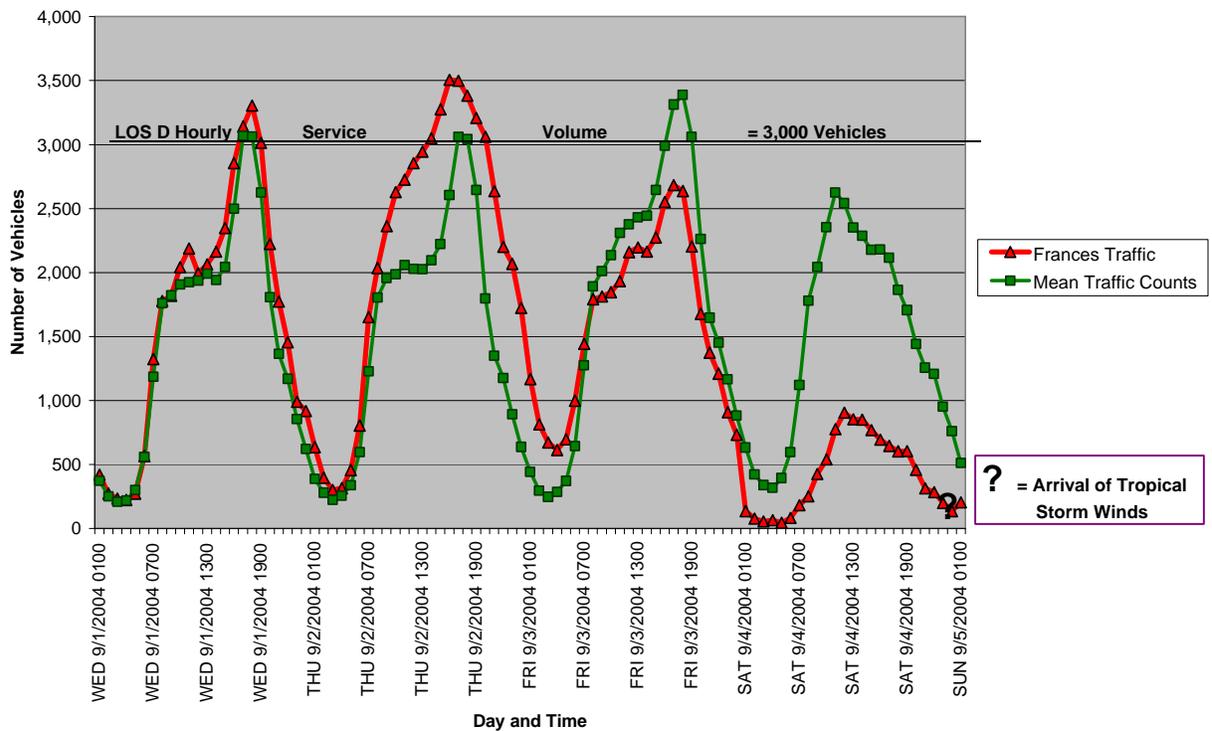
**Figure 22. Frances - I-75 Northbound Near Punta Gorda (0350 NB)**



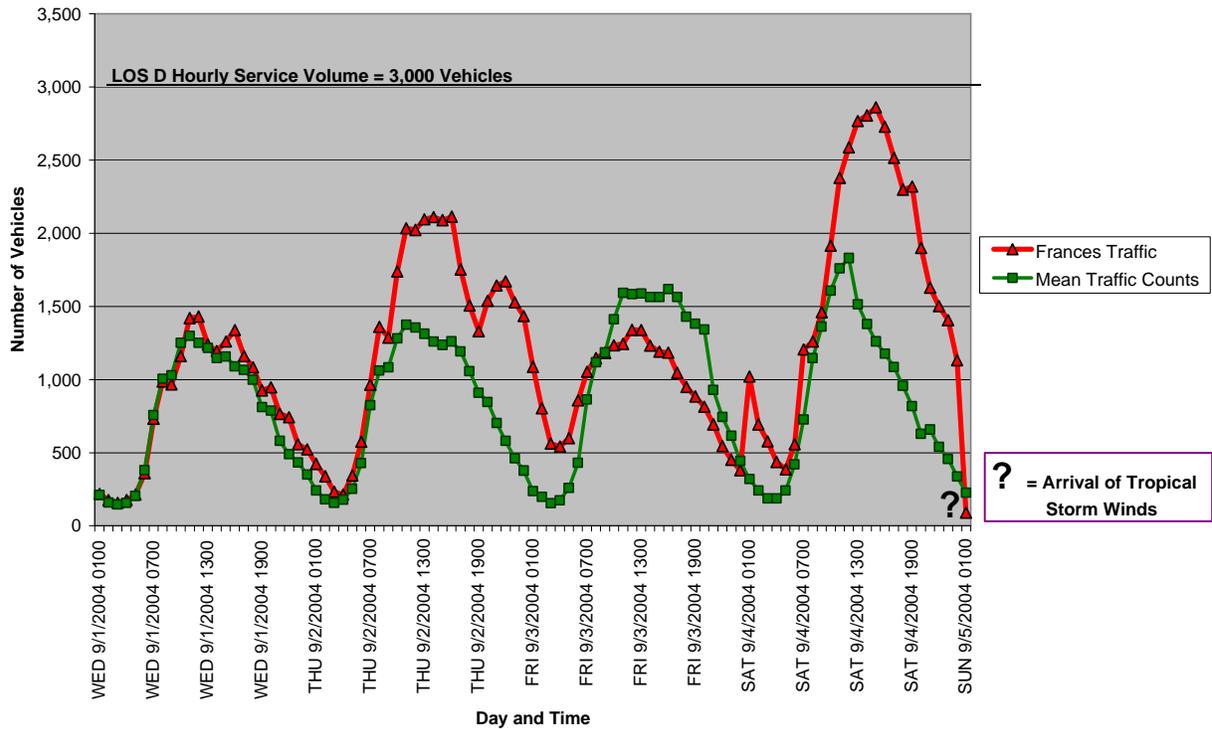
**Figure 23. Frances - I-75 Northbound Near Sarasota (0225 NB)**



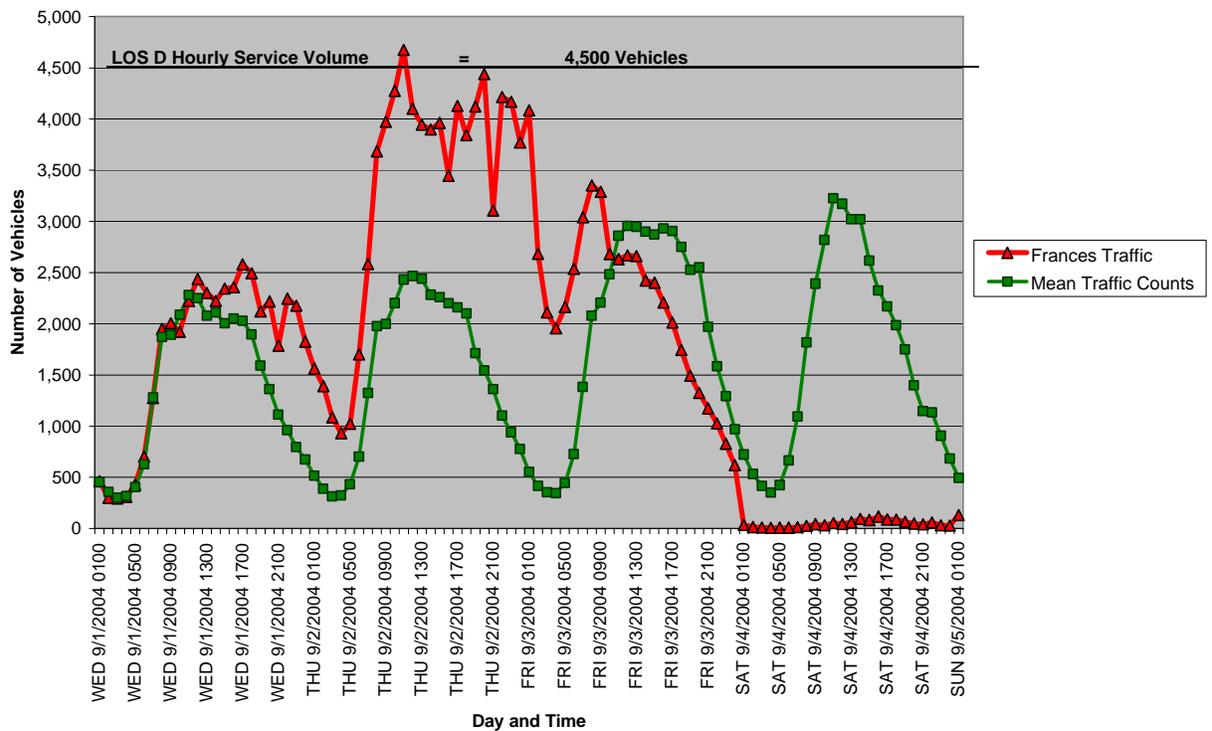
**Figure 24. Frances - I-75 Northbound Near Zephyr Hills (0190 NB)**



