Emergency Evacuation Assessment For the SJTPO Region

June 30, 2004

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INTRODUCTION

The South Jersey Transportation Planning Organization (SJTPO) regions covers a relatively large land mass, and is home to over a half million permanent residents and hosts over a quarter million jobs. The primary mode of travel in the region is the automobile, supplemented by local and regional buses. These vehicles travel mainly on a primary highway system that consists of a limited number of major arterials. These arterials must serve the dual purposes of providing regional mobility and access to centers of activities for longer-distance travel, as well as localized mobility and access for commuters and residents. During the peak period, demand far exceeds capacity, resulting in congestion and high levels of delays.

The SJTPO region has a very significant inflow of people throughout the recreational season. During an emergency, the ability to evacuate this large population base, which is many times greater than the year-round population, is critical. Evacuation may be necessary during severe weather, when roadways are flooded, making many impassible. The ability to provide a system that can withstand the adverse elements and reliably move a large number of persons in a limited amount of time is a fundamental need of the shore communities and the region.

Demographic and travel model forecasts indicate significant growth in the region's transportation needs over the next twenty years. The shore/recreational counties of Atlantic and Cape May will add nearly 100,000 people and nearly 75,000 jobs over a 25 year period, as depicted in Table 1, below.

Table 1 - SJTPO Region Population and Employment Forecasts

	POPULATION				EMPLOYMENT			
	Total		Change		Total		Change	
County	2000	2025	Net	%	2000	2025	Net	%
Atlantic	252,552	330,367	77,815	30.8%	125,739	189,516	63,777	50.7%
Cape May	102,326	123,066	20,740	20.3%	40,012	49,375	9,363	23.4%
Cumberland	146,438	181,481	35,043	23.9%	60,400	86,470	26,070	43.2%
Salem	64,285	67,500	3,215	5.0%	22,600	24,860	2,260	10.0%
Total	**565,601**	**702,414**	**136,813**	**24.2%**	**248,751**	**350,221**	**101,470**	**40.8%**

Source: SJTPO and Census 2000

This growth, however, does not come without a price. This growth translates into increased congestion and delays getting to and from the region's shore communities particularly during the peak summer months. Delays of the magnitude experienced today, which are forecast to grow in the future, pose a serious constraint in the ability to evacuate the region in the event of an emergency or disaster.

For a number of years, completion of the Route 55 Freeway into the Cape May shore has been viewed as having significant potential to improve in the ability to move people, in particularly during peak travel times and in evacuation conditions. In order to test the impact of such an infrastructure improvement, a special analysis was performed using the South Jersey Travel Demand Model (SJTDM). This analysis was conducted as part of the process to update and enhance the SJTDM. This memorandum details the process and results of testing the impact of the completion of the Route 55 freeway.

To investigate the magnitude of this problem, an evacuation scenario was developed and tested using the South Jersey Travel Demand Model. The model was used to evaluate the ability of the region's roadways to evacuate a large number of vehicles in a short time period. The scenario was designed to test what might happen if a sudden disaster were to trigger a full and immediate exodus of the Shore areas in Cape May and Atlantic Counties on a typical summer Friday evening, where commuter and recreational travel are near a peak. The analysis identified critical links and bottlenecks and tested the improvements likely to occur by constructing the Route 55 completion. Overall, the assessment indicated

that a significant improvement in the region's ability to move people to safe areas will occur if Route 55 freeway is completed.

METHODOLOGY

The South Jersey Travel Demand Model was placed into service in 2000. Model applications include support of regional travel forecasting efforts and the air quality conformity assessment. The model was upgraded as part of the 2004 RTP Update as part of an ongoing process to refine the quality and accuracy of the process. The current enhancements included an update to a new base year of 2000 consistent with the 2000 Census and revised demographic projections, and refinements to the mode split, trip table building process, and network assignment process.

The SJTDM served as the primary analysis tool in this study. First, an evacuation scenario was developed to simulate trip making that would occur if the shore region required evacuation. The scenario was not directly based on any one event as a trigger, but rather on a scenario where an immediate evacuation order was issued, and the severity of the event sufficient to result in general compliance with the evacuation order.

The SJTPO region was divided into a series of districts that were classified as either "safe" or "danger" districts based on their proximity to shore areas. These districts are depicted in Figure 1. Danger areas were those districts where we assumed that all personnel would be evacuated "from". Safe districts are those areas where we assumed personnel would be evacuated "to". In order to establish reasonable district classifications, Storm Surge Maps produced by the Army Corp of Engineers were used. An example of these maps are depicted in Figure 2. These maps illustrate flood inundated areas based on different classes of Hurricanes. In Cape May a Class 1 Hurricane (light purple) covers most of the shore townships and inland to the GSP and most of the area on the Bay side of Cape May. Classes 2 (darker purple), 3 (yellow) and 4 (pink) Hurricanes would cover most of the rest of Cape May county leaving only a small area in northwest Cape May County as a "safe" (white) haven. For this analysis the Class 4 Hurricane flood areas (from light purple to pink) were used to estimate the safe and danger districts.

