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# Transportation Emergency Management for Significant and Extreme Events: Lessons Learned and Best Practices for Preparedness, Operations, Response, and Communications

International Bridge, Tunnel and Turnpike Association
February 2022

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## Introduction

In recent years, growing traffic congestion on urban roadways and the intense reliance on roadways for mobility and wellbeing in rural areas make any disruption to typical road operations troublesome and challenging for transportation operators, including toll facilities. Significant events refer to extraordinary external disruptions to the typical operations of the transportation system. The realm of significant events includes severe weather (e.g., heavy snow and ice, hurricanes, high wind conditions, etc.), natural disasters (e.g., flooding, fires, earthquakes, etc.), manmade disasters (e.g., terrorism, insurrections, etc.), and planned events (e.g., Olympics, sporting events, large public gatherings, etc.). This report focuses on extreme weather events but notes the similarities that such events hold with most significant events in requiring extraordinary operations, regionally coordinated actions and decisions, multidisciplinary collaboration, clear communications among public agencies and private service providers, and effective customer and traveler information.

In general, transportation operations and emergency management responses to significant events must be adaptive and responsive to the life cycle of an event, including pre-event planning and preparedness, response phase and emergency operations, recovery and business resumption, and after-action activities and reporting. In all cases, planning and emergency exercises in times of non-emergencies is a hallmark of the most effective transportation response capabilities and responses.

This report provides a basic understanding of the processes and tools that enable transportation operations and emergency management organizations to develop and implement a "playbook" for addressing significant events. Coordination within each organization and across regional entities is an essential ingredient for effective emergency management and responses to significant events. Plans, decisions, and actions must be well integrated among individuals at varied organizational levels and disciplines from a variety of agencies responsible for managing and responding to significant events. Participants include senior-level government officials, transportation operators (including tolling and road operations personnel), incident management specialists, public safety personnel, communications professionals, and federal/state/regional experts and resources.

This report explores best practices and critical success factors in emergency management and response, based upon use cases and studies that highlight lessons learned from past events. The report is intended to use past experience to summarize critical success factors, best practices, lessons learned, and currently available and new systems, technologies and equipment for event management and response.

## Problem Statement

In recent years, transportation operations and systems throughout the world have been disrupted by extreme weather events. Snow and ice storms, intense hurricanes, extreme flooding, and wildfires have forced extended road closures and endangered motorists. Climate change is making these disruptions more frequent and intense events. Extreme weather and other significant events pose risks for service delivery and availability of assets and systems, not to mention the safety concerns for travelers and

emergency response personnel. Transportation operators have faced these challenges with a growing expectation from travelers and government officials that the transportation system will function for emergency mobility purposes throughout an event and recover rapidly afterwards. The response from transportation operators is driving organizational changes, new operations and management activities, increased specialization of staff and systems, new standards and procedures, and substantive workforce development and training.

## Critical Success Factors for Managing Significant Events

**Planning and Readiness** - Preparedness for managing extreme events always benefits from pre-planning that builds organizational agility and capability for responding to potential event scenarios and their consequences. Establishing a comprehensive emergency response plan is an essential first step to ensure employees and contractors understand roles and responsibilities within the organization and the required coordination outside the organization. An emergency response plan typically addresses:

- preparation, early actions, and preventive activities,
- testing and readiness for critical equipment and systems,
- availability of backup power and fuel,
- telecommunication reliance,
- workforce readiness and availability,
- asset protection and impact mitigation measures,
- operations communications and coordination mechanisms,
- partnerships and inter-agency coordination plans,
- traveler information and public communication plans, and
- clear, tested, and unarguable public agency leadership.

Additionally, establishing plans for disaster recovery, business continuity, and business resumption before an emergency helps ensure organizational preparedness through all phases of managing an emergency. Finally, the availability of predetermined traffic management plans, evacuation routes, and alternative routing options promote timely and smooth execution of operating contingencies in the height of busy emergency response activities.

**Continuous Improvement and Practice** - The best emergency response plans are regularly updated and improved, using after-action reviews and lessons learned from prior events to strive for continuous improvement. Drills and exercises that anticipate potential scenarios and impacts are helpful to practice possible responses and coordinated actions and decision making. Many transportation operators recommend drills and tabletop exercises that simulate a real emergency as most beneficial in testing communications, the command structure, resource allocation, and logistics.

