

Alternatives to Road Building to Improve Hurricane Evacuation in
Coastal South Carolina

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I. EXECUTIVE SUMMARY

Hurricanes will consistently threaten the coastal residents of South Carolina. Revamped evacuation strategies would alleviate the need for additional road building as a solution for safe, efficient, and effective hurricane evacuation. Development in coastal zones, coastal erosion, rising ocean levels, changing climate levels, and a growing population all contribute to the susceptibility of South Carolina to hurricane disasters.¹ It has been noted that South Carolina's roadway infrastructure is constrained in its capacity for westbound travel during emergency situations.²

According to some, the solution is to increase the highway infrastructure by adding additional roads and highways to undeveloped areas.³ As an example, the South Carolina Department of Transportation is currently working on a few proposals for the already congested Myrtle Beach area that will ultimately lead to additional development and increased congestion in the region.⁴ The two major highway projects slated for this coastal region are Interstate 73 and the Carolina Bays Parkway.⁵ Two of the alleged purposes behind these projects are to alleviate local traffic congestion and to facilitate hurricane evacuation.⁶ Construction projects of this nature are expensive endeavors that will lead to further expansion in the coastal region, which in turn will further overcrowd our state's highways in emergency situations. There are numerous lower-cost and environmentally friendly alternatives to new road building which can be used to accomplish a safe and orderly hurricane evacuation.

These options include:

Expand Use of Technology to Provide Public Information
Computer Evacuation Modeling
Utilization of Intelligent Information Systems
Improve the Structure of Communications
Reverse Flow Operations
Staged Evacuation
Vertical Evacuation
Utilization of Public Transportation Systems
Public Shelters
Disaster Reserve Units and Volunteers
Stricter Zoning and Building Codes
Maximization of Existing Roadway Capacity
Establishment of Commercial Partnerships

II. INTRODUCTION

This paper explores areas that warrant further investigation by the State of South Carolina as alternatives to road building to improve hurricane evacuation. The Southeast's experience with Hurricane Floyd in 1999 proved that most states' current evacuation systems were inadequate. Floyd also demonstrated that there existed an exigency for additional capacity to

evacuation routes, improved coordination and planning across all-levels of state government, and the creation of informational systems that are effective.⁷

These areas of deficiency encompass many of the alternatives that should be considered by South Carolina versus constructing new thoroughfares.

Alternatives to be considered include expanding the use of technology to provide public information; improving communication between local agencies, state agencies, the public, and neighboring states; utilizing evacuation strategies such as contra flow, phase evacuation, and vertical evacuation; enhancing the use of public shelters and safe houses; promoting the use of existing reserve units and creating a disaster volunteer program; optimizing the use of current infrastructure and adopting stringent building codes; and creating partnerships with various private business organizations.

This article will briefly summarize the history of hurricane evacuation in South Carolina and will discuss the various options available to the state of South Carolina in lieu of road building. The first portion of the paper will provide information on hurricanes in the Southeast and offer some population figures for the coastal region of South Carolina. The second section will discuss the various alternatives, including improving the use of technology, improving communications, using various evacuation techniques, utilizing volunteers, enhancing the public shelter system, optimizing current infrastructure, and creating partnerships. Throughout this section, recommendations for the implementation of these proposed alternatives will be offered.

III. HISTORY OF HURRICANES IN SOUTH CAROLINA

Due to population growth in coastal regions, hurricane evacuations have evolved over the years from localized events to massive regional undertakings.⁸ Because of their regional effect, Hurricane George in 1988 and Hurricane Floyd in 1999 resulted in the two biggest evacuations in American history.⁹ In 2004, many people evacuated inland in Florida instead of north on Interstate 95 because of vivid memories the gridlock Hurricane Floyd created in 1999.¹⁰ Of the two massive hurricanes, Hurricane Floyd prompted the largest evacuation with more than three million people from Florida, Georgia, North Carolina, and South Carolina fleeing the coastal regions of each state.¹¹ Officials and residents never anticipated the enormous traffic volumes and shelter requirements that each state would incur over the evacuation's four-day period.¹² As a result of inadequate planning, countless people were marooned in their vehicles for more than twenty-four hours without food, fuel, and restroom facilities.¹³