It should be noted that the SJTDM extends into the DVRPC region and abuts the NJTPA region. The evacuation scenario did include trip assignments and distribution beyond the SJTPO borders but the impact analysis was limited to the SJTPO region.

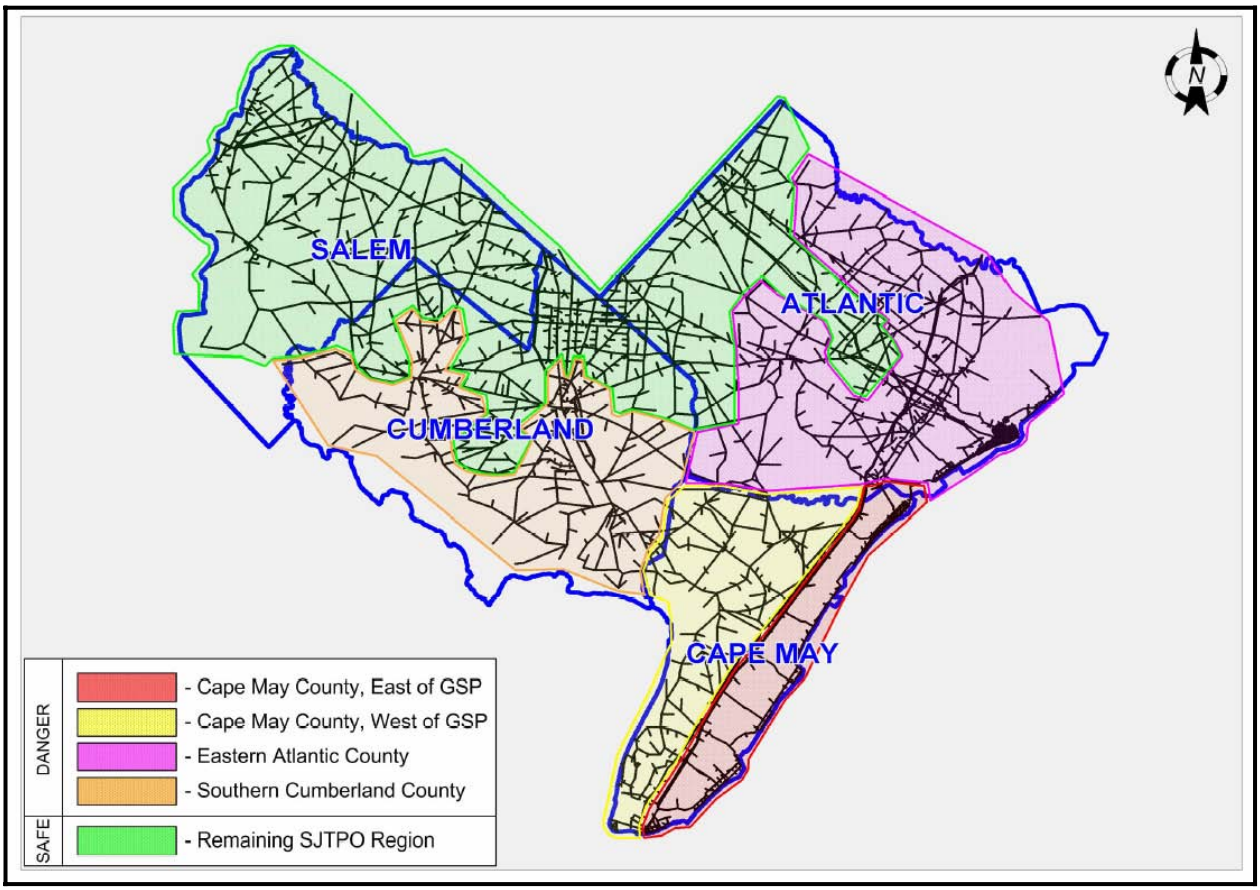

Figure 1 - Evacuation District Map

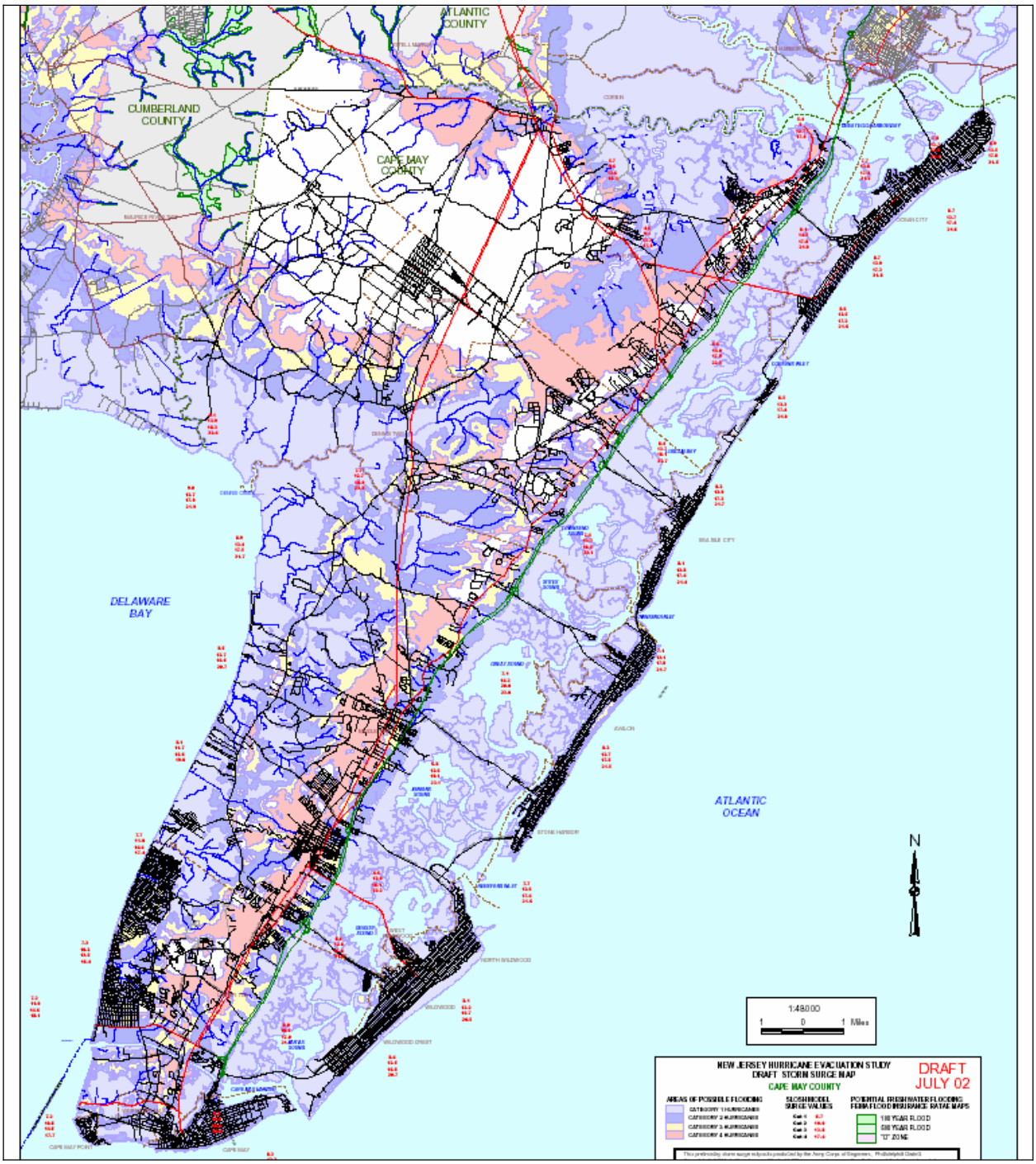

Figure 2 - Cape May Storm Surge Map

An evacuation trip table was developed based on the following simplified assumptions and the district maps:

- Local trips within the danger areas will cease to exist under the evacuation scenario. Trips traveling from danger district to danger district (danger-to-danger) were redirected to a safe district (danger-to-safe). The redirection was based on the existing danger-to-safe trip distribution in the district of origin, keeping the pattern of trips leaving the area under normal conditions as the guide.

- Inbound trips, which are defined as trips originating in a safe district and ending in a danger district, were reduced by 90%. The remaining 10% of the inbound trips were viewed to represent potential emergency vehicles and personnel entering and exiting the area to facilitate the evacuation process form a staging, logistics or rescue fashion, or essential health/welfare personnel reporting to duty.