**Ongoing Situational Awareness** - Knowing real-time operating conditions, traffic incidents, asset conditions, equipment locations, and resource logistics is a fundamental tool for effective emergency response. The ability to share such information with key partners and dependent organizations across a common information exchange platform adds tremendous response capability and coordination, which contributes to overall effectiveness. The capacity to monitor potential problem areas that could create dangerous and unsafe conditions helps ensure safety and prevent unplanned operational disruptions that may complicate emergency response and recovery. High-performing emergency response functions often leverage a central emergency operations center to bring all organizational disciplines (i.e., emergency management, operations, maintenance, traffic management, public safety, engineering, communications) together in one place. This not only promotes integrated decision making and

activities within the organization, but also facilitates regional coordination and supports unified command structures through center-to-center communications.

**Robust and Coordinated Communications Capabilities and Channels** - Communications are central to ensuring effective decisions among the many players that determine the outcomes of emergency management responses. The actions and decisions of front-line operations and maintenance personnel, network managers in Traffic Management Centers (TMCs), and motorists on the roads all interact to affect the ability of any of these stakeholders to navigate a significant event. Front-line operations and maintenance staff requires information to take action that ensure roadway availability, mobility, incident response, and safety. Network managers in TMCs monitor traffic and weather conditions, orchestrate incident management, manage roadside technology and systems, recommend routing alternatives, and understand potential facility closures and upstream and downstream traffic implications. Motorists traveling during severe weather conditions require information about whether to make a trip, and how and when to travel. Since their presence on the roads during extreme events complicates emergency management activities, decisions to close facilities, restrict travel, or ban certain types of vehicles are often necessary. Communication strategies must recognize the different audiences that require information during an event and use a wide variety of communication channels to reach all audiences.

## The Role of Technology and Data

**Regional Transportation Information Systems** - Transportation information systems are becoming more prevalent at regional levels, allowing integration and information sharing among the broad set of transportation operators, public safety organizations, incident responders (e.g., fire, tow, and medical first response), and government agencies at all levels. These systems aggregate and disseminate big data for situational awareness, operational decision support, predictive analytics, traveler information, data archives, and analytical tools for planning. These systems have application across a wide variety of emergency management use cases, such as:

- making better decisions through information from many sources in one easy-to-use format,
- understanding impacts of response actions on traffic,
- managing on-site responders,
- communicating directly with partners and stakeholders to coordinate responses and exchange information, video surveillance, and real-time traffic conditions,
- establishing common graphical user interfaces for traffic conditions and incidents on a common platform,
- distributing preparedness plans (i.e., evacuation routes, traffic management plans, shelter and emergency parking locations, fueling stations, etc.), and
- monitoring traffic and delay impacts of facility closures, rerouting, and potential troublesome locations.

**Meteorological Data and Expertise** - Emergency preparedness can be greatly improved with quality weather forecasts that provide insights into the magnitude, extent, and timing of impending extreme weather conditions. Transportation and road operators require real-time data on current weather conditions during events. Increasingly, weather resources and services are available to provide a centralized place to get information, gain better understanding of the confidence of weather forecasts, and develop weather scenarios. The ability to integrate this data into metrics that can prompt specific transportation decisions and preemptive actions for safety, mobility, and response. For instance, public

agencies may use internal thresholds to trigger responses, such as road closures in advance of predicted periods of heavy snowfall accumulation rates or tractor-trailer bans in advance of high-wind conditions. Forecasts and expertise from national sources should be used and disseminated to all involved. These resources can offer regular weather forecast updates and risk assessments throughout an extreme weather event and can also provide information to serve varied needs and audiences. Road Weather Information Systems (RWIS) also provide valuable data about roadway and pavement condition, and the real-time weather environment during events. RWIS sensors can measure temperature and pavement conditions, wind speeds and directions, visibility in fog and smoke conditions, road surface temperatures, wet/dry pavement status, and chemical concentration among other attributes.

## Leveraging Existing Business Processes and Systems

**Enterprise Risk Management and Vulnerability Assessments** - Risk and vulnerability analyses of significant events at the enterprise level is valuable in supporting the preparation of response plans, mitigation measures, and investment priorities. Determining the risks associated with possible facility disruptions and failures of systems or assets, as well as the likelihood of specific impacts, is useful in crafting a benefit-cost analysis and to justify resources and prioritize projects for preparedness, readiness, and mitigation.