To ensure this chaos would not occur again, the Federal Emergency Management Agency undertook a study of the evacuation methods used in Hurricane Floyd in order to create policies, procedures, and tools that both the federal government and the states could use in future situations under similar conditions.¹⁴ The Federal Emergency Management Agency enlisted the United States Army Corps of Engineers, who in turn contracted PBS&J (a civil engineering consulting firm in South Florida), to complete a southeast hurricane evacuation study.¹⁵ This assessment became the largest behavioral analysis

inquiry ever conducted by the federal government in a post-hurricane investigation.¹⁶

Fourteen hurricanes have hit the coast of South Carolina since the early 1900s.¹⁷ Hurricane Hugo in 1989 was the second costliest hurricane in history, causing approximately \$8 billion in damages.¹⁸ Also, Hurricane Hugo was recorded as the eleventh strongest hurricane in United States history at the moment of landfall.¹⁹ Hurricanes Bertha and Fran in 1996, as well as Hurricane Floyd in 1999, were subsequent tremendous storms that threatened the South Carolina coastline.²⁰

The South Carolina coast is a popular resort destination that is heavily populated and continues to grow both in tourism and new residents.²¹ South Carolina has eight coastal counties: Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, Horry, and Jasper.²² The total estimated residential population of these eight coastal counties as of July 1, 2003 is approximately 1,034,372 people, not including tourists.²³ South Carolina's coastal region has a low-lying geography encompassing 3,000 miles of actual shoreline and 190 miles of open coastline, making the area extremely vulnerable for potential storm surges.²⁴

IV. OPTIONS: ALTERNATIVES TO ROAD BUILDING

This section will discuss the various alternatives to road building to improve hurricane evacuation in South Carolina, including expanding the use of technology, improving communications, using various evacuation techniques,

utilizing volunteers, enhancing the public shelter system, optimizing current infrastructure, and creating partnerships.

Expand Use of Technology to Provide Public Information

Computer Modeling

Advancement in technology has spawned the use of computer modeling in disaster evacuations. Hurricane evacuation modeling systems include flood/geographic modeling systems (the SLOSH model and LIDAR) and traffic flow and strike probability modeling systems (MASSVAC, HURREVAC, OREMS, IMDAS, and the Evacuation Travel Demand Forecasting System).²⁵

- SLOSH stands for Sea, Lake, and Overland Surges from Hurricanes model. The software is used to predict and evaluate probable storm surges and flooding associated with a hurricane.²⁶ This model provides flood estimates generated from storm scenario input data and is widely used by most states.²⁷
- LIDAR stands for light detection and ranging.²⁸ It is a remote system that can be used to measure changes in the topography of the coast line. LIDAR technology is similar to RADAR technology.²⁹ Light is transmitted by the LIDAR instrument to the ground and then is reflected back to the instrument and analyzed.³⁰ This technology is extremely useful for coastal mapping and can be used to study changes in geography after a severe storm.³¹ Unlike traditional mapping technologies, LIDAR devices, such as NASA's

Airborne Topographic Mapper, can determine precise coastal elevations.³² Flooding can now be more accurately predicted.

- MASSVAC stands for Mass Evacuation and is a computer modeling system that was initially created to assist in nuclear power plant evacuations and has been used in the past to analyze hurricane evacuation strategies in Virginia.³³
- HURREVAC stands for Hurricane and Evacuation on a Computer. This product is a geographic information system used to track hurricanes, provide strike probabilities, predict wind speeds and flooding scenarios, and to estimate the timing of evacuation decisions.³⁴
- OREMS stands for Oak Ridge Evacuation Modeling System. OREMS is a vehicular modeling system that is used to analyze travel flow during emergency situations.³⁵ This program calculates clearance times and allows experimentation with alternate routes and evacuation strategies.³⁶
- IMDAS is an acronym for Incident Management Decision Aid System and is a simulation software solution designed to provide precise information on hurricane evacuation activities and alternatives.³⁷
- The Evacuation Travel Demand Forecasting System developed by PBS&J is a web-based system which was developed for the states

of Florida, Georgia, North Carolina, and South Carolina to input data that will result in forecasts of traffic congestion levels and traffic volume between states.³⁸ Types of information that can be entered are hurricane category, expected participation rate for evacuation, destination information, and tourist information.³⁹

South Carolina has recognized the need for simulation modeling and currently utilizes SLOSH, HURREVAC, and PBS&J's Evacuation Travel Demand Forecasting System.⁴⁰ These computer evacuation modeling systems assist the state of South Carolina in its hurricane evacuation decision-making processes when there is an impending storm that threatens the South Carolina coastline. LIDAR, OREMS, and IMDAS are new technologies that should be investigated by the state of South Carolina in an effort to enhance evacuation planning and implementation.