- Trips that originate in a danger district and are destined to a safe district (danger-to-safe) were left untouched.

- Trips that originate and end in a safe district (safe-to-safe) were also left untouched.

This logic is illustrated in the table below. The program to apply the logic is included in Appendix A:

Table 2 - Evacuation Factoring Method

		Destination	
		DANGER	**SAFE**
Origin	**DANGER**	Redirected to Safe District	OK
	SAFE	-90%	OK

These assumptions were applied to the 2025 PM peak period trip table (3PM to 7PM) for a Friday summer evening to generate a trip table designed to evacuate the typical expanded summer population from the SJTPO shore region to designated safety regions inland. The existing trip table totals are depicted in Table 3.

Table 3 - Baseline Trip Table Totals

		Destination		
		DANGER	**SAFE**	**TOTALS**
Origin	**DANGER**	310,901	77,192	388,093
	SAFE	74,457	4,314,226	4,388,683
TOTALS		**385,358**	**4,391,418**	**4,776,776**

The resulting trip table (Table 4) consisted of approximately 388,000 evacuation trips (trips traveling from the danger to safe districts. Given the estimated summer peak population of the four county SJTPO region, this number represents a conservative number of trips, as a complete evacuation would require more than a 24 hour period, as indicated in previous hurricane evacuation planning assessments.