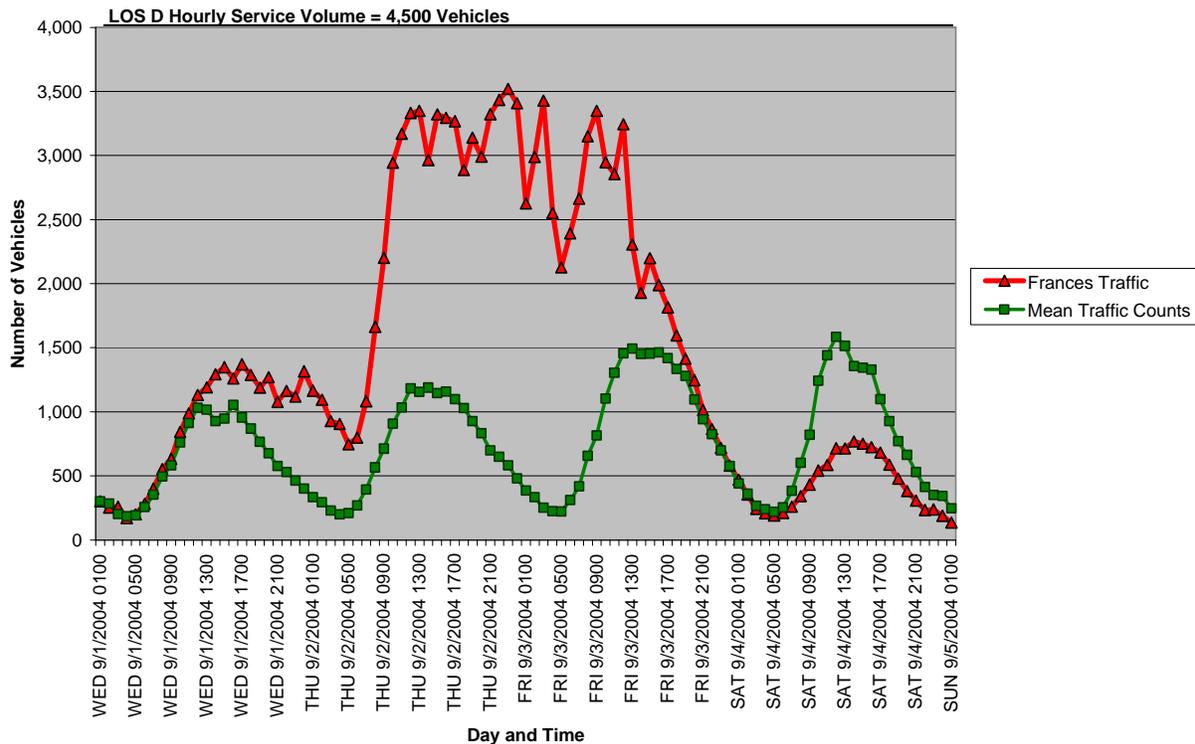
**Figure 25. Frances - I-75 Northbound Near Bushnell (0358 NB)**



**Figure 26. Frances - I-75 Northbound Near Ocala (0317 NB)**



**Figure 27. Frances - I-75 Northbound Near Florida / Georgia Line (0112 NB)**



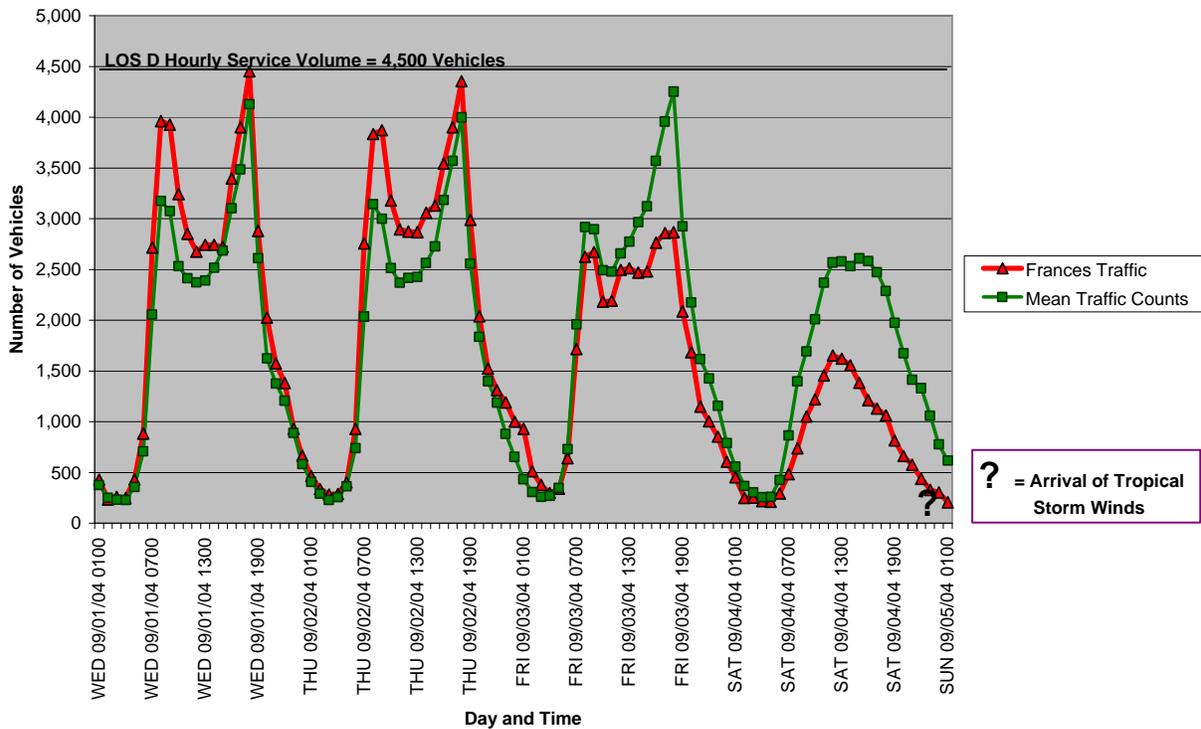
**I-75 Southbound (TTMS counters 0225 and 0350)**

- The two counters that registered significant increases in traffic over normal daily volumes were located in the Southwest Florida region. The northernmost station was 0225 in Sarasota (see Figure 28) with 0350 in Charlotte County near Punta Gorda (Figure 29) further south. Some of the other counters on I-75 discussed above also recorded increases in hourly traffic volumes over ADT in the southbound lane, but the difference between the hourly observed vehicles and ADT was the most pronounced at these two stations.
- The first hour of increased traffic prior to Hurricane Frances’ arrival occurred at both counters at about the same time 5:00 and 6:00 AM on the 1<sup>st</sup> of September 2004. The increase in the amount of traffic began well before any local evacuation orders were reportedly issued on either coast.
- The traffic at both locations remained consistently above normal for two days and then tapered off to below ADT levels simultaneously at 5:00 AM on September 3<sup>rd</sup>. During the periods of higher than average traffic flow on these two segments, a total of 15,800 vehicle

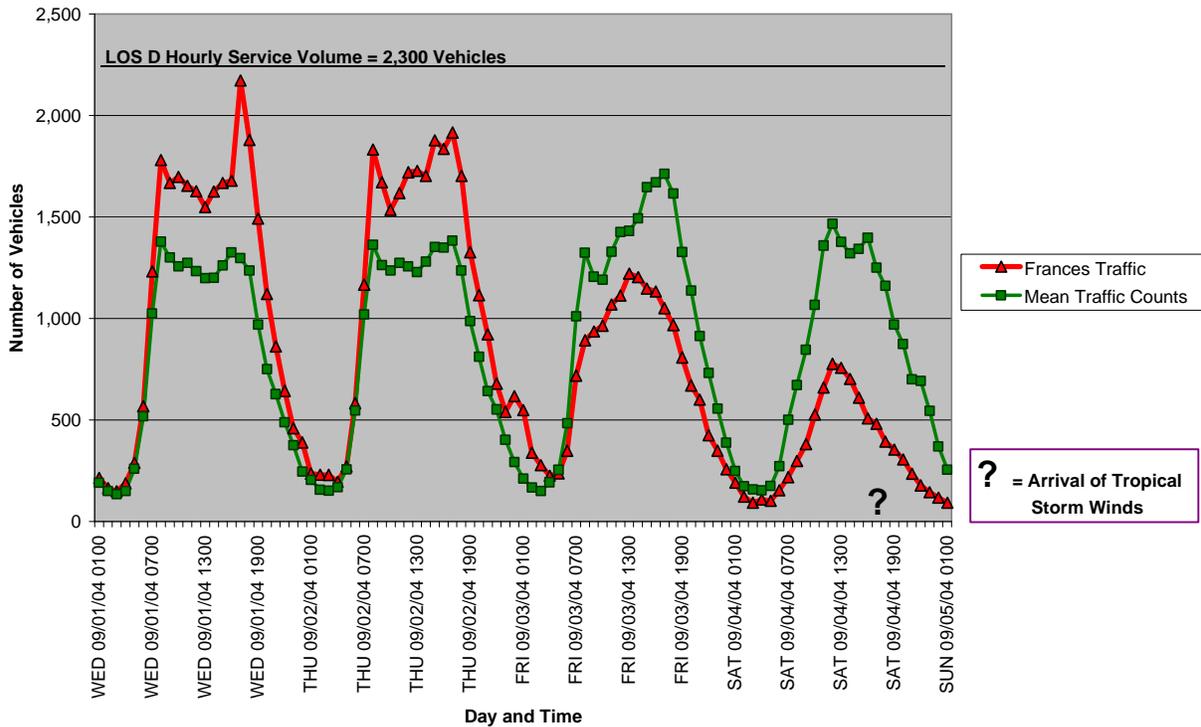
over ADT was processed at the Sarasota station and 14,300 additional vehicles were counted at the Punta Gorda site.

- According to the data from the TTMS counters, the increased volumes measured on these two segments during the Hurricane Frances event did not appear to create major problems with traffic flow or result in major congestion. However, in the absence of average speed data the evidence for these conclusions is not conclusive. Nonetheless, the hourly counts at both stations were well below normal levels by the arrival of tropical storm force winds, and had been for more than one full day.
- Another significant point regarding the data at these counters is the magnitude of the southward movement on I-75 during the evacuations. It is not likely that any hurricane evacuation transportation model developed for the Tampa Bay or Southwest Florida regions would have assigned such a large proportion of evacuating vehicles to travel south toward the end of the Florida Peninsula.