Intelligent Information Systems

Intelligent information systems and smart communication devices are computer networks, combined with sensors and cameras, to provide real-time information and monitoring.⁴¹ Systems are typically comprised of software, sensors, cameras, closed circuit television systems, computers, monitors, modems, wireless networking, dynamic message signs, and display mediums. A combination of the above technologies can be used to create intelligent transportation systems (ITS).⁴² An intelligent transportation system is a cost-effective and efficient way to provide traffic control systems, public safety,

traveler information, modeling and simulation, vehicle crash prevention, highway management operations and maintenance, weather observing and forecasting system, and surface conditions monitoring.⁴³ Intelligent transportation systems offer a medium in which states can maximize the capacity of their current infrastructure. Different states use various technologies and techniques.

Virginia offers a 511 service to people traveling within its borders.⁴⁴ This 511 system communicates road condition and traffic information via a network of sensors and interactive services such as telephone, internet web sites, and television.⁴⁵ The 511 system distributes information real-time to travelers.⁴⁶ Information is funneled to a central repository maintained by the Virginia Department of Transportation.⁴⁷ This repository collects information from the National Weather Service which provides information on current weather conditions, the Virginia Department of Transportation and the Virginia State Police which provide information on accidents, work zones, and travel conditions, and by local organizations who provide tourism information.⁴⁸ A study conducted by the state of Virginia claims that virtually half of its travelers modify their travel arrangements with information supplied by the 511 system.⁴⁹ Virginia pays for the 511 system through advertising and promotions, sponsorships, sales of special services, and data sales.⁵⁰ The cost to implement a 511 system for a population of 1.5 million people is approximately \$18 million plus marketing costs.⁵¹ Annual maintenance and operation costs are approximately \$1.1 million plus marketing expenses.⁵²

The internet is another communication technology that is underutilized. The state of Florida has implemented www.floridadisaster.org as an interactive way for its residents to obtain real-time information on potential emergency situations.⁵³ These types of web services can range from a few hundred dollars a month upwards to six figures a month depending on the complexity.⁵⁴ The internet and selected web sites can be accessed through home computers, computers at shelters, and via mobile phones for those who are traveling and desiring updated information. People can now enter in their zip code and receive specific instantaneous information regarding their neighborhood, including evacuation routes, flood zones, and status of the storm.⁵⁵ Residents can obtain graphical and detailed information on shelters, evacuation zones, surge zones, public services, and location.⁵⁶ The shelter section offers a map which highlights the location of shelters on evacuation routes and conveys vacancy information.⁵⁷ The evacuation zones section provides comprehensive information, including maps, on evacuation routes, road closures, and mandated/suggested evacuation zones.⁵⁸ The surge zone portion of the web site offers graphical information on current and forecasted danger and surge zones.⁵⁹ The public services area communicates information on various assistance services that are available to residents, while the locate information allows a user to zoom into his current location and obtain pertinent information regarding that locale.⁶⁰

The internet is a powerful tool that can and should be utilized to disseminate information to the public on pending emergent situations. There are

numerous devices that can obtain information from the internet via current wired infrastructure, cellular towers, and satellites. Such equipment as mobile phones, pagers, portable computers, personal digital assistants, watches, interactive television sets, and navigation systems in automobiles are fairly inexpensive and are fast becoming commodities in today's society.⁶¹ Cellular phones are often equipped to receive text and audio messages and it is possible for many of these phones to call or notify their owners with official emergency broadcasts.⁶² Pre-assigned evacuation routes and shelters can be sent via email before an impending storm. For those who do not have access to the internet, real-time data can be transmitted electronically to radio and television stations in an effort to expedite information to the public.⁶³ Wireless access is gaining in popularity. There are initiatives in many areas to offer wi/fi access as an enticement to attract visitors.⁶⁴ States need to embrace technology and exploit its full potential in managing and maximizing evacuation capacity.