Table 4 - Evacuation Trip Table Totals

		Destination		
		DANGER	**SAFE**	**TOTALS**
Origin	**DANGER**	-	388,093	388,093
	SAFE	7,445	4,314,226	4,321,671
TOTALS		**7,445**	**4,702,319**	**4,709,764**

With the evacuation trip table synthesized, the SJTDM was run to determine the performance of the system to move the trips throughout the study area. This run was defined as the “baseline” run, as no network changes were made to the SJTDM. The future year 2025 was chosen for assessment.

Next, a what-if scenario was developed to test the region’s ability to move people more effectively during an evacuation situation. This what-if, or “build” scenario, consisted of the completion of NJ 55 from the existing terminus in the City of Millville, Cumberland County, to the Garden State Parkway (GSP), in Dennis Township, Cape May County. The proposed four-lane, limited access freeway would be built primarily as a new road extending from Route 55 to cross CR-548, Hunter’s Mill Road, CR-550, and CR-651 before following Route 83 on the existing, upgraded alignment to US-9 and GSP. The proposed alignment is depicted in Figure 3.

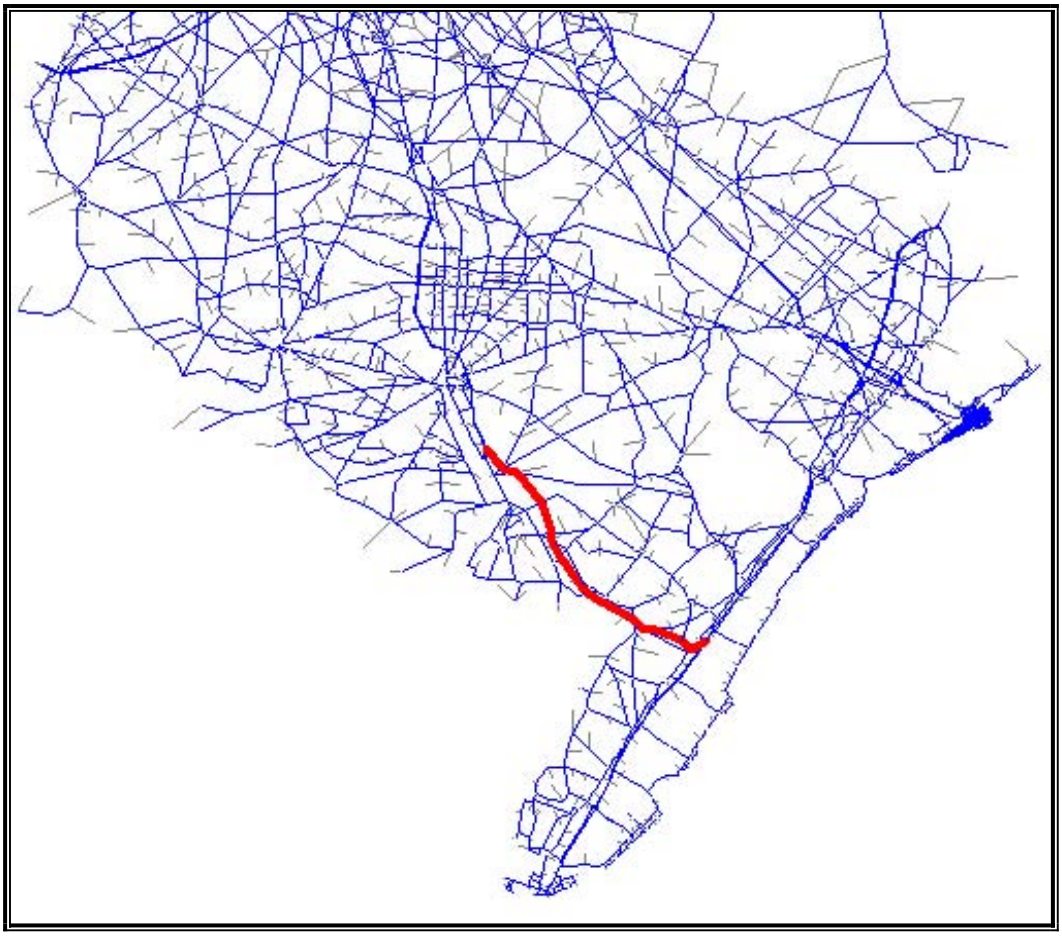

Figure 3 - Proposed Route 55 Alignment

The proposed Route 55 was added to the base scenario 2025 network, and it represented the only infrastructure change in the build network. The SJTDM was then run with the build network and the same 2025 evacuation trip table as utilized in the baseline assessment. To highlight the effectiveness of the what-if scenario, the results of this run was compared to the results of the **Baseline** scenario. The assignments were done for the evening peak period which is from 3PM to 7PM on a typical July weekday. PM peak period results were then extrapolated over a 24-hour period to generate daily evacuation figures.