**Figure 28. Frances - I-75 Southbound Near Sarasota (0225 SB)**



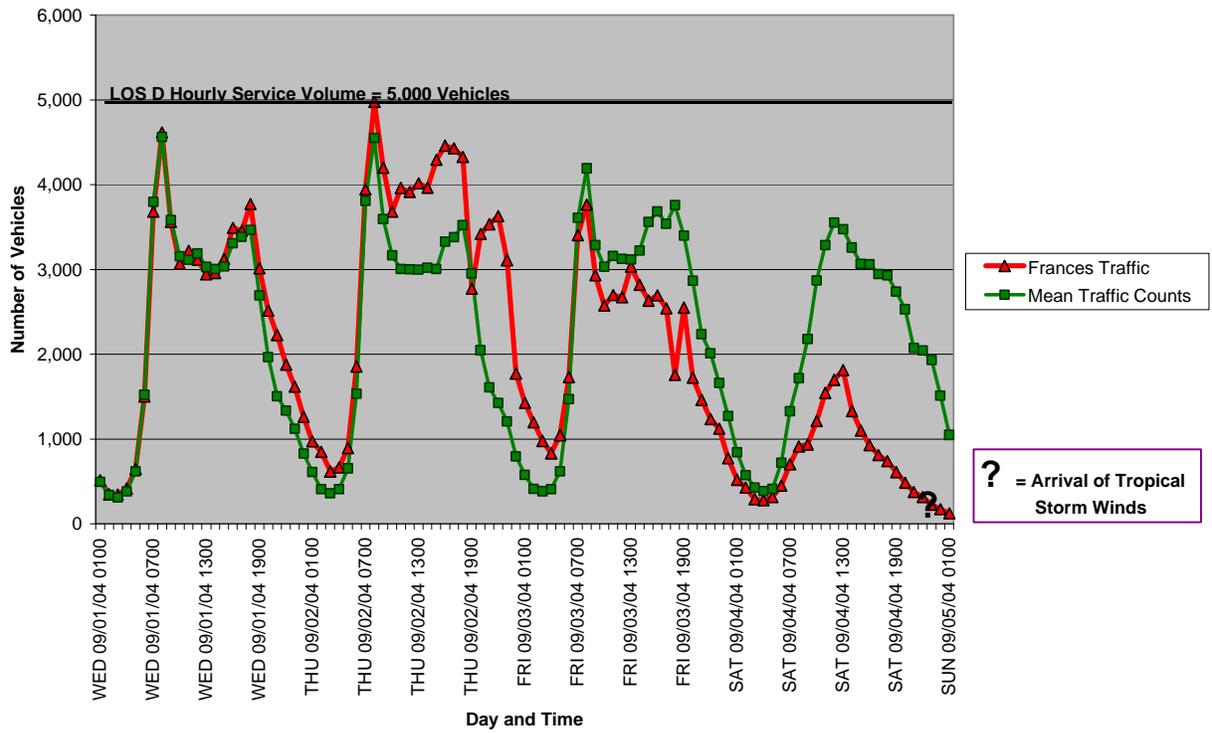
**Figure 29. Frances - I-75 Southbound Near Punta Gorda (0350 SB)**



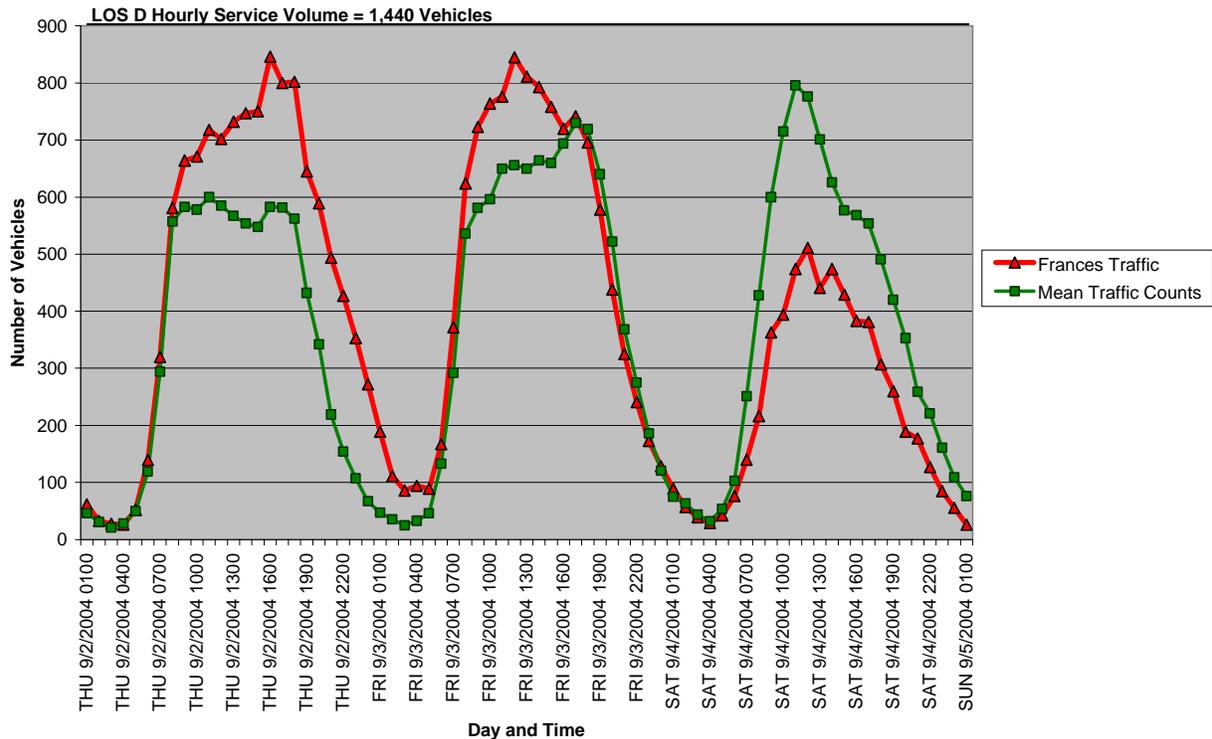
**I-4 Westbound (TTMS counter 0106), US 19 Northbound (TTMS Counter 0044) and US 301 Northbound (TTMS Counter 0018)**

- These miscellaneous counters have been included in this discussion to show that other available routes were used by evacuees during Hurricane Frances. As seen through the figures provided by these traffic counters, the timing of the beginning of the mass movement on these roadways, the duration of higher than average traffic volumes and the time when hourly counts dropped below normal traffic levels correspond with the other traffic counters on nearby roadway segments.
- The I-4 at Plant City and US 301 at Waldo traffic counters (see Figures 30 and 32) show that the majority of traffic that used those roadways did so concurrently with the high volume hours on I-75.
- The traffic counter on US 19 at Homosassa (Figure 31) shows that higher than normal traffic volumes were moving north well before evacuation orders were reported to have been issued by the jurisdictions in the Tampa Bay region.

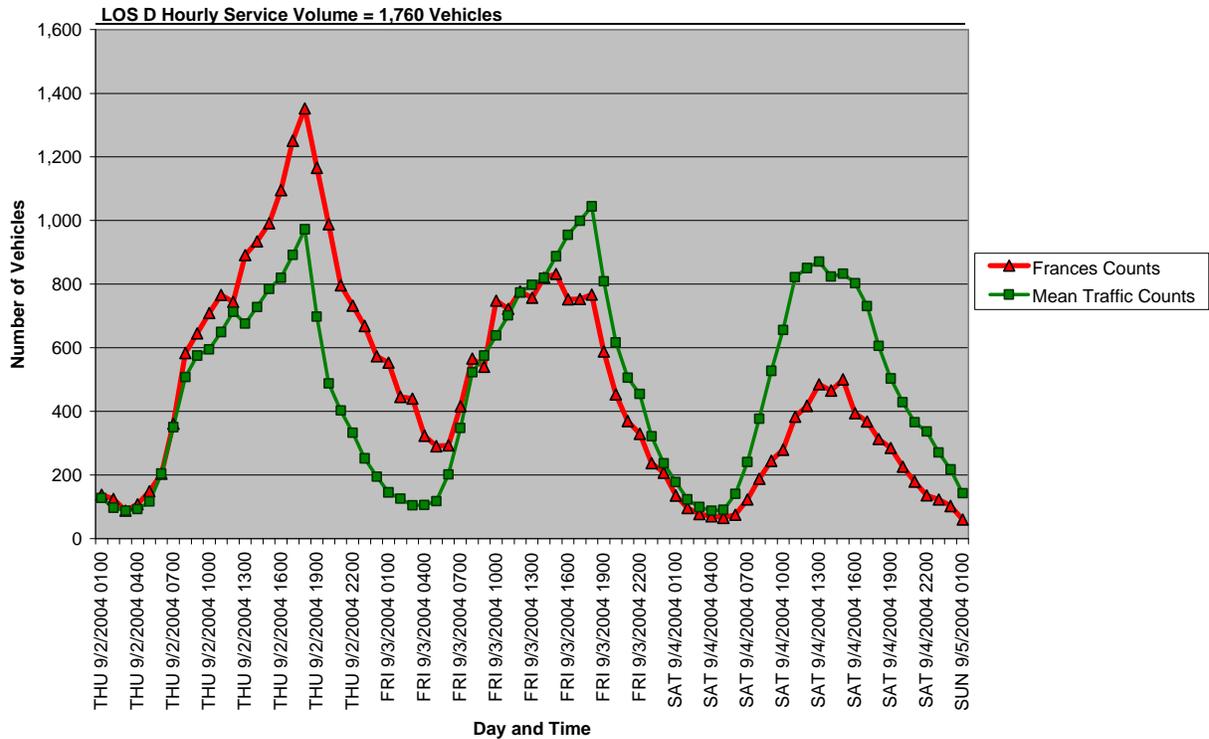
**Figure 30. Frances - I-4 Westbound Near Plant City (0106 WB)**