Radio and television continue to be useful tools. For those residents who do not have access to the types of current technology discussed in the previous paragraph, the state of Florida has signed an agreement with Florida Public Radio to broadcast information on its thirteen radio stations during an impending hurricane.⁶⁵ These thirteen FM stations provide coverage for 98 percent of the state of Florida.⁶⁶ Hurricane evacuation route signs identify the appropriate radio station for the local area.⁶⁷ For those who do not listen to public radio and for those who have not seen the evacuation route signs on the highway, the state

should heavily advertise that people should tune to their local public radio station for emergency broadcast information. The state of Delaware has acquired its own FM radio station to provide travel information to its residents and visitors.⁶⁸ As noted above, television can be enhanced by offering real-time information for its viewers.

Improve Communications

There are three essential elements for coordination and communication of information in an emergency situation.⁶⁹ First, it is crucial for agencies to understand how individuals will react in an emergency situation.⁷⁰ Keeping the public informed with timely and accurate information while giving explicit directions to those who are in the hazard zone is important.⁷¹ Also, it is important to advise those who are not in danger to remain where they are and wait for further instructions from public officials.⁷² Second, there must be effective and efficient information exchange among emergency management personnel, transportation officials, and local agencies.⁷³ Finally, there must be detailed and comprehensible courses of action that can be implemented by both public officials and the public at large.⁷⁴

In the past, preparation for hurricane evacuation has been the sole duty of law enforcement and emergency management.⁷⁵ There is a current need to involve other agencies and to adopt standardized practices, policies, and procedures between states and local agencies. FEMA mandates that all states develop and maintain an emergency operations plan.⁷⁶ In most states,

evacuation planning and implementation is conducted at the local level with state officials coordinating the local activity.⁷⁷ Researchers at Louisiana State University conducted a survey of 18 coastal states and determined that most of the states' emergency plans varied with their strategies, emergency management terminology, assignment of resources, emergency command structures, and delegation of authority.⁷⁸ Each state also seemed to vary on evacuation implementation times and evacuation types.⁷⁹ As an example, in South Carolina evacuations are classified as mandatory or voluntary, where as Virginia evacuations are classified as recommended or voluntary.⁸⁰ How the public perceives a state's warnings has a direct impact on how many people decide to evacuate and at what moment they decide to evacuate.⁸¹ Heavy spikes in traffic because of misinterpretation can cause inefficient travel flow.⁸² In an effort to standardize best practices for emergency response, the Department of Homeland Security has published the *National Response Plan* to provide states and local agencies with a comprehensive approach to managing emergency and disaster situations.⁸³

To improve evacuation operations, there should be a standardization of radio codes, frequencies, and equipment for emergency personnel throughout a region to allow state and local agencies to effectively communicate. South Carolina has enacted the Palmetto 800 System to combat this problem; however, due to a lack of funding, numerous public safety agencies are not able to subscribe to this essential service.⁸⁴ Such standardization would enable

emergency personnel to efficiently handle evacuations and promptly attend to any problems along evacuation routes. Perhaps lottery proceeds, a grant from the federal government for homeland security, or a half-cent sales tax could help fund such standardized equipment for emergency operations. North Carolina has implemented an online satellite communication system, funded by a grant from the federal government, which allows all its counties to talk in the event cellular service is not available.⁸⁵

All coastal and neighboring states should implement intelligent transportation and information systems with a central repository for information to improve communication. These systems should have a standard platform and should be able to communicate real-time data to in-state residents and travelers, as well as bordering states. Utilization of intelligent transportation systems would keep traffic moving and improve coordination for cross-state evacuations.

Another way to improve communication in emergency evacuation situations is to implement multi-state evacuation plans, complete with formal mutual aid contracts between states.⁸⁶ For additional information, FEMA offers information concerning mutual aid on its web site (www.fema.gov/preparedness/mutual_aid.shtm). Also, if a storm calls for a multi-state evacuation, the establishment of a regional operations center for coordination of multi-state activity would be beneficial to evacuees.

Communication is essential in an emergency situation. Timely and accurate information to the public will enable people to make informed decisions

on how to respond to an evacuation order during a hurricane.⁸⁷ Effective communication links all involved in a crisis situation and is the cornerstone of an efficient evacuation. Emergency evacuation plans must be consistently updated and revised due to changing technology and experiences from previous experienced disasters.⁸⁸ The creation of a hurricane task force or the undertaking of a research study by a major university for best practices may warrant consideration.

Evacuation Options

This section discusses various evacuation options such as reverse or contra flow, phased evacuation, vertical evacuation, and public transportation systems.