EVACUATION RESULTS

The model output was summarized to explore the changes in trips originating from or destined to the five general areas, aggregated from designated danger areas within the shore region. Area 1 was defined as Cape May East, Area 2 as Cape May West (2), Area 3 as Atlantic County, and Area 4 as Cumberland County. The results are displayed in Table 2.

It should be noted that the SJTDM extends into the DVRPC region and abuts the NJTPA region. The evacuation scenario did include trip assignments and distribution beyond the SJTPO borders but this impact analysis was limited to the SJTPO region.

Table 5 - Evacuation Scenario Statistics

	Baseline	Build (with Route 55 extension)
Vehicle Hours Traveled	1,369,174	1,337,817
VHT improved	2.29%	
Base Evacuation Trips (Vehicles)	**388,025**	
Average Vehicle Occupancy	2.0	
	PM Peak Period	24 Hours
PM Peak Volume to Daily Volume Ratio	22.4%	
Additional Vehicles Saved	**8,886**	**39,670**
Additional Persons Saved	**17,772**	**79,339**

Overall, an additional 8886 vehicles were able to move through the region under the build scenario in the PM peak period. It should be noted that over half of the total trips in the region are from Atlantic City and Atlantic County. The number of evacuation trips leaving Atlantic City may be overstated in the above table, as all Atlantic internal local trips, such as casino trips, shopping, and beach trips, were routed out of the area under the evacuation trip table. A number of these trips would not be made under emergency situations. However, as the total number of trips in the evacuation scenario is well under the total peak population, the overall analysis is still conservative.

To better focus on the impact to the Cape May area, the Atlantic County trips were factored out of Table 5 to generate Table 6, depicted below:

Table 6 - Evacuation Scenario Statistics without Atlantic County Trips

	PM Peak Period	24 Hours
PM Peak Volume to Daily Volume Ratio	22.4%	
Additional Vehicles Saved	**2,956**	**13,196**
Additional Persons Saved	**5,912**	**26,392**

The scenario testing indicates that vehicle throughput in the danger districts as defined by the number of vehicle hours traveled (VHT), improves by 2.29% during the PM peak period. This improved throughput translates into an additional 2,956 vehicles can make it through the danger districts to safety during the PM peak period. Based on an estimated vehicle occupancy of 2.0, an additional 5,912 people could make it to safety during the PM peak period.

Hourly volume forecasts indicate that the PM peak period represents 22.4% of the daily volume. This takes into account off peak trip making activity, which is generally lower volumes. As it is likely the entire 24 hour period of evacuation will occur under peak conditions due to the capacity limitation of the network, it is a conservative estimate to assume the peak 4 hour period only represents 22 percent of a 24 hour volume, as opposed to about 17 percent if the volume held steady over the 24 hour period. Using the 22.4 percent estimate, an extrapolating over a 24-hour period from the PM peak period translates into an additional 13,196 vehicles, or and additional 26,392 persons that can make it to safety if Route 55 freeway is completed (see Table 3).

These results indicate the critical need to complete Route 55 to address emergency evacuation in the region. A very significant number of persons can reach safe areas each hour with Route 55 freeway completed. It has a significant impact throughout the region in addition to its impact on Cape May, as demonstrated by the data in Tables 2 and 3.

CRITICAL SEGMENTS

Assessing the results of the model runs indicates that the completion of Route 55 freeway significantly changes the travel patterns in the SJTPO region, particularly in an evacuation situation. In general the roadways in Cape May county and Atlantic counties which are already burdened during a normal Summer weekend, become severely overburdened in the event of an evacuation. Completing Route 55 Freeway changes the traffic volumes on several critical links. These links are described below and illustrated in Figure 4.

The biggest shift in traffic is in the *GSP/9 north/south corridor* and the *AC Expressway/30 east/west corridor*. Motorist who are predicted to travel northbound on the GSP and then westbound on the AC Expressway under the baseline scenario to get to western New Jersey or Pennsylvania are now drawn to the Route 55 corridor. This shift starts on the GSP and Route 9 where Route 55 freeway would terminate (near Route 83) and continues north some 22 miles ending at the AC Expressway interchange. The shift continues on the AC Expressway (ACX) from the GSP interchange west another 22 miles to the Atlantic County border and continues into Camden County. A secondary benefit of available capacity on the ACX is that traffic shifts from Route 30 onto the ACX showing a positive benefit to Route 30 in the ACX/30 east/west corridor.

Although most of the *GSP/9* corridor benefits from the completion of the Route 55 freeway, the five-mile section of the corridor between Route 657 and Route 83 (where the freeway would begin) experiences much more congestion with the completion of Route 55. Traffic that was normally using Route 47 and Route 657 to travel north and west is diverted onto this section of the corridor in order to access the freeway. This is the only section of roadway in the SJTPO region that is expected to see much greater volumes and levels of congestion during an evacuation with the Route 55 freeway in place.

