LOUISIANA TRANSPORTATION RESEARCH CENTER
LTRC

TECHSUMMARY January 2013

SIO No. 30000380 / LTRC Project No. 11-6GT

Quantifying the Key Factors that Create Road Flooding

INTRODUCTION

Road flooding is a serious operational hazard for many low-lying areas across southern Louisiana. This hazard is especially acute for the region's emergency evacuation routes, which must be accessible for safe evacuation prior to an approaching hurricane. Emergency managers and decision-makers need additional tools regarding the factors and conditions that contribute to inundated roads to mitigate the risk of flooding during hurricanes. Numerous factors contribute to road flooding, including storm speed and direction, tidal ranges, wind speed, and storm surge. Many of these factors are deterministic and can be derived from available coastal weather services. Hurricane storm characteristics are modeled by the National Hurricane Center (NHC) and provided as a geospatial data product distributed for approaching storms at specified intervals.

OBJECTIVE

The fundamental objective for this study was to perform the research and develop techniques for quantifying the key factors that contribute to road flooding and a vehicle's flood risk. This research will help decision-makers identify and assess the flood potential of vulnerable state-maintained roads, so they can develop mitigation and response strategies for these vulnerable routes. This study assessed the relationship between flood characteristics (e.g., flowing versus standing water and wind driven water) and vehicle class (e.g., size, weight, clearance, etc.). Additional research was performed to analyze the flood risks to civilian and military vehicles.

SCOPE

As a proof-of-concept project, it was executed in three phases. First, the potential inundation hazards were compiled and computed for flood-vulnerable, state-maintained routes in five LADOTD districts in southern Louisiana. Second, a decision support tool that synthesizes these flood hazards was developed to validate the techniques for calculating and representing inundated road surfaces. Finally, research will assess vulnerabilities and risks associated with vehicle type and flooded roads.

METHODOLOGY

The techniques employed for this project have been organized into four primary development phases: (1) data collection and processing, (2) inundation modeling, (3) decision support tool implementation, and (4) assessment of vehicle vulnerability relative to flood risk.

Data Collection and Proceessing. These data were needed to conduct this project and were collected from LADOTD and other sources as noted.

- Pavement Management System (PMS) Road Data: State-maintained road survey data were provided by the LADOTD Pavement Management Systems (PMS), Section 21.
- Surge-Vulnerable Routes: A list of vulnerable routes was provided by the LADOTD Office of Operations. Storm Surge Data: Potential flood heights from hurricane-induced storm surge was acquired and used to estimate inundation over flood-vulnerable, state maintained routes.
- SLOSH Storm Surge Models: Storm surge estimates were extracted from the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) modeled data products published by the National Weather Service (NWS) and maintained by NHC.
- SLOSH MEOW and MOM Data Products: The SLOSH storm surge model provides two composite data products: the Maximum Envelope of Water (MEOW) and Maximum of MEOWs (MOM). The MEOW provides surge estimates over a given basin relative to simulated storm conditions. The MOM surge product represents a composite of maximum inundation estimates simulated by MEOWs for a given storm category.
- Real-time Water Level Observations: Real-time water level data are acquired for gauges maintained by the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA).

LTRC Report 497

Read online summary or final report:
www.ltrc.lsu.edu/publications.html

PRINCIPAL INVESTIGATOR:
Joshua D. Kent, Ph.D.
(225) 578-5260

LTRC CONTACT:
Gavin Gautreau, P.E.
(225) 767-9110

FUNDING:
Operations

Louisiana Transportation Research Center

4101 Gourrier Ave
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

Inundation Modeling. The potential inundation hazards were computed by subtracting road elevation from modeled estimates of hurricane induced storm surge (the maximum SLOSH MEOW surge heights). Real-time water level observations from near-by gauge facilities were also assigned to the road points using a proximity analysis tool. The modeled output were compiled and maintained within a file geodatabase. Inundated road segments (i.e., point features) were symbolized to depict the maximum storm surge for a given hurricane scenario.

Decision Support Tool. A geographic information systems (GIS) software platform was used to quantify, qualify, and display the road surface elevations and storm surge inundation estimates on roads identified by LADOTD as being vulnerable to hurricane-induced storm surge. The platform offers a near real-time, data-driven decision support tool capable of synthesizing the key factors and conditions that contribute to the flood risks on state-maintained roads across southern Louisiana. Web-links to the nearest water and tide gauge facilities were added to each road point feature to provide real-time water level observations. The ArcGIS MXD was used to assemble and synthesize this data in order to provide a consistent framework for depicting hurricane-induced storm surge over road surfaces within a district. Inundation and road characteristics are stored as feature attributes and made accessible using the default map tools provided by the ArcGIS software.

Vehicle Vulnerability to Flood Risk. The research concluded with a risk analysis of flood hazards associated with vehicle type. The analysis addresses the relationship between flood characteristics (e.g., flowing versus standing water and wind driven water) and vehicle type (e.g., size, weight, and ground clearance) to determine the vehicle's flood risk.

CONCLUSIONS

This project developed techniques for quantifying key factors that contribute to flood hazards on Louisiana's roads. By compiling actionable data within a common framework, decision-makers are provided with an intuitive, operational tool for assessing the flood risks due to hurricanes on vulnerable, state-maintained routes. Road segments are represented as point features symbolized to illustrate a worst-case scenario of inundation. Basic road attributes (including route name, number, and control section); surface elevations; inundation estimates; and nearest water/tide gauge facility are accessible in a single, consistent, and easy-to-use operational framework.

A simplistic approach for computing vehicle risk followed a generalized, three-staged conditional function in which the buoyancy, frictional forces, and lateral forces were combined to assess flood risk to civilian and military passenger vehicles. The outcome of these findings have been compiled in tables, summarizing by type minimum flood depth and water velocity necessary for destabilizing a vehicle.

RECOMMENDATIONS

To further this proof of concept research, the following recommendations are made:

1. **Inundation Modeling Enhancements**
   - Ensure updated surge data and current road elevations integrated into the system.
   - Improve inundation estimates by incorporating additional sources and include more real-time data products.
   - Identify and incorporate additional hydraulic data/types (riverine, lacustrine, and flash-flood events).
   - Pursue the integration of the tide and water gauge real-time data as model parameters.
   - Reduce uncertainty and provide a more comprehensive assessment of the risk by incorporating local effects with surge estimates.

2. **Decision Support Tool Enhancements**
   - Provide a more robust operational instrument; newer computational techniques that are more robust and agile are recommended to support real-time decision making.
   - Develop future applications of this tool as a custom Web-based application that can both calculate and present the inundation estimates more efficiently than ArcGIS software.
   - Implement a Web-based platform for a more efficient, accessible tool that can effectively integrate multiple, real-time data products published by authorities sources.

3. **Vehicle Flood Risk Assessment Enhancements**
   - Devise a comprehensive, hierarchical vehicle classification scheme that distinguishes vehicles according to size, weight, clearance, and function.
   - Measure vehicle buoyancy using gross vehicle weight rating (GVWR) weight ratings instead of reference curb weight.
   - Evaluate and assess hydrostatic and dynamic pressures relative to specific vehicles aerodynamic design and water mass.

4. **Overcoming Social Challenges**
   - Publishing vehicle specific risk assessments can result in the unintentional consequence of passively endorsing flood-risk complacency among the general public. A challenge for future research will be to identify an investigative strategy that will simultaneously broaden knowledge and awareness of vehicle flood risk without compromising efforts of the "turn around, don't drown" (TADD) campaign.