Reverse Flow Operations

Reverse flow operations or contra flow entails reversing inbound lanes on major thoroughfares to accommodate outbound traffic in emergency situations.⁸⁹ Sixty-one percent of coastal states, including South Carolina, have implemented contra flow into their emergency evacuation plans.⁹⁰ States vary on the contra flow strategy they will incorporate. There are four variations that have been primarily adopted: 1) reverse all lanes, 2) reverse one inbound lane and reserve the other inbound lane for emergency use of inbound vehicles, 3) reverse one inbound lane and keep the other inbound lane open for any inbound traffic, and 4) use the left shoulder of the outbound lane as an outbound lane.⁹¹

Reversing all lanes has been noted to increase outbound traffic capacity by approximately 70 percent.⁹² Reversing one inbound lane has the effect of increasing outbound capacity by 30 percent, while using the outbound shoulder of an outbound lane minimally increases capacity by approximately eight percent.⁹³ It has been said that clearance times for Key Largo, Florida City, and Islamorada, in the Florida Keys, would only improve by one hour with the addition of an outbound lane.⁹⁴ Studies of Hurricane Floyd indicated that evacuation times were reduced by approximately by 40 percent in South Carolina when all lanes on an interstate were reversed.⁹⁵

Phased or Staged Evacuation

Phased evacuation is another technique that can be used as an alternative to road building.⁹⁶ Evacuees can be notified through ITS technology with their designated timeframe to evacuate and with their pre-assigned evacuation route. People will usually act as instructed when threatened by an impending monstrous storm.⁹⁷ Phased evacuation, if done properly, could possibly relieve “shadow evacuation.” “Shadow Evacuation” occurs when people living outside the danger zones unnecessarily evacuate increasing congestion on roadways.⁹⁸ The Florida Keys offer a good example of a proposed phased evacuation plan. For category 3, 4, and 5 hurricanes; the local governments of the Florida Keys enforce a mandatory evacuation of non-residents 48 hours before the impending storm.⁹⁹ The next wave of evacuations occurs approximately 36 hours before estimated landfall.¹⁰⁰ These evacuees consist of hospital and nursing home

patients, special needs residents, and owners of mobile homes.¹⁰¹ The final phase consisting of residents is evacuated at the 30 hour mark.¹⁰² Simulations indicate that clearance times for residents would be shortened by approximately six hours using phased evacuation.¹⁰³

Vertical Evacuation

Vertical evacuation is another option to consider in hurricane evacuations. Vertical evacuation occurs when people attempt to evade flooding by evacuating to higher ground or to higher floors within a building.¹⁰⁴ Buildings considered for vertical evacuation should be inspected by a professional engineering firm to determine if the building can withstand the forces of a strong hurricane.¹⁰⁵ It has been noted that the high winds of a hurricane can damage tall buildings.¹⁰⁶ Winds from Hurricane Alicia damaged high-rise buildings in Houston, Texas, even though Houston is somewhat inland.¹⁰⁷ With these findings, even if a building is deemed structurally sound to withstand hurricane force winds and flooding, it might be prudent not to rely on this method of evacuation and to use vertical evacuation in high-rise buildings as a method of last resort.

Public Transportation Systems

Transportation systems such as buses, trains, and airplanes should be utilized to maximize evacuees in mandatory evacuations. Local transit authorities, private bus services, and National Guard vehicles can be used to transport the sick and elderly to inland hospitals and shelters.¹⁰⁸ Railways can be contracted by local government to evacuate those without vehicles, while

airplanes can be used to evacuate those who can afford normal and discounted fares.

Public Shelters and Safe Houses

Public shelters and safe houses (refuges of last resort) play a vital role in mass evacuation. Public shelters are provided for those who cannot evacuate and for those that attempt to evacuate but have no place to go.¹⁰⁹ Refuges of last resort are identified strongholds along evacuation routes that serve as a last ditch endeavor to save lives.¹¹⁰ These safe houses are designed, but not guaranteed, to withstand category 3, 4, and 5 conditions.¹¹¹

A state's public shelter policy should continuously be reviewed and enhanced. States should partner with universities, colleges, and community colleges that have facilities suitable for shelter use in order to provide additional host county sites in non-impacted areas.¹¹² South Carolina could partner with USC, Clemson, Francis Marion, Lander, Winthrop, College of Charleston, and some of the technical colleges to offer shelter services. If a state liability waiver was offered, there are a number of private institutions, such as Newberry, Charleston Southern, and Wofford, that could offer refuge to evacuees.¹¹³ Other initiatives a state can make include offering public access to computers in shelters and to partner with the health department to staff special needs shelters throughout the region.¹¹⁴