**Figure 31. Frances - US 19 Northbound Near Homossassa (0044 NB)**



**Figure 32. Frances - US 301 Northbound Near Waldo (0018 NB)**

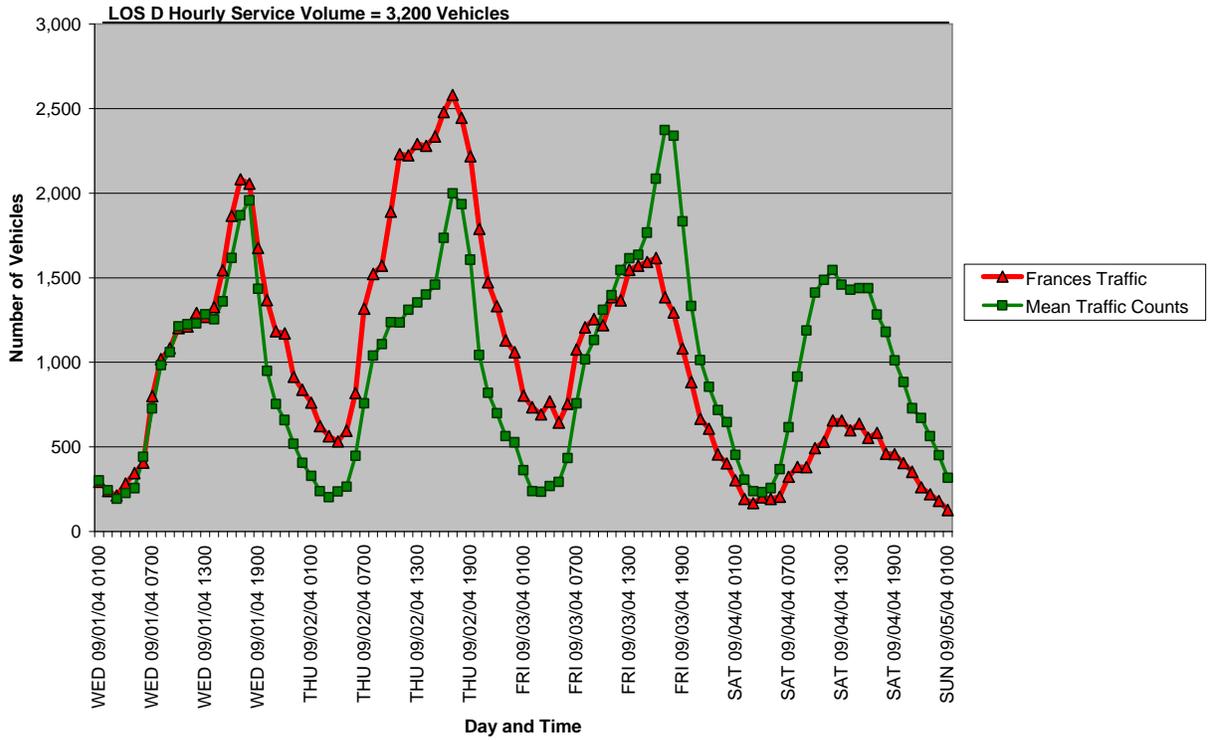


**I-10 Westbound (TTMS counters 0109, 0238, 0220, 0218, 0287, 0156)**

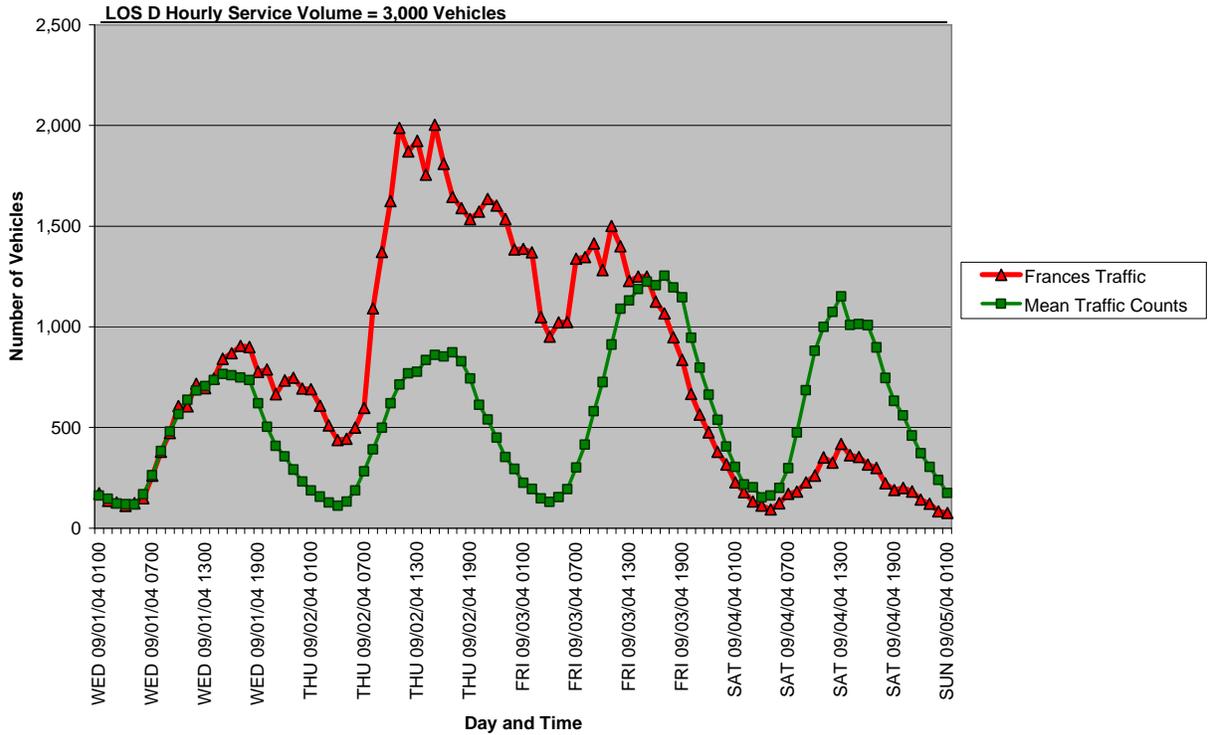
- I-10 is extensively covered by six traffic counters, all of which were operating in emergency mode during Hurricane Frances. In the westbound direction they are: counter 0109 located at Baldwin near US 301 (Figure 33); 0238 near Live Oak and after the junction with I-75 (Figure 34); 0220 near Quincy in Gadsden County (Figure 35); 0218 near Marianna (Figure 36); 0287 in Walton County (Figure 37); and 0156 at the Florida - Alabama state line (Figure 38).
- At 5:00 AM on September 1, 2004, the easternmost counter, just west of Jacksonville (See Figure 33 below), was the first to consistently measure higher than normal traffic on I-10 moving westbound, although for an inexplicable reason the station at the Florida - Alabama state line (Figure 38) did also. The other five counters roughly also began measuring increased hourly counts in succession from east to west. All six counters except the one near Marianna (Figure 36) which was having technical issues were recording higher traffic volumes than normal by the end of the day on September the 1<sup>st</sup>.
- All six traffic counters, except Marianna’s recorded that the period of heightened traffic volumes, most likely attributable to Hurricane Frances, extended beyond two days, ranging from a low at Live Oak with 49 hours to 65 hours at the westernmost site on the state line.

- The measured total traffic counts above the ADT figures at each station escalated from east to west, although the numbers tapered slightly at the state line.
  - The additional vehicle count total at the Baldwin counter indicates that approximately 21,200 vehicles either from I-95 or the Northeast Florida region were heading westbound on I-10.
  - The counter west of the junction with I-75 indicates that a total of 11,000 additional vehicles were added to the overall flow along this portion of I-10. Presumably a certain proportion of the vehicles sensed at the Baldwin station continued northbound on I-75. It is also likely that some northbound traffic on I-75 also switched to the westbound lanes on I-10.
  - It appears that many of the additional trips measured at the Live Oak traffic counter continued past Tallahassee to get counted at the Quincy station. Evidently, evacuation traffic on US 19, US 319 and other roadways contributed approximately 3,500 vehicles to the overall number of additional vehicles that reached the roadway segment near Quincy.
  - A drop in the total number of vehicles from 35,700 to 25,200 between Quincy and Walton County provides an indication that approximately 10,000 vehicles changed routes to US 231 into eastern Alabama or found other destinations in the Florida Panhandle, such as Panama City or other locations inland. In looking at the additional vehicle totals from the TTMS counter (0050) at the Florida – Alabama state line (see Figure 41) it appears that most of the 6,000 + additional vehicles measured at that location probably came from I-10. Reportedly none of the counties in the western Panhandle issued evacuation orders, mandatory or otherwise, although some spontaneous evacuations from those coastal areas cannot be ruled out.
  - A decrease of 4,000 total vehicles over ADT at the westernmost I-10 counter near the Alabama border indicates that approximately 20% of the additional trips from the previous counter in Walton County opted to remain in Pensacola and other western Panhandle communities. Nonetheless, approximately the same numbers of total vehicles over normal figures were measured going into Alabama as left Duval County over 350 miles to the east.
- In assessing the hours of peak traffic at the counters on I-10, there is little indication that the measured hourly volumes at any location created major problems with traffic or impeded the flow of vehicles westbound on I-10. There were no instances at any TTMS sensor on I-10 where the hourly traffic counts exceeded the evacuation service volumes for those roadways.