**Budgeting and Capital Programming Decisions** - Analytical tools may assist organizations in making resource allocation decisions that could prevent damage during future extreme events. Benefit-cost analyses, net-present-value analyses, and life-cycle cost analyses have assisted transportation agencies in justifying the allocation of limited resources to preparedness initiatives and investments that may prevent or mitigate negative impacts of significant events. Such analyses are often difficult to communicate convincingly because they rely on probabilistic inputs to portray the uncertain nature of storm events and the varying likelihoods of damage that may occur.

**Asset Management Programs** - Asset management systems offer a basis to prepare for infrastructure contingencies and resilience plans that are often required in emergency management activities. The availability of asset condition assessments, performance metrics, and as-built drawings provide a foundation for preventive measures, resiliency protections, and contingency and recovery plans in the event of asset failures. Emerging technologies, such as LiDAR, can offer invaluable assistance in asset damage assessments for engineering staff to develop effective corrective actions.

**Highway Design Standards** - Transportation infrastructure operators are increasingly taking a long-term view of the resilience of infrastructure designs to protect new assets from the threats of extreme events. Infrastructure design practices and standards often consider the ability of new assets to withstand environmental stresses placed on an asset. The design of roads, bridges, culverts, storm water drainage systems, and utilities generally consider impacts of temperature ranges, precipitation, and wind. As environmental changes are better understood, designs may need to change as well.

## Best Practices

- Strong coordination practices led among public transportation agencies, law enforcement, public safety agencies, and police forces are of hallmarks of high-performing emergency management functions. A best practice is to back this coordination role with formal institutional relationships and agreements. The nature comprehensive emergency management requires participation of many different agencies and organizations, often from other jurisdictions and states, and always across

many disciplines. A strong coordaining structure allows responses to extreme weather and large-scale events from different levels of government and an array of other public and private organizations. Effective coordination balances different organizational mandates, responsibilities, and standard operating procedures with the need for collective decisions, coordinated responses, and integrated communications.

- A Unified Incident Command Structure established by the public agencies involved in the response effort is a best practice for large scale incidents, allowing a multi-agency or multi-jurisdictional approach, with the incident command leadership of the response managed as a unified command. The approach brings together the incident commanders of the organizations involved in the management of the incident to coordinate an effective response, while allowing each organization to carry out its own jurisdictional, legal, and functional responsibilities. The unified command connects the responding organizations and provides a means for consensual decision making as an integrated response team. This approach ensures that organizations work collaboratively to establish incident objectives and strategies, share information, maximize the use of available resources, and enhance the efficiency of the overall response.
- Communication is among the most important emergency management functions. This includes the communications among organizations and across disciplines involved in the response plan, as well as maintaining effective relationships with state and federal agencies that may have resources and expertise to offer. In addition, transportation operators should utilize a full array of media outlets to reach many different audiences in keeping the public informed and safe. Social media is increasingly important today and these communication strategies benefit from a social media staffing presence in Emergency Operations Centers to coordinate with traditional media relations. A comprehensive communication plan coordinates press briefings, web updates, email notices, 511 messages, and key stakeholder outreach to elected officials, municipal and local agencies, transit operators, and the trucking and logistics industry.
- Rapid response, expedited recovery, and business resumption often benefits from streamlined management decision making and execution. The extent of the recovery needed following extreme weather events and the high expectations to restore the transportation system to normal operations as soon as possible, often result in the use of creative contracting and procurement strategies. These may include the redirection of existing contracts to supplement recovery efforts and expedited new contracting and procurement processes.

## Lessons Learned from Prior Events

- Improve and strengthen relationships with public emergency management agencies to leverage available resources and expertise.
- Increase training for the workforce to ensure awareness of emergency roles and responsibilities throughout the preparation, emergency response, recovery, and after-action reviews of each incident.
- Make early decisions on vehicle restrictions and facility closures to ensure coordination with bordering jurisdictions and allow travelers to make contingency plans and arrange alternatives.
- Ensure more availability and access to interoperable response equipment and systems, including compatible radio and telecommunication systems and integrated transportation system management systems.
- Establish streamlined and expedited procurement practices to ensure ready supplies of emergency equipment and supplies and adequate backup capacity for power, telecommunications, and fuel.

