# Urban Ferries and Catastrophic Floods

## Experiences and Lessons Learned in Brisbane, Australia, and New York City

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**Both Brisbane, Queensland, Australia, and New York City have experienced catastrophic weather events in recent years. In January 2011, the Brisbane River flooded, inundating more than 20,000 houses; in October 2012, superstorm Hurricane Sandy hit New York City and produced a major storm surge that flooded much of the city. Ferry systems in both cities were badly affected. Comparative research was used to explore how each city's ferry operators and managers addressed the impacts before, during, and after those events. A review of published materials related to the two systems during and after the disasters was supplemented by interviews with key agency personnel in each city, conducted in mid-2013. Results suggest that how ferries are affected by floods and other disasters and how ferries may be used to rapidly respond to and provide for post-flood transport needs depend entirely on context. The linear river ferry operations of Brisbane suffered much terminal damage, and operations were unable to recommence service as a result of debris and the swollen nature of the river for many weeks after the flood. In contrast, within 2 days, New York City ferries were reintroduced on key routes and were introduced to new emergency locations to provide mobility for citizens who were unable to use other transport modes because of storm damage. The lessons learned by the operators include essential areas that authorities must address before a disaster: infrastructure design and resilience, disaster planning, insurance and legal requirements, staff management, and coordination during the reconstruction phase. Findings suggest that authorities can significantly reduce damage and improve recovery times if they plan and prepare for such events well ahead of time.**

A January 2011 flood devastated the city of Brisbane, Queensland, Australia; the CityCat ferry system was out of operation for more than 4 weeks. New York City was ravaged by Hurricane Sandy in October 2012, but its East River Ferry service was running again 2 days after the storm surge and delivering vital transport capacity when key subway and road links were inoperable or faced severe difficulties. The aim of this paper is to document the experiences of ferry operators during and after these two major weather events, determine why the outcomes were so different in Brisbane and New York City, and learn lessons from operators and managers for the benefit of the wider ferry community.

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*Transportation Research Record: Journal of the Transportation Research Board, No. 2459,* Transportation Research Board of the National Academies, Washington, D.C., 2014, pp. 127–132.
DOI: 10.3141/2459-15

The rest of this paper is organized as follows. First, the published research on ferries in disasters is summarized and highlights preparedness and response issues. Then, the two analyzed ferry systems are introduced, and the study approach and methods are described. Results of interviews and reviews of the ferries before, during, and after the studied weather events are provided. Finally, key lessons learned from the study, implications for planning and policy, and avenues for additional inquiry are summarized.

## BACKGROUND

Ferries can be central to, affected by, or useful in major emergencies. Ferry disasters still occur, particularly in developing countries, even though ferries are the safest form of transport in North America and Europe (*1*). River ferry systems feature little infrastructure beyond their terminals, which can be dramatically affected by major flood events. Similarly, marine terminals for sea ferries can be destroyed in hurricanes and tsunamis. For example, in Aceh, Indonesia, the Boxing Day tsunami in December 2004 killed more than 100,000 people and destroyed ports and ferry terminals up and down the west coast of Indonesia, primarily on the island of Sumatra; nevertheless, ferries were integral in resupplying transport and goods to those locations hit by the tsunami (*2*). Ferries and small boats also played significant roles in response to other disasters: the evacuation of lower Manhattan, New York, on September 11, 2001 (*3*); the landing of U.S. Airways Flight 1549 in the Hudson River in New York in January 2009 (*4*); the New York City blackout of 2003 (*5*); and bushfires in southern Tasmania, Australia, in January 2013 (*6*).

Even so, the role of ferries for community emergency management in general and assisting affected communities in particular is not well described in the literature. The *Guidelines for Ferry Transportation Services* only vaguely describe emergency response involving ferries for the U.S. Virgin Islands, Hawaii, and similar sites and suggests that ferry operators should comply and participate "in emergency disaster relief plans and drills, wherever appropriate" (*7,* p. 104). More detailed outlines of the roles of ferries in disaster recovery include the work of the Bay Area Council of San Francisco, California (*8*), which recommends designating a waterborne emergency response fleet in advance of any major earthquake that would disrupt road and rail transport significantly, as well as reviews of Hurricane Sandy (*9, 10*), which describe the extensive emergency and nonemergency ferry service provision that made a major contribution to the city, especially when key road and subway links were cut.