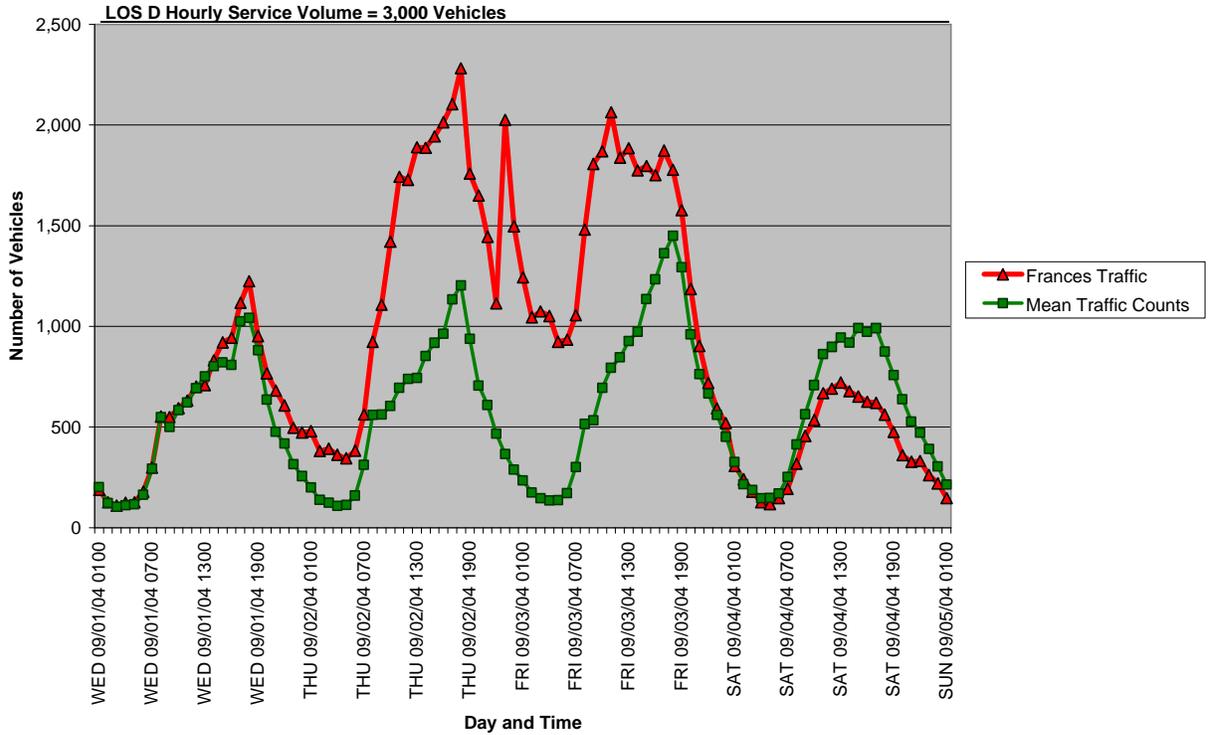
**Figure 33. Frances - I-10 Westbound Near Baldwin (0109 WB)**



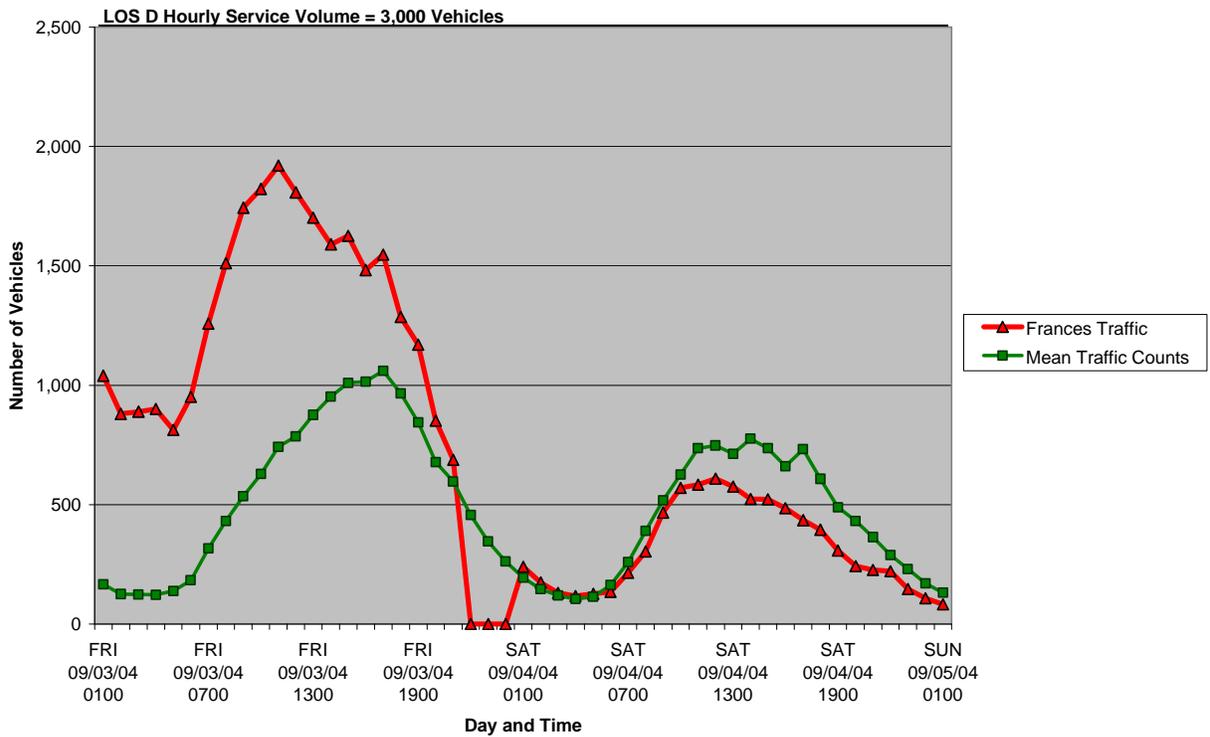
**Figure 34. Frances - I-10 Westbound Near Live Oak (0238 WB)**



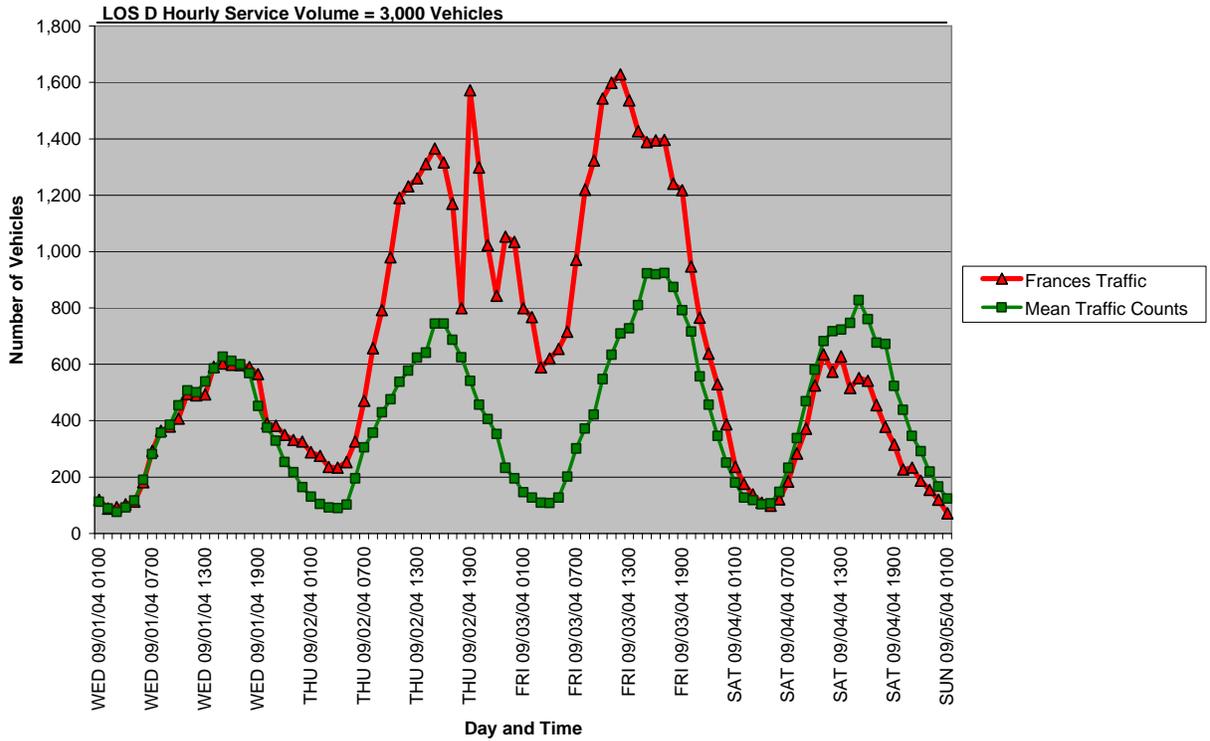
**Figure 35. Frances - I-10 Westbound Near Quincy (0220 WB)**



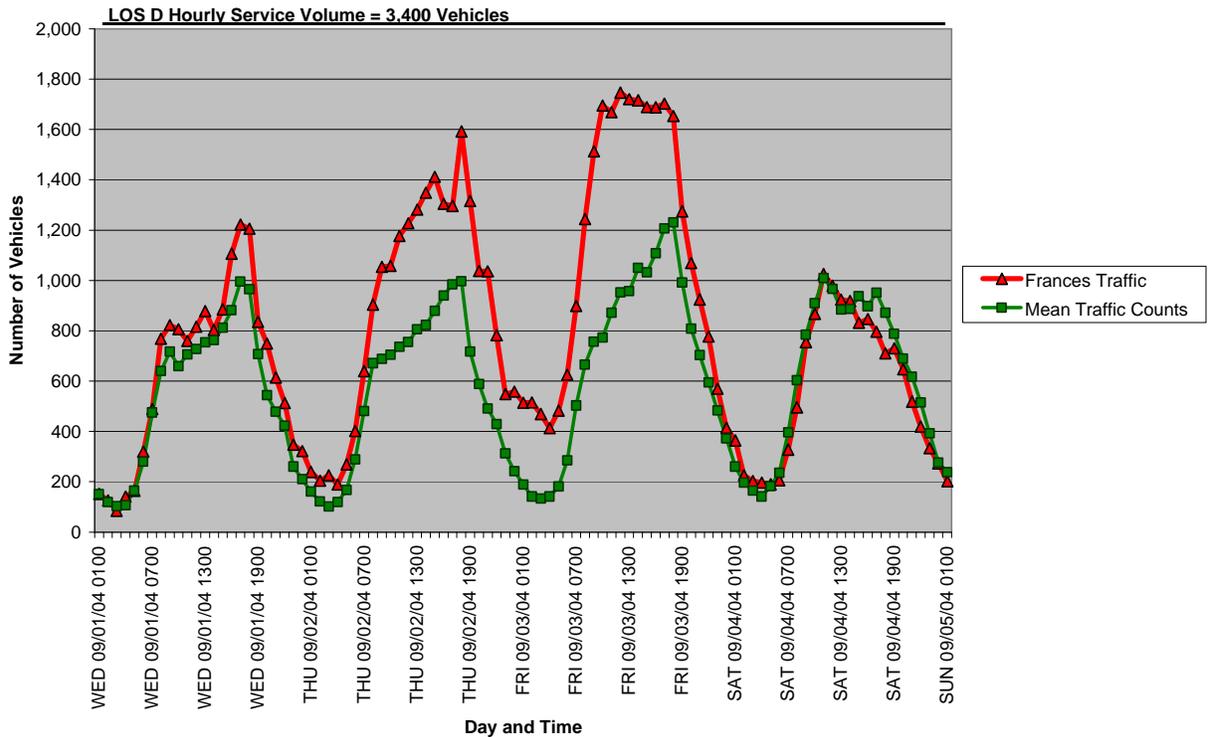
**Figure 36. Frances - I-10 Westbound Near Marianna (0218 WB)**