NJ Route 50 is a state highway running diagonally about 27 miles from the GSP in Upper Township to Route 30 in Egg Harbor City. In addition to the north/south GSP and Route 9, Route 50 connects to most of the region's other critical east/west arterials and highways that would be used in the event of an evacuation. These include the ACX, Route 30, Route 40, Route 322 and Route 49. With the completion of Route 55 much of the traffic that is bound for the east/west roadways in Atlantic County would be redirected onto Route 55. This would dramatically reduce the amount of congestion on Route 50 and the adjoining routes, and provide enhanced access and mobility for local residents.

Route 559 is an Atlantic County roadway that runs about 27 miles from Somers Point at the shore to Route 30 in Hammonton. At the southeastern end Route 559 splits into two roadways (Route 559 and Alternate Route 559) in Egg Harbor Township and runs parallel for about eleven miles into Somers Point. Much like Route 50, Route 559 intersects the GSP and Route 9 as well as most of the region's other critical east/west arterials and highways that would be used in the event of an evacuation. These include the ACX, Route 30, Route 40, Route 322 and Route 50. With the completion of Route 55 some of the traffic that is bound for the east/west roadways in Atlantic County would be redirected south onto Route 55. This would reduce the amount of congestion on Route 559 and create available local and regional capacity in southern Atlantic County.

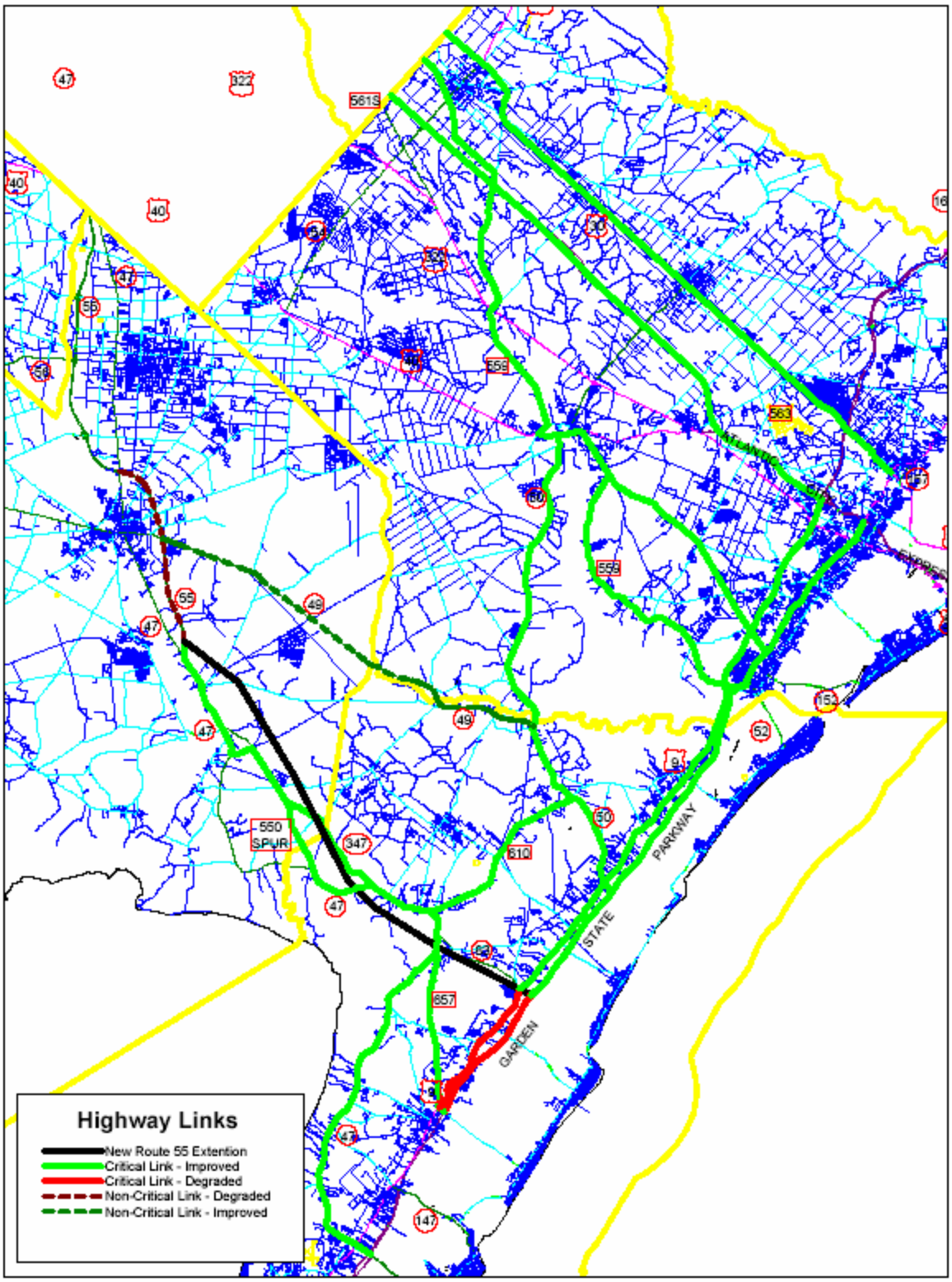

Figure 4 - Critical Links

NJ Route 47 is the primary regional east/west access roadway to the Cape May Shore area. In the SJTPO region it extends about 52 miles from Vineland in Cumberland County to Wildwood City in Cape May County. The Route 55 freeway combined with a portion of the GSP would serve the same east/west corridor as Route 47. With the presence of this limited access facility a great deal of traffic would be shifted onto Route 55. This will reduce congestion on Route 47 from the GSP/9 areas in Middle Township to the terminus of the existing Route 55 in Millville. This congestion relief would extend to the parallel Route 347 section through Dennis and Maurice River Townships.