Various civic and professional organizations can play a role in reducing the need for public shelters by initiating and sponsoring programs that will provide

host families in non-impacted areas to sponsor and provide refuge to their fellow members in need of shelter. Pinellas County in Florida has been promoting a “Host Home Hurricane Alternative” which pre-assigns evacuees to host families in non-evacuation zones.¹¹⁵

Another possibility to reduce traffic on the highways is to build “retrofit rooms” in designated safe houses along evacuation routes.¹¹⁶ A “retrofit room” is an in-home shelter that can withstand category 4 hurricane force winds.¹¹⁷ These rooms, developed by a professor in Florida, can be constructed in bathrooms or closets of existing houses or structures for approximately \$3,000 per room.¹¹⁸ Materials can be purchased at home improvement stores such as Home Depot and Lowe’s.¹¹⁹

The above suggestions can reduce congestion on highways and enhance public safety. With the combination of active hurricane seasons in the Atlantic and limited hotel space, South Carolina must plan to accommodate not only evacuees from its own state, but from neighboring states as well. In August and September of 2004, Florida was pummeled with four successive hurricanes.¹²⁰ Hurricane Charley, Hurricane Frances, Hurricane Ivan, and Hurricane Jeanne made landfall in Florida within an eight-week time frame causing approximately \$20 billion in damage.¹²¹ These hurricanes could have easily traveled up the coast at a moment’s notice and made landfall in Georgia, South Carolina, North Carolina, and Virginia. As Hurricane Francis was taunting Florida, there was

twice the normal traffic volume on Interstate 95 at the South Carolina Georgia border due to evacuees from Florida.¹²²

Disaster Reserve Units and Volunteers

The use of trained volunteers is a cost-effective and efficient way to provide services for disaster relief. There are many areas in which volunteers could contribute to the evacuation process. South Carolina could utilize the state constable auxiliary (www.sled.state.sc.us and www.sconstable.org), the state guard (www.scguard.com), volunteer shelter managers (www.avaintl.org and www.floridadisaster.org/director_office/citizen_corps/resources.htm), and volunteer emergency medical personnel (www.hhs.gov and http://floridadisaster.org/director_office/citizen_corps/mrc.htm). The state constable auxiliary could provide additional person power in the law enforcement arena. State constables could be used for traffic control at crossovers, intersections, highway interchanges, rest areas, and other critical segments. This group can also be used to assist local law enforcement agencies in their preparation for hurricane evacuation. The state guard could be used in numerous situations. The guard could block intersections during contra flow operations or could assist in evacuating low mobility citizens. A program to identify and train volunteer shelter managers might be enacted.¹²³ Also, volunteer emergency medical personnel should be identified and trained for deployment to shelter locations. The effective use of emergency medical personnel in shelters would enable special needs residents the opportunity to

stay in local shelters. Florida has implemented a Medical Reserve Corps to assist in various types of emergency situations.¹²⁴ The productive deployment of volunteers during an evacuation process is another avenue that needs to be explored before money is spent on creating new roads.

Infrastructure

Zoning and Building Codes

Zoning and building codes can be effectively used to manage development in coastal areas. Low density development in hazardous coastal zones will limit the number of evacuees. Perhaps planned development communities that limit multi-unit housing, hotels, and high rises are a viable option. Rate of growth ordinances (ROGO) and moratoriums in the overall master development plan of a community can help achieve a lower density.¹²⁵ The goal of this type of ordinance is to provide a fair distribution of building and use permits while being legally defensible.¹²⁶ States often encourage growth for the economic benefits without taking notice of the potential overall costs.¹²⁷ Rapidly increasing population growth in coastal areas could counteract the lifesaving technology advances in construction techniques and storm forecasting.¹²⁸ There needs to be a balance when managing growth, as growth restrictions, such as limits on building permits, can be politically unpopular.¹²⁹

Zoning that requires builders to construct buildings and houses that can withstand the forces of category 3, 4, and 5 hurricanes will result in less people having to evacuate the immediate coastal region. Most of the damage caused by

Hurricane Andrew in 1992 was due to poorly built structures and deficient inspection.¹³⁰ Strict building codes in coastal areas not subject to a storm surge will ensure safe places for evacuees to seek shelter.