**Figure 37. Frances - I-10 Westbound Near DeFuniak Springs (0287 WB)**



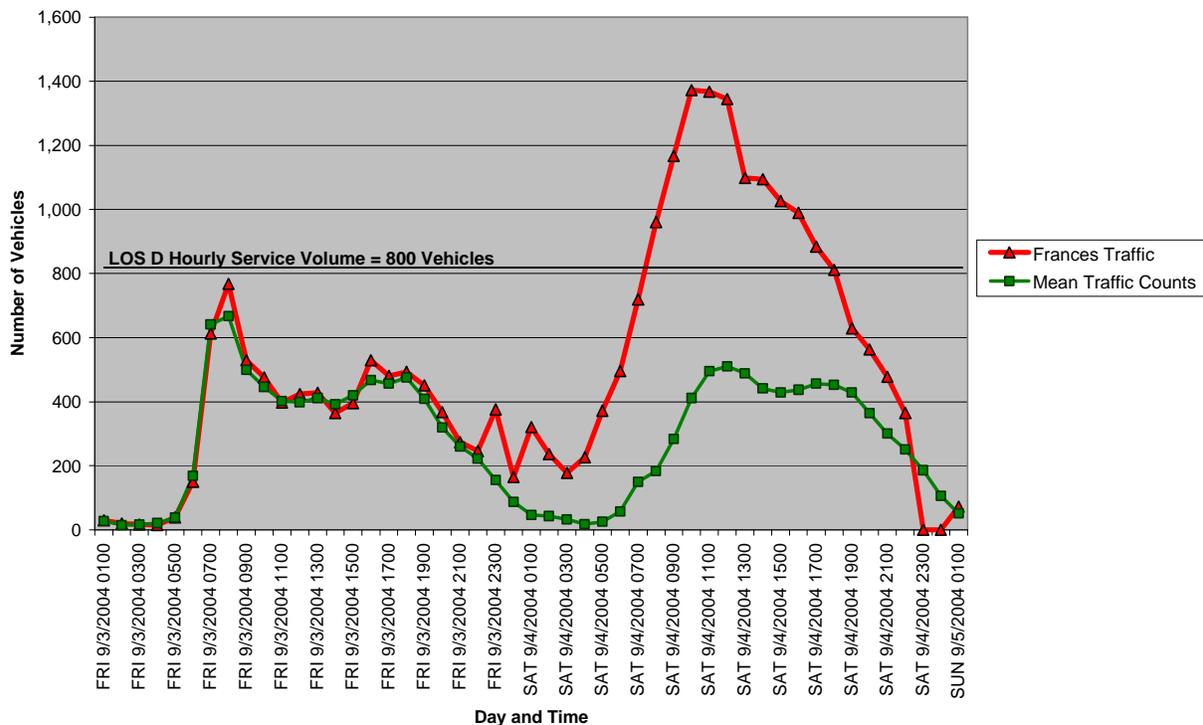
**Figure 38. Frances - I-10 Westbound Near Florida / Georgia Line (0156 WB)**



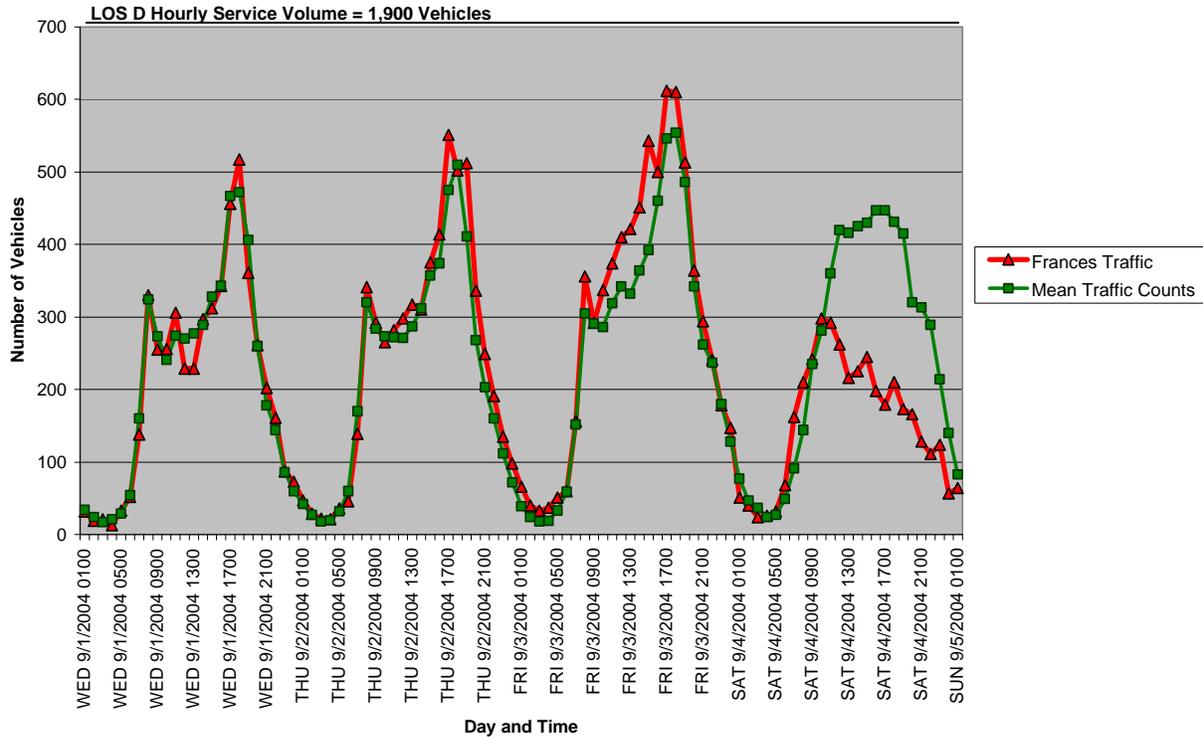
## US 319 Northbound (TTMS counters 0296 and 0349)

- US 319 has two TTMS traffic counters covering a relatively short distance between Ocklochonee Bay and the Florida Georgia state line; 0296 is located near Crawfordville in Wakulla County (Figure 39) and counter 0349 (see Figure 40) is near the state line with Georgia in northern Leon County.
- Of note regarding this particular roadway during the Hurricane Frances event is that the counter in Wakulla County registered 10,600 vehicles over the average daily traffic totals for the period and that only 1,500 vehicles continued into Georgia. If only 3,500 additional trips were added between Live Oak and Gadsden County on I-10, a sizable portion of the vehicles traveling up US 319 during the Hurricane Frances event probably sought refuge in Tallahassee or possibly traveled up US 27 into southwestern Georgia.
- Additionally, on the 4<sup>th</sup> of September as Hurricane Frances became a threat to the Big Bend area of Florida, the evacuating vehicles most likely leaving the coast south of Tallahassee caused the number of vehicles traveling northbound on US 319 to exceed the hourly evacuation service volume for 11 hours. For three of those hours, the traffic counts were 69% over the theoretical evacuation capacity of 800 vehicles per hour for that roadway. This situation may well have resulted in congestion and impeded traffic flow during those peak hours.

**Figure 39. Frances - US 319 Northbound Near Crawfordville (0296 NB)**



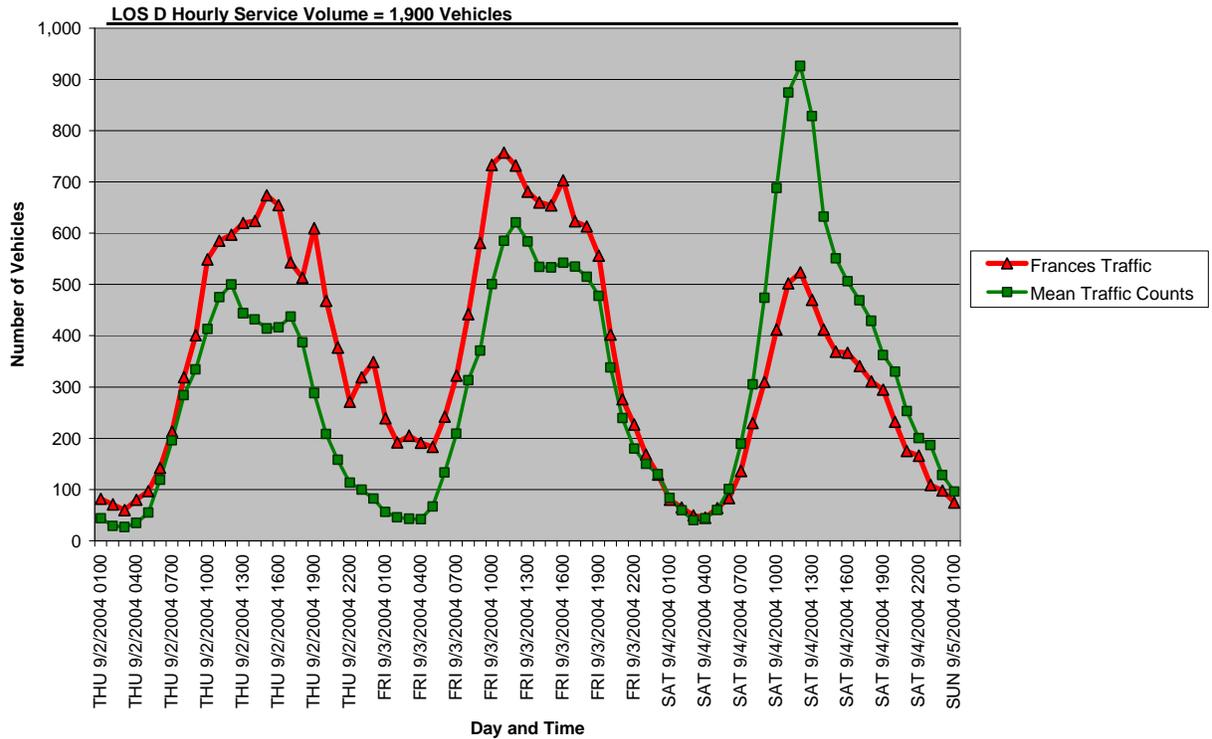
**Figure 40. Frances - US 319 Northbound Near Florida / Georgia Line (0349 NB)**