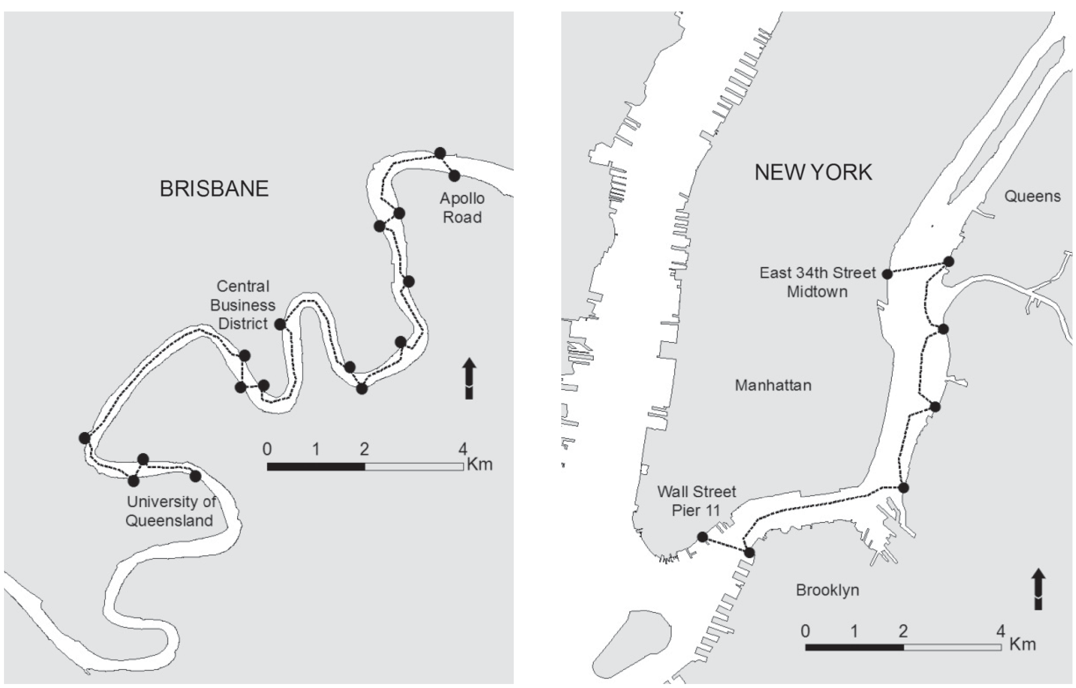
The literature on transportation resilience and response to natural disasters is more advanced. Freckleton et al. suggest evaluation and preparedness frameworks for the resilience of transport networks (*11*). Croope and McNeil present similar research in the postdisaster context (*12*). Mongioi et al. researched the roles of planning organizations and travel demand management managers in assisting with postdisaster transport planning and operations (*13*). Transport operators and managers must both plan for and prepare assets and operations for possible emergencies. Operators and managers should participate in incident action planning, designate resources for particular tasks in advance, and ensure that they are part of regional incident management systems (*14*). Ferries may play a specific role in evacuations, logistics (e.g., transporting specialists to a scene, supplying goods to isolated locations), and postdisaster public transport operations when road and rail systems are down. Regulatory frameworks may limit or discourage ferry response to emergencies. Incident managers and key authorities can assist by exempting ferry operators from some usual safety regulations to encourage operators to help how they can, as the U.S. Coast Guard did on September 11, 2001 (*15*). By preparing more resilient systems that can assist with recovery, ferry operators may "reduce the probability of failure within the system and reduce the consequences of any failure that occurs, thus improving recovery time" (*11,* p. 2).

Diverse cities worldwide—including Copenhagen, Denmark; Gothenburg, Sweden; London; Brisbane; Sydney, New South Wales, Australia; New York City; and Bangkok, Thailand—now operate linear river ferries. Therefore, planners must consider how these systems can (*a*) better withstand flood and storm surge disasters to which they are vulnerable and (*b*) best be used to assist with essential transport needs in the immediate recovery phase after a disaster. Kendra et al. note the importance of considering the unexpected problems that occur for transport providers (in this case, river ferries) during disasters, the organizational response and nontraditional resources that might be needed, the preplanning steps required, and the best crisis management procedures (*3*). The recent trials of these two cities, Brisbane and New York City, offer an opportunity to explore such questions.

## BRISBANE AND NEW YORK CITY FERRY SYSTEMS

The two cities examined in this study—Brisbane and New York City—are very different. Australia's third-largest city by population, Brisbane is home to slightly more than 2 million residents; in contrast, Greater New York City boasts almost 20 million residents, making it the most populous city in the United States. Both cities feature a linear river ferry system. The routes and terminals for Brisbane CityCat services and the East River Ferry in New York City are provided in Figure 1 at the same scale. Of course, other ferries operate in both cities, particularly in New York City. But these two linear systems are the focus of this study because they are similar in size, vessel type, terminal type, and operations. However, their experiences after weather disasters in 2011 and 2012 (flood and hurricane, respectively) were very different. A direct comparison of these systems allows a useful examination of how managers and operators planned for, reacted to, and learned from the emergency events, as well as a look at the contexts that helped shape outcomes in each city.

Because Sipe and Burke (*16*) and Camay et al. (*17*) describe these two ferry systems at length, only a summary is provided here. Both systems operate 7 days a week, all year. The vessels differ slightly (Brisbane runs catamarans, and New York City runs a single-hull fleet); however, both the first-generation CityCats and the East River Ferry vessels accommodate a maximum of 149 passengers during the week. (The New York ferry runs 399-passenger double-deck vessels on weekends.) Both systems feature open-air standing and seating areas on board. CityCat offers more terminals and shorter average stop spacing than does the East River Ferry, but both use so-called spud barges (pontoons with long posts on each of the four corners that allow floating up and down, but not sideways) with attached ramps as terminals. The ramps, access ways, and vessels of




(a) (b)

FIGURE 1 Routes and terminal locations of ferry systems studied, 2013: (*a*) Brisbane CityCat and (*b*) East River Ferry, New York City (East River Ferry also serving as eighth terminal at Governor's Island, New York, in summer).