County Route 657 (Dennisville Road and Stone Harbor Boulevard) is a ten-mile county arterial that serves as a connector roadway between the shore town of Stone Harbor to Route 47 in Dennis Township. The seven-mile section running between the GSP/9 area in Middle Township to its terminus at Route 47 operates as a parallel north/south route in conjunction with Route 47 through Middle Township. Similar to Route 47, traffic is drawn off Route 657 onto the GSP and finally onto Route 55 freeway. This relief allows Route 657 to function more like the local arterial that it was designed to be.

County Route 610 (Dennisville-Petersburg Road) is a local north/south arterial roadway that serves as a collector/distributor between two of Cape May's principal state highways, Route 47 in Dennis Township and Route 50 in Upper Township. This seven mile stretch would normally be used by travelers in Cape May bypassing the GSP connecting to Route 50 to gain access to the ACX to head west. With the completion of Route 55, traffic and congestion are drawn off of these roadways and onto Route 55 leaving this roadway to serve local traffic in the upper portion of Cape May.

NJ Route 49 is 54-mile state highway that runs east/west from the NJ Turnpike in Salem County to Route 50 in Cape May County. It is the only roadway in the region to pass through all four SJTPO counties. Route 49 operates as both a regional local roadway. Some sections function as an arterial with speed limits of 50 mph and no signal controls, while other sections function as a local street with many curb cuts and signals spaced at less than half-mile intervals. The sixteen-mile section that connects Route 50 to the existing Route 55 freeway section serves travelers in Upper Cape May, lower Atlantic and eastern Cumberland counties. With the completion of the Route 55 freeway Route 49 will experience some congestion relief as traffic is redirected onto the freeway via Route 50 and Route 610.

In summary, completing Route 55 freeways relieves much of the regional arterial network and enhances its performance. This contributes to the overall ability of the system to better move people under extreme conditions in a shorter period of time with the freeway completed.