- Prepare deposition plans for debris and large-volume snow removal, including environmental permits and waivers that might be required.
- Coordinate over a large geographic area to address toll policy and waivers of vehicle restrictions for oversized and overweight vehicles. Utility vehicles and tree services for recovery and clean-up often come from great distances to assist in recovery and service resumption efforts. Often, these vehicles expect waivers of tolls and various typical travel restrictions. Coordinated responses across jurisdictions can improve the overall response and reduce misunderstandings resulting from differing policies.
- Adopt more effective internal communications platforms and enhance communication strategies for disseminating road condition information and traveler advisories and alerts.
- Conduct post-event after-action reviews and audits to identify improvements for future emergency response actions.

## Summary

As the world is challenged by more frequent and severe weather conditions, including extreme snowfall, winds, flooding, and other natural disasters, the following is of utmost importance:

- Ensure clear public leadership, by setting up a Unified Incident Command Structure (UICS).
- Issue prevention and safety measures, such as travel restrictions and vehicle bans, well in advance of the phenomenon.
- Communicate all relevant warnings and restrictions effectively by all means of media.
- Consider fully the impacts that actions on one part of the network may have on adjacent facilities and networks and execute parallel actions required to avoid unintended and dangerous consequences.
- Establish continuous line of communication of all stakeholders with the UICS
- Institute high-alert procedures and mechanisms that ensure availability and quick response of all relevant responders as needed.

## Appendix: A Review of Transportation Emergency Management During Specific Severe Weather Events

A number of high-profile weather events over the last several years have focused the public's attention on how tolling and transportation organizations react in a crisis. Just in the first two months of 2022, four separate storms have had dramatic impacts on some road users and highlighted opportunities for improvement to prevent traffic delays that are measured not in minutes or hours, but days.

- In Virginia, in the first few days of 2022, a storm with rapidly-falling snow caused a number of jackknifed tractor-trailers and hundreds of other accidents that made a 40-mile stretch of Interstate 95 impossible to traverse by car. Hundreds of drivers either abandoned their vehicles altogether or were stranded on the highway overnight.
- Days later a similar snowstorm hit Kentucky, leading Governor Andy Beshear to declare a state of emergency while schools closed and an untold number of drivers were left stranded in their vehicles on highways across the state.
- In February 2022, Winter Storm Landon had major impacts on a number of states, including ones that are not accustomed to major winter weather events. Texas, specifically, saw a 17-hour backup on Interstate 10 northwest of San Antonio. Again, jackknifed tractor-trailers were blamed for making it difficult, and in some cases impossible, for cars to travel to their destinations.
- In Greece—a country better known for its warmer weather in a Mediterranean climate—a storm brought heavy snow in January 2022 that stranded 3,000 vehicles on a major toll road outside of Athens. Authorities in Greece discussed the idea of closing roadways to trucks ahead of the storm, with the hope of avoiding a fate similar to that of Kentucky or Virginia where jackknifed trucks were among the primary culprits for the day-long backups. These warnings went unheeded, and the snow arrived several hours earlier than predicted. As a result, the following morning the Greek national roadway closed to trucks and restricted access to vehicles without chains, creating added volume on the toll road and closures in multiple spots due to accidents. The added volume of trucks and general traffic toll road caused backups, making it harder to plow the road and perform rescue operations. The Hellenic Army was eventually called into rescue stranded motorists and ultimately open the road up to traffic once again.

Though each of these instances is distinct in terms of the amount of snow, the duration of the winter weather in question, the state of the affected road before it was hit with weather, and several other factors, they share many things in common with each other, and with other extreme weather events that have strained roadways and stranded travelers in the last eight years. Taken together, these examples paint a portrait not of unprepared or willfully ignorant roadway management, but uniquely challenging traffic circumstances colliding with truly unprecedented extreme weather events.

### Atlanta, Georgia – 2014

For two days in January 2014 an exceptionally powerful winter storm plunged nearly all of metro Atlanta into a state of "total gridlock," in the words of the Georgia Governor's Severe Winter Weather Warning and Preparedness Task Force, which drafted a report and made recommendations after the weather event had ended.

The storm that set upon Atlanta between January 28 and January 29 in 2014 was unusual for numerous reasons, as the Task Force's report observed. For instance, since 1929 (the year Atlanta began keeping records of snow), there had "only been 13 occasions when the maximum temperature was less than or equal to 30° F that coincided with snowfall." In comparison, on January 28, when the storm hit, the temperature never rose above 27° F—meaning it was the coldest it had ever been in Atlanta when snow fell. Furthermore, the month in which the storm occurred was the 12th coldest January on record (since 1878) and the coldest January in 29 years.