**US 231 Northbound (TTMS counter 0050)**

- This traffic counter is located on US 231 near the Florida – Alabama state line (Figure 41 below) serving as a link from I-10 into southeastern Alabama. Unfortunately, this traffic counter was not turned on until Thursday September 2<sup>nd</sup>, so the total number of vehicles over ADT on this segment is not available. Based on the chart of traffic volumes measured by counter 0287 on the segment of I-10 on which the US 231 interchange is located (see Figure 37), evacuation traffic probably began using this road during the evening of September 1<sup>st</sup>.

**Figure 41. Frances - US 231 Northbound Near Florida / Alabama Line (0050 NB)**



**Comparison of ETIS Travel Demand and Congestion Level Forecasts to TTMS Counter Data during Hurricane Frances**

- Table 3a through 3d relate the hours where Telemetered Traffic Monitoring System (TTMS) traffic counters were recording traffic counts that exceeded the average daily traffic (ADT) figures to weather related and operational events that were occurring during Hurricane Frances.
- Table 4 below provides a comparison between the travel demand and congestion level forecasts with the actual numbers of additional vehicles over the average daily traffic (ADT) figures collected for those same segments. The table does not include all segments on a particular corridor, only those segments on roadways covered by ETIS and having an operational Telemetered Traffic Monitoring System (TTMS).
  - In cases where both HES and ETIS data were appropriate and available for the road segments included in this table, those data were provided. In most instances for this table

only the ETIS data is provided since many of these segments with TTMS sensors are used by many counties from many different regions simultaneously for evacuation. This multi-regional travel demand data is not always readily available from most regional HES Transportation Analyses. Because ETIS is specifically designed to consolidate the maximum travel demands for many counties and regions during an evacuation event, and therefore most the appropriate data for the purposes of this analysis, its vehicle forecast are by far the most prevalent figures in the table. Where appropriate, the HES vehicle numbers were included in the table 4.

- The first column provides the name of the specific roadway segment used to compare HES / ETIS forecast data with the actual values recorded by the TTMS counters during the Hurricane Frances evacuation event. These roadways are aggregated by corridor and listed in succession based on the likely travel direction of evacuation traffic, in most cases south to north and west to east.
- The column labeled HES / ETIS Hourly Service Volume indicates how many vehicles per hour each specific roadway segment can process in one direction under hurricane evacuation conditions. The figure normally used in the HES and ETIS to characterize the roadway segment's ability to convey traffic is Level of Service (LOS) D, one step lower than maximum theoretical hourly through-put (LOS E). This slight attenuation of hourly capacity takes into account reductions caused by higher than normal traffic volumes, the potential for less than optimal weather conditions and a certain degree of duress imposed by the situation on the drivers using the roadway.
- The third column relating to HES / ETIS Predicted Number of Vehicles provides the total number of vehicles forecast in the HES or by ETIS to use that particular segment of roadway during the entire course of an evacuation. The travel demand figures provided in this column relate only to the additional number of vehicles on the roadway generated by evacuation orders and not the entire number of vehicles using the roadway segment. The number of over average daily traffic (ADT) figures, also known as the "background traffic" is not included in these figures. In most cases, for the reasons explained above only the ETIS data is provided.
- The data under the column heading of HES / ETIS Predicted Congestion Levels is the forecast amount of time needed to process the travel demand in the previous column

given the hourly directional service volume figures provided in the second column. In most cases, for the reasons explained above, only the ETIS data is provided.

- The next column labeled Additional Number of Vehicles over ADT during Event provides data regarding the actual values recorded by the TTMS counters during Hurricane Frances. This column specifies the difference between the total number of vehicles counted during the evacuation event against those normally using the segment (ADT) during the higher than average volume hours. For comparisons of forecast versus real event data, the values in this column also specifically relate to the data in the third column under the HES / ETIS Predicted Number of Vehicles heading. This additional vehicles figure is also reiterated at the bottom of Table 3a - d in the row labeled Difference Between Recorded and ADT Volume During Evacuation Period.
- The Total Number of Vehicles Recorded during Event column in Table 4 represents the total number of vehicles counted during the same hours as in the previous column, or the additional vehicles plus the historical number of vehicles for that time and day (ADT). The total vehicles column information is also found in the Total Number of Vehicles Recorded during Evacuation Period row at the bottom of Table 3a - d.
- The column labeled Number of Hours above ADT During Event Column specifies the length of time that each TTMS counter recorded hourly vehicle counts above the standard deviation of the ADT traffic volumes. The hours in this table coincide with the bright green boxes for each counter in Table 3a - d as well as the row labeled Total Number of Hours above ADT Volume. The data in this column also relates specifically to the final column in the table called Actual Service Volume / Evac Vehicle Ratio.

### **Caveats Regarding the Analysis of Traffic Counter Data Relative to HES and ETIS Figures**

The following points must be taken into consideration when comparing the traffic counter data collected during the hurricane evacuation against the figures contained in the HES the Abbreviated Transportation Model (ATM) or generated by ETIS.

- Some of the differences between the vehicle counts from roadway sensor data and the evacuating vehicle figures provided in the HES related products are attributable to the generalized information collected by the traffic counter itself.

- The hourly vehicle numbers recorded by traffic sensors are strictly raw data with no differentiation between the evacuation trips and those not leaving an area in response to a storm threat. Therefore, the counters cannot assist in determining when the first or last trip used a roadway segment with the express purpose of evacuating. The customary criteria for establishing the hour an evacuation begins or ends from traffic counter data is when the number of recorded vehicles exceeds or drops below ADT figures. Although this is a reasonable method, there are many likely scenarios where a significant number of vehicles may be on the roadway leaving an area in response to a potential hurricane threat days in advance of the ADT values being exceeded by traffic counts. Clearly, determining when the evacuation began and ended relative to the traffic counts can have a significant impact on the number of vehicles considered to be evacuating.
- The inability to definitively separate evacuation from non-evacuation trips in the traffic counter data may also account for further differences in the number of vehicles recorded on a roadway segment for an event and the vehicle demand forecasts provided in the HES-related products. Even for those hours when actual vehicle counts are significantly above ADT at a roadway segment, the actual proportion of evacuation to non-evacuation trips cannot be discerned from the traffic counter data. Again, the general rule of thumb for separating the evacuation from the non-evacuation trips is to use the ADT figures, so that the vehicle counts over that number constitute the traffic associated with evacuations. As in the discussion above, using the ADT as a method to mete out the different types of traffic recorded at a counter site during evacuations, while valid, does not necessarily constitute the real number of evacuating to non-evacuating vehicles. It could easily be argued that during evacuations, the amount of traffic normally using a roadway would be suppressed since many people are evacuating rather than going to school, work and their other routine daily destinations. Especially over time as more vehicles are involved in the evacuation, the higher the proportion of evacuating to non-evacuating vehicles recorded on a roadway segment.
- Finally, traffic counter data cannot be used to differentiate the high traffic volumes due to evacuations from those caused by special events or other traffic anomalies. The height of hurricane season also coincides with the beginning of college football season, high tourist season and many one-time or recurring special events. If hurricane evacuations coincide

with other high-traffic volume generating events, the vehicle counts in these overlapping instances would not be able to discriminate between those two types of vehicle trips.

- There are significant variations in the methodologies used by the HESs, ATMs and ETIS to determine the number of vehicles on key roadway segments during evacuations. These variations may also serve to exacerbate the differences between the traffic counter figures and the evacuating vehicle forecasts provided in the HES products during an evacuation event.
  - In addition to the number of vehicles trips specifically associated with evacuations, the methodology for calculating the clearance times provided in the HESs does factor in the trips considered to be background traffic. Background traffic is the other vehicles using an evacuation roadway segment for purposes not specifically related to evacuating from the tropical cyclone. The background numbers used in the HES clearance time methodology are based on annual ADT averages which would not account for the wide daily variations in normal traffic that may exist on days when evacuations are occurring. This difference in determining the normal traffic in developing the clearance times may account for differences between the HES and actual counter figures during the theoretical evacuation period for a particular event.
  - The ATM vehicle figures provided in the Vehicles by Roadway and Clearance Time tabs for key evacuation roadway segments in the spreadsheets do not include the background traffic numbers. However, the clearance times provided in the ATMs do factor in the additional time needed for the key roadway segment to process the background vehicles.
  - The ETIS figures do not factor in the number of vehicles that would be considered background traffic on each of the modeled roadway segments. Therefore, the forecast number of vehicles for each roadway segment in ETIS includes those additional vehicles theoretically using the roadway for evacuation purposes only. Certainly this fact may account any differences between the total vehicle traffic count recorded by a traffic counter and the ETIS forecasted number of vehicles on a roadway segment during an evacuation event.
  - Differences in the way that the HES transportation model and ETIS factor in participation rates will have an impact on their agreement regarding the vehicle numbers for a roadway segment. Whereas the vehicle by road segment numbers in the HESs and initial versions

of the ATMs are based on fixed, behaviorally derived evacuation participation numbers, ETIS allows the user to select those variables based on storm and other situation-specific parameters. Additionally in the HESs, each traffic evacuation zone, evacuation zone and each housing type has its own set of participation rates already selected, while the percentage selected in ETIS applies to the entire population that is committed to evacuate by the user in the program. Therefore, these differences in the application of participation rates between the HESs and ETIS can account for any discrepancies between the evacuating vehicle figures from both sources.