APPENDIX A

Evacuation Logic Program

(EVAC.PRG)

```
                                parameters matrix1, ezone, output


        ***************************************
        *MATRIX1 = files of matrices in ASCII
        *EZONE = evacuation zone look up table
        *OUTPUT = output file
        ***************************************

if parameters()= 3
        * bypass menu procedure if batch file driven
   numparam = 3
else
        * Else go into interactive mode
        numparam = 0
        matrix1='evac.prn    '
        ezone='evzone  '
        output='evac    '
clear
@ 2,1 say 'This program converts 1900 zones SJM into'
@ 3,1 say '8 evacuation zones (4 danger and 4 safe zones)'
@ 4,1 say 'It reallocates trips to safe zones and reduces danger-zone bound trips by 90%'

@ 7,1 say 'Matrix 1 (in ACSII: i(10), j(10), mat(5), vol(5)):  ' get matrix1
@ 9,1 say 'Evacuation zone system look up table (dbf):         ' get ezone
@ 10,1 say 'Output files (4 files will return: dbf, dat and out):  ' get output


read
endif


clear
close all
set status off
set safety off

run del *.out
clear

? "Programme is working..."
?

creat table dummy1 (orgn n(10, 0), dest n(10, 0), purp n(5, 0), vol n(5, 0), o_ezone n(10, 0),
d_ezone n(10, 0), e_vol n(10, 0))

        ***************************************
        *ORGN = origin in 1900 zone system
        *DEST = destination in 1900 zone system
        *PURP = purpose/matrix no
        *VOL = volume
        *O_EZONE = origin in ezone (evacuation) system (8 zones: 1-danger zone cape may, east of
gsp,
        *                                                    2-danger zone cape may, west of gsp,
        *                                                    3-danger zone atlantic city,
        *                                                    4-danger zone cumberland,
        *                                                    5-safe zone dvrps-nj,
        *                                                    6-safe zone dvrps-penns,
        *                                                    7-safe zone external/other nj,
        *                                                    8-safe zone rest of sjtpo
        *D_EZONE = destination in ezone system
        *E_VOL = evacuation volume
        ***************************************


use dummy1
appe from F:\Evacua~1\matrix\&matrix1 sdf
sort on orgn, dest, purp to dummy2
close all
```

```
        ***************************************
        *group 1900 zones into 8 evacuation zones
        ***************************************

use dummy2
sele 2
use "F:\evacua~1\safety~1\"+alltrim(ezone)+".dbf"

sele 2
index on str(ozone) to dummy3
sele 1
set rela to str(orgn) into evzone
replace all o_ezone with &ezone->nzone
set rela to
set relat to str(dest) into evzone
repl all d_ezone with &ezone->nzone
copy to F:\Evacua~1\matrix\&output
close all


use F:\evacua~1\matrix\&output
repl all e_vol with 0

        ***************************************
        *remove all danger-danger trips (x100 to capture the decimal place)
        ***************************************

i=1
do while .t.
if i>4
        exit
else
        j1=alltrim("sub")+alltrim(str(i))
        j2=alltrim("sub")+alltrim(str(i+4))
        calc sum(vol) for o_ezone=i .and. d_ezone<=4 to &j1
        calc sum(vol) for o_ezone=i .and. d_ezone>4 to &j2

        if i>4
                exit
        else
                replace e_vol with round(((&j1*vol/&j2)*0+vol), 2)*100 for o_ezone=i .and.
d_ezone>4
        endif
endif
i=1+i
enddo

clear
? "...almost done"
?

replace e_vol with vol*100 for o_ezone>4 .and. d_ezone>4

        ***************************************
        *reduce safe to danger zone traffic by 90%, (x100 to capture the decimal place)
        ***************************************

replace e_vol with round(0.1 * vol, 2)*100 for o_ezone>4 .and. d_ezone<=4


calc sum(e_vol) for o_ezone<=4 .and. d_ezone<=4 to e_dd
calc sum(e_vol) for o_ezone<=4 .and. d_ezone>4 to e_ds
calc sum(e_vol) for o_ezone>4 .and. d_ezone<=4 to e_sd
calc sum(e_vol) for o_ezone>4 .and. d_ezone>4 to e_ss
calc sum(e_vol) to e_all

calc sum(vol) for o_ezone<=4 .and. d_ezone<=4 to dd
calc sum(vol) for o_ezone<=4 .and. d_ezone>4 to ds
calc sum(vol) for o_ezone>4 .and. d_ezone<=4 to sd
calc sum(vol) for o_ezone>4 .and. d_ezone>4 to ss
calc sum(vol) to all
```

```
clear
set alternate to "F:\evacua~1\matrix\"+alltrim(output)+".out"
set alte on
?
? "Reported on "
?? date()
?? ", "
?? time()
?
? "Total original trips: "
?? alltrim(str(all)) at 60
?
? "     original danger-danger trips: "
?? alltrim(str(dd)) at 60
?? " ("
?? alltrim(str(round(dd*100/all, 2),6, 2))
?? "%)"
? "     original danger-safe trips: "
?? alltrim(str(ds)) at 60
?? " ("
?? alltrim(str(round(ds*100/all, 2),6, 2))
?? "%)"
? "     original safe-danger trips: "
?? alltrim(str(sd)) at 60
?? " ("
?? alltrim(str(round(sd*100/all, 2),6, 2))
?? "%)"
? "     original safe-safe trips: "
?? alltrim(str(ss)) at 60
?? " ("
?? alltrim(str(round(ss*100/all, 2),6, 2))
?? "%)"
?
?
? "Total trips after reallocation: "
?? alltrim(str(round(e_all/100, 0))) at 60
?
? "     danger-danger trips after reallocation: "
?? alltrim(str(round(e_dd/100, 0))) at 60
?? " ("
?? alltrim(str(round(e_dd*100/e_all, 2),6, 2))
?? "%)"
? "     danger-safe trips after reallocation: "
?? alltrim(str(round(e_ds/100, 0))) at 60
?? " ("
?? alltrim(str(round(e_ds*100/e_all, 2),6, 2))
?? "%)"
? "     safe-danger trips after reallocation: "
?? alltrim(str(round(e_sd/100, 0))) at 60
?? " ("
?? alltrim(str(round(e_sd*100/e_all, 2),6, 2))
?? "%)"
? "     safe-safe trips after reallocation: "
?? alltrim(str(round(e_ss/100, 0))) at 60
?? " ("
?? alltrim(str(round(e_ss*100/e_all, 2),6, 2))
?? "%)"
?
?
?? "Output files: "
?? alltrim(output)
?? ".dbf"
?? ", "
?? alltrim(output)
?? ".dat (1900 zones)"
?? ", "
?? alltrim(output)
?? "8.dat (8 evacuation zones)"
?? " and "
```

```
?? alltrim(output)
?? ".out (statistics)"
?
set alte to

copy fields orgn, dest, purp, e_vol to "F:\evacua~1\matrix\"+alltrim(output)+'.dat' sdf

sort on o_ezone, d_ezone, purp to dummy4
sele 3
use dummy4
copy fields o_ezone, d_ezone, purp, e_vol to "F:\evacua~1\matrix\"+alltrim(output)+'8.dat' sdf
close all


run del dummy*.*
run del *.bak
run del *.fxp
run del *.idx
run del *.out

quit
```