Traffic volume was driven in part by Atlanta metro area openings and closings and combined with severe ice conditions to make highways and other roads impassable. This, in turn, limited the ability of emergency services to reach people stranded in their vehicles and forced thousands of motorists to shelter in their cars for up to 24 hours. Students and teachers were similarly unable to leave schools and had to stay for the night.

The Task Force identified four overriding issues that contributed to the problems that struck Atlanta in January 2014:

- A failure to fully implement a state-level command structure.
- Inadequate and unclear guidance to the public.
- Inadequate or incomplete communication across state agencies.
- A need for more preparedness drills.

None of these issues belonged to any one state or city authority; the responsibility for how events transpired those two days in January 2014 was shared across the area's transportation and public safety organizations.

## Bedford and Somerset Counties, Pennsylvania – 2016

In January 2016, a similarly historic storm struck the southern half of Pennsylvania, resulting in "over 500 vehicles and hundreds of motorists being trapped and stranded for approximately 24 hours along a rural 12-mile section of the Pennsylvania Turnpike's mainline," an After-Action Review (AAR) report on the event outlines in its opening paragraphs.

Pennsylvania's Acting State Climatologist, at the time, reported that the storm was in the top three or top five highest snowfall events for a 24- or 48-hour period in southeastern Pennsylvania's history. The snowfall was not dispersed evenly as "total snowfall amounts ranged from approximately 36 inches across many portions of southern Pennsylvania to as little as 0.5" along the I-80 corridor," said the AAR report.

The January 2016 storm in Pennsylvania also illustrated the challenges of relying on weather forecasts to plan a response and allocate resources in the crucible of an extreme weather event. Actual snowfall totals well exceeded even the forecasts and varied significantly across the state. Figure 1 on the following page was included in the AAR and sourced from the U.S. National Oceanic and Atmospheric Administration (NOAA). It provides a good visual representation of how much the actual snowfall varied from the weather forecasts during the storm, which illustrates how challenging the emergency management plans of transportation authorities can be in the face of changing weather conditions.

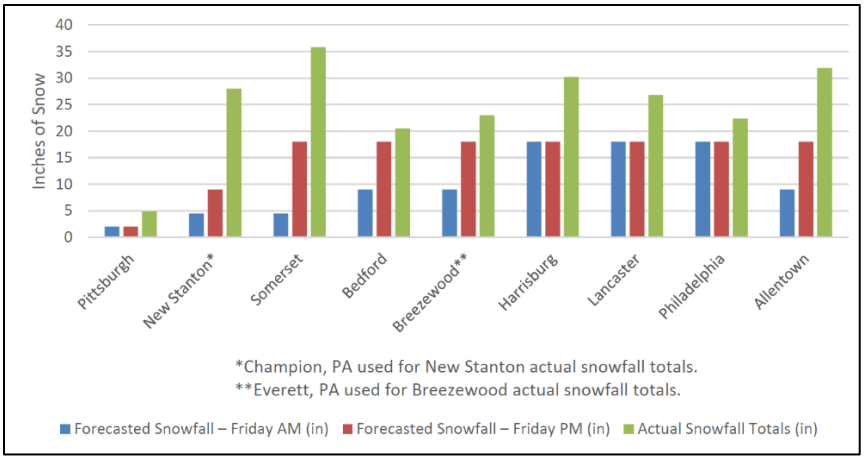


Figure 1. Pennsylvania Winter Snow Forecast and Actual Accumulations – January 2016

## Broome County, New York – 2017

Fourteen months later, and 300 miles northeast of the epicenter of Pennsylvania's 2016 weather event, another unprecedented extreme snowfall event left much of Broome County, New York (home to the Binghamton metropolitan area) under at least 30 inches of snow. An After-Action Report focused on the Broome County storm noted that between March 14-15, 2017, the area was inundated with snowfall that "broke a 24-hour snowfall record that dated back to February of 1961."

The hamlet of Endwell received the brunt of the storm, with snowfall totals measuring 36.2 inches by the time the weather event concluded. Presenting a particular challenge to area transportation authorities in this instance was the rate at which snow fell, according to the AAR. "At one point, snow was falling at more than four inches an hour, taxing the ability to successfully remove snow and necessitating a complete travel ban, including interstates, within Broome County," the report said.

