RECOMMENDATIONS AND CONCLUSIONS

Summary of Accomplishments

The project has been divided into four main sections: an upgrading analysis, an inventory analysis, a study of priority setting, and an analysis of using seasonal forecasts to manage levels of spares and reserves for highway equipment. The first section, examines the pros and cons of strengthening highway equipment so that it is more resilient to hurricane force winds. Some upgrading alternatives have been considered, and data has been gathered on the cost of these upgrading alternatives. The alternatives were compared in five hurricane scenarios (Categories 1 through 5.) For each category the potential damage is calculated for each level of upgrading. From this, the cost of replacing damaged equipment would be calculated for each level of upgrading and each hurricane category. Graphs comparing the potential damage and the cost of upgrading a type of equipment enable VDOT to easily compare alternatives and choose the one that best meets its objectives.

The second part of the report deals with the inventory analysis. This section examined the trade-offs between storing different levels of alternative inventory in terms of cost and time to implement. Other factors such as opportunity loss and temporary replacement accompany the evaluation. Data has been collected on sign sizes and types of equipment used on the highways. Calculations of equipment levels needed for recovery were made for each category of hurricane and this produced an understanding of the amount of equipment needed for recovery from a disaster. Then sources of these materials were examined, and the trade-off of keeping equipment in storage and producing it after the disaster was considered. The end result is an evaluation of different inventory policies and an idea of where additional equipment would come from in the event of a large-scale disaster.

The third section of the report details priority setting for the recovery from a hurricane. The goal is to give the client an optimal path to recovery, i.e. determine which roads should be repaired first based on the location of certain critical facilities and other alternative criteria. To start this off, large-scale maps of the Suffolk district were created, and relevant road segments, intersections, and critical facilities were identified. Spreadsheets were developed that produce a preliminary path to recovery based on the location of those critical facilities. The concept of connectivity was included into the measure of road priority, in order to connect the most people to the most places the fastest.

The final section of the report used forecast and cost information to make a good assessment for managing reserves. As could be seen, long-term and short-term decision-making on reserves involves numerous models and criteria.
The decision tree gives ideas on how to plan for the long-term and short-term. A sequence of decisions can be analyzed using this method. The model helps the decision-maker determine what could be required. A community cannot return to daily activities when its road system is not functional. Managing the required quantities of reserves of

signs, signals and lights to be prepared in case of a hurricane is a difficult task. One has to be able to find an appropriate level where there is a reasonable amount of reserves yet achieve low costs and be able to contribute to an expeditious recovery in case of a hurricane.

A result of this project will be this report and a web page created for use by VDOT. The web page has been created, and a technology transfer seminar will be conducted for VDOT personnel. The web page includes all of the spreadsheets VDOT needs to run a successful hurricane recovery, and these spreadsheets may be downloaded at http://www.virginia.edu/~risk/recovery/home.html. The web page will also include tutorials, and will be updateable as new roads are built and conditions change.

VDOT can access the entire recovery plan via the Internet. The hurricane recovery homepage provides step by step instructions on how to use the analysis tools along with how to update and expand the tools. Members of VDOT are responsible for maintaining the web page. Maintenance of the web page includes updating and changing the analysis tools. In the future, other states and cities will be able to access the web page to help examine ways to begin a hurricane recovery plan in their area.

With the web page in place, the next step for VDOT is to implement the methodology developed by the project team. The project team needs to create workshops and tutorials to transfer the technology to VDOT employees. Without the knowledge of the technology, the tools are useless to VDOT. The only way that the hurricane recovery plan will benefit the Suffolk District is if VDOT uses the information obtained to prepare for a hurricane. VDOT must accept this plan as part of their recovery efforts and create a team to maintain the analysis tools.

Recommendations

The following are the main recommendations to the highway agency:

- Notice the problem: Hurricanes can cause region-wide damage to traffic equipment
- Consider four remedies:
  1. upgrading equipment
  2. keeping spares and reserves of highway equipment on hand,
  3. priority setting of roads for recovery
  4. using seasonal forecasts to determine the levels of reserve equipment
- Distinguish between short and long-term recovery efforts. Short-term efforts involve temporary replacements while long-term efforts have permanent replacements.
- Evaluate different upgrading or spares policies by assessing the cost before a hurricane strikes and the damage, cost, and recovery time after a hurricane.
- Adapt spares and reserves to hurricane-center and other seasonal forecasts.
- Perform impact analysis using the various storm categories
- Consider the trade-offs between investment in spares and/or upgrading and the times and costs of recovery
- Adopt the models for estimating the costs and effectiveness of upgrading and spares policies
- Consider upgrading only of routes critical to a community's well-being in a hurricane
- Use probability distributions of wind speeds for different categories of storms to model hurricane impact on equipment
- Consider critical facilities throughout the road network in setting priorities for recovery, using accessibility to the critical facilities as a measurement of the importance of restoring a damaged road
- Consider the following categories of critical facilities: health, safety, education, food, alternative transportation, and governmental operations
- Maintain a web site for support of recovery of signs, signals, and lights. This web site may be adapted in the future to evaluate and prepare for the damage caused by other disasters..

Two examples of the recommendations follow:

These examples illustrate some possibilities for upgrading and increasing spares and reserves for the Suffolk District. The information in the tables was obtained by using the spreadsheet tools available on the Internet.

Table 7.1 illustrates different policies for upgrading overhead signs in the Suffolck district. Assume the following:

- VDOT upgrades overhead (two-pole span) signs on critical routes (10% of installed base = 35 signs)
- VDOTS pays 3.3% of total cost annually
- Replacement cost per sign = $75,000

- Upgrade policy phased in over 30 years

Table 7.1. Policy Comparison for Upgrading Overhead Signs

			Percentage of damaged signs on critical routes				
Policy	Level (mph)	Annual Cost*	I	II	III	IV	V
No upgrading	0	$0	2	6	14	27	37
Moderate	10	$11,000	1	3	10	21	31
Aggressive	40	$50,000	0	0	2	8	15

* over 30 years

Table 7.2 compares different policies for spares for ground signs in Suffolk District when one assumes that VDOT pays 5% of total cost annually and there are 12,000 ground signs installed.

Table 7.2. Policy Comparison for Spares and Reserves for Ground Signs

			Post Hurricane Cost (In $1,000)				
Policy	Storage Level	Annual Pre hurricane Cost * (In $1,000)	I	II	III	IV	V
No increase	17%	5	22	53	95	381	453
Moderate	25%	8	0	7	51	263	335
Aggressive	35%	10	0	0	17	167	240

* Over 20 years