Existing Roadway Infrastructure

Use of current infrastructure should be optimized. It appears as if states are implementing this strategy as it has been noted in a recent presentation by the Federal Highway Administration that along coastal regions “there has been less than a 1% increase in the number of lane miles.”¹³¹ Before constructing new roads in undeveloped areas, a complete inventory of existing routes, including each road’s physical condition, should be undertaken. Studies should include average number of travelers per day and maximum capacity loads. Bottlenecks should be identified and existing alignments in critical areas should be upgraded. Crossovers for contra flow use should be installed on major highways. If there is still a need for additional capacity, current roads could be widened to add additional lanes. This would minimize the impact on the environment, as well as cost less than building new roads. When renovating or adding to existing roads, consideration should be given to adding shoulders that could withstand traffic or adding auxiliary lanes in critical segments.

Construction/Work zones during hurricane season should be minimized on evacuation routes.¹³² Contingency plans to remove work zones should be in place.¹³³ Contracts for construction projects should contain special provisions clauses for emergency evacuation situations.¹³⁴ These provisions should include

a mandate to stop working, remove all equipment, and to open the work zone to traffic.¹³⁵

Partnerships

South Carolina can partner with leaders in commercial segments such as insurance, travel, and cellular providers. Solid partnerships with commercial organizations can improve communication to the public, reducing panic in mass evacuation situations and thus reducing traffic congestion.

Insurers could offer services through a link on the state's web portal.¹³⁶ A system could be set up in which insurers email the insured prior to evacuation with copies of policies and detailed steps to take if a claim is incurred by the insured. This process could help increase the efficiency of those evacuating.

The travel industry is a prime area in which agreements concerning hurricane evacuation could be made. Travel agents, resorts, and chambers of commerce can offer special vacation destination packages to residents of areas poised for evacuation. These packages would be severely discounted and only offered during a specific time period, similar to the last minute deals that the cruise lines offer. The destination packages would include airfare, bus fare, or train fare to the offered destination. Airline packages could include three-day trips to Las Vegas. Bus packages could include three-day trips to the upstate of South Carolina, Atlanta, or the mountains of Western North Carolina. Train packages might offer destinations to Tennessee or Kentucky. These would be short excursions targeted towards people who are adequately insured.

Partnerships with leading cellular providers are fundamental in a situation requiring mass evacuation. Cellular systems typically overload during a surge in mobile phone activity.¹³⁷ Once overloaded, it is nearly impossible for mobile phone users to complete calls.¹³⁸ If calls cannot be completed, communication with travelers comes to a grinding halt. To combat this situation, states may offer incentives or initiate contracts with the cellular industry to ensure that there is enough capacity along evacuation routes for high volume call activity during emergency and evacuation situations. At minimum, cellular providers should ensure that there is adequate capacity to enable all mobile devices along evacuation corridors to receive updated text messages from public officials during emergency situations. This strategy might persuade people to utilize rural evacuation routes instead of major highways because they would have the ability to communicate and receive advisory updates during the evacuation period.

Finally, the state could partner with home builders and home remodeling contractors. The state could market the “retrofit room” concept to home builders and contractors in coastal regions in an effort to encourage the public to outfit homes not located in flood zones with in-home shelters.¹³⁹ These in-home shelters would reduce the number of people who believe they have a need to evacuate.¹⁴⁰

V. CONCLUSION

Urban sprawl is affecting our coastal regions as more and more people migrate to the South Carolina shores. Some think that increasing South Carolina's roadway infrastructure with projects such as Interstate 73 is the answer to reducing congestion and to increasing capacity during emergency evacuation situations. An interstate that begins in Michigan and terminates on the coast of South Carolina will do nothing more than increase development and further frustrate the hurricane evacuation problem. Most of the population growth attributed to these roadway projects will be in low-lying areas that are prone to flooding and storm surge. As this happens, loss of life becomes a real concern as a hurricane threatens the coast. It has been stated that there is a strong likelihood that one out of six hurricanes a year will make landfall in the United States causing an estimated \$10 billion plus in damage.¹⁴¹ With these statistics, it is only a matter of time before South Carolina will be staring down the throat of another monster. Instead of spending millions in taxpayer money to fuel congestion through new road building, the state should take a look at its current assets and maximize its current tool chest with the various technological and logistical options at its disposal.

VI. ENDNOTES

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