In a section titled "Lessons Learned," the AAR recommended closing gaps in the area's ability to adequately respond to such extreme weather events. For example, the report found that "this event included the countywide closure of roadways," but noted that "if this was not the case, and only select roads were closed, there [was] no real method to track road closures within the [Emergency Operations Center (EOC)]." New York's "511" telephone information service monitors and tracks state-level road closures, but not local ones, meaning that, in the future, if authorities wanted only to close certain roads and not others, there was no central way of keeping track of that information.

Another lesson learned affecting the ability of county and state officials to respond to the emerging crisis was that several organizations had "limited or no plans to get 'essential' personnel to and from work during a storm event," including hospitals, health care facilities and group homes. This led some facilities to house off-shift employees in nearby hotels to ensure availability of essential workers throughout the storm.

Other "Lessons Learned" in the AAR include the fact that the city of Binghamton lifted its local travel ban before the county lifted its county-wide travel ban, leading to major public confusion about whether they should be on the roads or not. Additionally, the report notes that the Broome County EOC still relied on paper recordkeeping at the time, which made for far less efficient operations and communications between local and state authorities.

The AAR recommendations fit a pattern where inadequate response and execution was affected by a lack of clear severe weather response.

## Austin-Travis County, Texas – 2021

More recently, and during a time when the United States was in the thick of the COVID-19 pandemic, Winter Storm Uri struck the central part of the country in February 2021. The results were that about half the population of the U.S. was placed under a winter weather alert issued by the National Weather Service, and five million people experienced blackouts. "The storm led to the largest blackout since the Northeast Blackout in 2003 and was the deadliest winter storm since the Storm of the Century in 1993," said the Austin-Travis County AAR published in the storm's wake. "In the state of Texas, Winter Storm Uri created in excess of $195 billion in damage, making it the costliest natural disaster in Texas history."

The Austin-Travis County AAR is an extensive document, and it much more plainly makes the connections that other reports typically only hint at. In a section assessing how the city, county and state authorities performed in terms of "Leadership and Coordination," the AAR notes that "the city (Austin) and county do not have winter storms in their climate change and extreme weather events projections," before recommending that authorities "include considerations for extreme winter storms and freezing in climate change hazard and threat assessments in planning and preparedness."

Again, the most likely reason why no such contingencies existed in the city and county's emergency preparedness procedures up until 2021 was simply that they had never had to contemplate the occurrence of a winter storm that was so significantly worse than anything preceding it. It just does not snow all that often, or all that much, or get all that cold or icy in Texas; at least it did not until Winter Storm Uri.

Other sections highlight gaps that cumulatively indicate how outside the perceived realm of possibility Winter Storm Uri was for Austin and Travis County. In the "Transportation" section specifically, the AAR noted that Austin simply did not have enough emergency vehicles equipped to drive in inclement weather rougher than a bad thunderstorm. "For example, emergency services vehicles such as Austin Fire Department's ladder trucks and city ambulances were, in some instances, unable to navigate roadways." Elsewhere the report notes that the Texas Department of Transportation had a limited inventory of de-icing material to use statewide. "Not all city departments maintained an inventory of snow chains; some had snow chains available that did not fit vehicles currently in use. Personnel lacked the training to maintain, operate, remove and drive using snow chains, and safely drive in winter weather conditions," the report said.

Each of the storms referenced in this Appendix had severe impacts on roadways and motorists and were considered "unprecedented" in magnitude and effects. When assessing the response of transportation authorities to each of them, it would behoove the public and regulatory bodies to consider the lack of precedent when seeking to assign blame for the devastatingly negative consequences of these extreme weather events. It might be easier and more immediately soothing to chalk these failures up to one organization, one incident or even one human being, but the truth is that the entire globe will continue to face incidents like these as climate change's impacts become more potently felt. Rather than seeking scapegoats, authorities should focus their energies on preparing for the next event and building the kinds of institutional bonds, coordinated plans, and integrated systems that will become ever more important as "unprecedented" events happen more often, and with greater intensity, than anyone had imagined.

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*The International Bridge, Tunnel and Turnpike Association (IBTTA) is the worldwide association for the owners and operators of toll facilities and the businesses that serve them. Founded in 1932, IBTTA has members in more than 23 countries on six continents. Through advocacy, thought leadership and education, members are implementing state-of-the-art, innovative user-based transportation financing solutions to address the critical infrastructure challenges of the 21st century. For more information, visit www.ibtta.org or join us on Twitter @IBTTA or #TollRoads*

February 2022