- Finally, the interval between the collection of socio-economic, behavioral and roadway data for the last hurricane evacuation study / restudy can also accentuate differences between the traffic counter evacuating vehicle numbers and those provided in the HESs or in ETIS. Many of the hurricane evacuation studies / restudies in Florida were completed on or before 2000. Therefore, the data used to develop socio-economic figures for those studies was not based on the most recent U.S. census, but instead on the one conducted in 1990 with projections to the study date. Many regions in Florida are experiencing dynamic population growth where four or five years can mean a significant increase in the number of evacuating vehicles. Certainly that is true for the Southwest Florida, Treasure Coast, Tampa Bay, East Central Florida and Northeast Florida regions, many of which were impacted during this hurricane event.
- The congestion times provided by ETIS are not the same as clearance times in the HESs and do not coincide with the total number of hours that a counter recorded hourly volumes above ADT.
  - The ETIS congestion time represents the hours of expected travel demand for that specific roadway segment and is determined by dividing the forecast number of vehicles by the hourly directional service volume (e.g. a roadway segment that has an hourly directional service volume of 1,000 vehicles can process a total travel demand of 10,000 vehicles in 10 hours).
  - The congestion time calculated by ETIS represents only the queuing delay time component of an HES clearance time. The other components of an HES clearance time not included in the ETIS figures are mobilization time (usually accounted for by the response time) and the travel time.

- Unfortunately much of the operational data regarding the effective times of evacuation orders, levels of evacuation and other details which have an impact on evacuations, and hence traffic volumes and timing, is not complete. Most of this operational data was collected during the post-storm surveys that were conducted as part of this report effort.
- In this case, almost none of the clearance time figures in the HESs or in ETIS can be validated by how long the roadway segments with traffic counters actually experienced higher than normal traffic volumes. Almost all of the traffic counters witnessed very long periods where the vehicle counts, probably due to evacuations from Hurricane Frances, were above the average daily totals. Even relatively obscure evacuation routes experienced extended episodes where the hourly traffic totals during the event were above the normal daily figures. Evidently, evacuees from all the at-risk regions began evacuating, many without the benefit of an evacuation order, very early relative to the storm's approach and landfall and they did so quite slowly. For the most part the evacuation roadway network was allowed to process the travel demand for this event in small increments over a long time span rather than all at once.
- Another shortcoming to relating the traffic counter data to clearance times and roadway segment travel demand forecasts for this event is that many of the TTMS stations are located at regional evacuation links. There are very few instances where a TTMS traffic counter is located on a roadway that is most likely used by a single county for evacuation: US 29; US 192/SR 520/SR 50/SR 528, SR 71, US 231 below I-10 and US 1 at Key Largo are about the only TTMS sites that can be used to validate county clearance times. Of the routes specified above, only US 192 and SR 520/SR 50/SR 528 were directly impacted by evacuations from Hurricane Frances. In those cases, the differences between the HES and counter data during this event may be due to variations in participation rates, evacuees from other regions and other circumstantial factors that cannot be quantified in a transportation model. The increased traffic volumes on the other routes above during the event were probably attributable to the evacuation traffic from the Florida Peninsula trickling through the evacuation network toward their final destination locations. Even the regional clearance times and travel demand forecasts are based on incomplete or outdated information. Only 13 of the 32 inland counties in the State of Florida have current evacuation data; and counties such as Polk, Alachua, Leon and others have the potential to impose a significant number of

evacuating vehicles on the statewide evacuation roadway network. Therefore, the travel demand forecast figures in ETIS and the regional clearance times in many of the regional HESs do not factor in the vehicles from many of the inland counties.

- Using the figures in Table 4 and the traffic counter data included in the above charts (Figures 1 through 41) and in Table 3a - d, the following observations apply to Hurricane Frances:
  - In many cases, the ETIS forecast of travel demand for roadway segments with traffic counters were higher than the actual number of additional vehicles over ADT that were recorded by the traffic counters. Much of this is possibly attributable to an overestimation of participation rates by local emergency management offices, which is a very subjective figure in almost all cases.
  - Other reasons for the discrepancies between the HES / ETIS roadway segment travel demand figures and the traffic counter totals during Hurricane Frances are: lack of data regarding some inland counties and their contributions to the evacuating number of vehicles; spotty data regarding evacuation zones or what populations were ordered to evacuate; and outdated information regarding the destinations of out-of-county evacuees.

## Conclusions

1. From Wednesday, September 1 to Monday, September 6, 2004, an additional 859,200 vehicles over the average daily directional trips (ADT), or a total of 1,353,600 vehicles, used the major evacuation routes out of the South Florida, Treasure Coast, East Central Florida, Northeast Florida, Central Florida, Tampa Bay, Withlacoochee and North Central Florida Regions. The average number of hours that all activated traffic counters on the Florida evacuation roadway network recorded above average volumes was 43.5 hours.
2. According to the survey data collected from the most affected counties during this event, the primary observation by local emergency management officials was that fuel availability was the predominant problem during the evacuation, followed by heavy traffic. Other evacuation problems cited by the surveyed county officials were inadequate signage and construction.
3. Only two out of the 27 counties surveyed for this event, Palm Beach and Volusia, indicated that gridlock conditions occurred on the roadways during the evacuation. Palm Beach sited the roads around Yeehaw Junction and Volusia County specified State Route 40 westbound where it constricts from two lanes down to one lane in each direction was prone to gridlock.
4. The traffic counters indicate that the increase in traffic volume, most likely caused by the approaching hurricane, over the Average Daily Traffic (ADT) at virtually every traffic counter began well in advance of evacuation orders being issued in nearby counties. These increased volumes indicate that people evacuated along the east coast of Florida before they were ordered to do so. The slow metering of traffic onto the evacuation roadway network played a large part in keeping congestion throughout the state from becoming widespread gridlock. In a number of cases the roadway hourly traffic counts dropped below the ADT for that segment even before evacuations were ordered in the adjoining counties.
5. Furthermore, despite the significant number of additional vehicles processed at all segments with traffic counters; there are no indications that congestion drastically decreased the hourly thru-put on any of those roadways. There were anecdotal accounts of serious bottlenecks occurring on I-75 during the Hurricane Frances evacuation. There were also accounts regarding how the traffic volumes on I-75 on the evening of September 2<sup>nd</sup> / 3<sup>rd</sup>

almost caused the State of Georgia to implement a contra-flow operation on their portion of I-75 north of the State line. Nonetheless, the traffic counter data shows that a majority of the segments in Florida did not approach, much less exceed their hourly maximum service volume at any point during the hurricane evacuation. Furthermore none of the counters show evidence that the number of vehicles processed during each hour of the evacuation dropped significantly due to saturation flow or traffic queuing conditions on I-75 or any other roadway.

6. The only counters that registered hourly vehicle counts that were higher than their hourly evacuation service volume were:
  - a. Florida Turnpike northbound near Fort Pierce in St. Lucie County (1 pm to 4 pm on Sept 2<sup>nd</sup>);
  - b. US 17 northbound near San Mateo in Putnam County (12 pm to 6 pm on Sept 2<sup>nd</sup>);
  - c. I-75 northbound near Golden Gate in Collier County (3 pm to 6 pm on Sept 2<sup>nd</sup>);
  - d. I-75 northbound near Punta Gorda in Charlotte County (1 pm to 8 pm on Sept 2<sup>nd</sup>);
  - e. I-75 northbound near Sarasota in Sarasota County (6 pm on September 1<sup>st</sup>, 8 am on Sept 2<sup>nd</sup>, and 6 pm on Sept 2<sup>nd</sup>);
  - f. I-75 northbound near Zephyr Hills in Pasco County (5 pm to 7 pm on Sept 1<sup>st</sup>, and 2 pm to 8 pm on Sept 2<sup>nd</sup>);
  - g. I-75 northbound near Ocala in Marion County (11 am on Sept 2<sup>nd</sup>); and
  - h. US 319 northbound near Crawfordville in Wakulla County (8 am to 6 pm on Sept 4<sup>th</sup>).
7. Any definitive statements about the existence of congestion, or gridlock on any of the above roadways is not possible without average speed data normally collected at these traffic counters throughout Florida. Unfortunately, that data is not available for this event and it cannot be reconstituted.
8. The seemingly early start to most people's evacuation trips also helped to ensure that the roadway segments were clear well before the arrival of tropical storm force winds at that site. The traffic counters indicate that all of the evacuation roadway segments on which they were located were clear of major traffic volumes before landfall or arrival of tropical storm force winds.

9. The performance of ETIS in determining the cumulative evacuation travel demand for the state's roadway is mixed. Of the segments with traffic counters, the ETIS travel demand figures were within 52% of the recorded values, 8 of them higher and 9 of them lower. Other than the generic reasons cited above, there are no other apparent reasons evident in the data for the discrepancies between the observed and the forecast values. During the storm, incomplete information about local protective action decisions, their timing and participation rates can certainly affect the accuracy of the ETIS travel demand forecasts for certain roadway segments. Even after the storm, the information collected from local emergency management can have major implications for the accuracy of the scenario used to assess the program, which in turn can have a dramatic impact on the program's results. ETIS relies heavily on the accuracy of local information, and the results from the program are greatly influenced by the quality of that data. Unfortunately, the collection of local evacuation related data is the most difficult part of the ELT mission. Nonetheless, ETIS would benefit greatly from a concerted effort to update socio-economic, behavioral, roadway capacity and other data used to generate the travel demand figures and clearance times.