**TABLE 1 Features of CityCat and East River Ferry Systems**

| Characteristic | Brisbane CityCat | East River Ferry |
|---|---|---|
| Year introduced | 1996 | 2011 |
| Management | Terminals owned by Brisbane City Council; ferries managed under contract by TransDev | Terminals owned by New York City or private interests; ferries managed under contract by BillyBey Ferry Company |
| Number of ferries in fleet | 19 | Minimum of four in service during weekdays |
| Maximum cruising speed in operation | 25 knots | 28 knots |
| Ferry capacity | 149 or 162 passengers | 149 passengers |
| Number of terminals | 16 | 7 (8 in summer) |
| Average daily passengers | ~11,500 (2010–11) | 2,862 (2011) |
| Average weekday headway | 19 min | 20 min |
| Fare structure | Integrated ticketing; fares integrated to same zonal structure and price as broader Brisbane (Translink) public transport fares; one-way cross-river adult fare US$2.96, full route one-way fare US$4.12; no monthly passes; multiple concessions provided | Separate ticketing; one-way adult ticket (any length) US$4, monthly pass US$140; limited concessions provided |

SOURCE: TransDev, Brisbane City Council, Translink.com.au, New York City Economic Development Corporation, and www.eastriverferry.com

both systems are compliant with relevant disability access legislation. CityCat offers more extensive operating hours in the morning and evening, especially on weekends, than the East River Ferry. Both systems provide a mixture of cross-river opportunities and linear line-haul transit on a parallel system, as defined by Thompson et al. (*18*), to serve commuters, students, tourists, and other markets, and are supplemented by their operators (and other operators, in New York City) by an additional set of cross-river ferries in and around the corridor. Key features of the two systems are provided in Table 1.

## METHODS

A systematic desktop review was conducted of published material on the two ferry operations in Brisbane and New York City before, during, and after the flood events. The review was supplemented with materials provided by and interviews conducted (in June and July 2013) with pivotal officers responsible for the ferry systems. Conducted by telephone, the interviews followed previously supplied question scripts. Interviews were partially transcribed, then comments were proposed for use and sent to interviewees for comment and revision. Participants included a representative of the Brisbane local government who was responsible for contract management and oversight of the ferry system and a representative from New York City with similar responsibilities. Interviews focused on participant roles; institutional arrangements; and events leading up to, during, and after the disaster. Interviewees also were asked to share key lessons learned from their experiences.

## BRISBANE CITYCAT AND 2011 FLOOD

Brisbane flooded previously in 1893 and 1974, and a flood-retention dam was built at Wivenhoe to prevent another catastrophe of such a scale. A La Niña monsoonal trough in late 2010 brought extensive rainfall to the region, and December 2010 was the city's wettest month on record (*19*). In early January 2011, dam waters eventually exceeded Wivenhoe's supply capacity, and major water releases were ordered to protect the dam wall. Flooding began in Brisbane on January 11, and residents on 2,100 streets were evacuated before the 4.46-m peak on January 13 (*20*). Some 20,000 houses were inundated, and much of the built infrastructure along the river was destroyed.

Limited advance warning of the likelihood of flooding was available before the event, as dam operators commenced fast water release. This release dramatically swelled the Brisbane River, increased its flow rate, and added significant debris. The ferry operator, TransDev, became increasingly concerned about the debris. The 25-knot CityCats experienced some problems with the increased flow rate, but the 10-knot cross-river ferries were unable to operate safely. On January 9, as the threat of a major flood became imminent, TransDev ceased all ferry operations and immediately prepared to secure the system's assets.

The terminals were decommissioned and prepared for flooding as best they could. In hindsight (remembering that before the event, the dam was widely believed to prevent such floods from occurring), the design of most terminals was insufficient to withstand the coming flood. Electricians were sent out to disconnect electricity, and everything that could be moved to higher ground was moved. The fleet was moved to a sheltered harbor in Moreton Bay. Even though that bay can be relatively placid, the vessels were not rated or approved for use in open water, and the Brisbane City Council's insurance did not cover the vessels outside the safety of the river mouth. However, the river was about to be unsafe. The state government regulator, Maritime Safety Queensland, swiftly granted approvals, and the council's treasury section granted insurance in time for the fleet to be moved to the bay. This decision proved successful: of the 19 CityCats and nine cross-river ferries, only one vessel sustained minor damage from floating debris; the rest were unscathed. The same could not be said for the terminals. Television footage showed terminals and other infrastructure being battered by debris or washing away. Ramps were not designed to hinge and swing with the torrent, and the pontoons were not streamlined. Landing areas were immersed, and ticket machines and other infrastructure were destroyed. Of the 24 terminals in the system, seven incurred major damage, seven incurred moderate damage (four at the more serious end of the scale), and the rest incurred only minor damage (*20*).

As the waters receded, damage inspections began. Divers inspected the piles, many of which had moved. Temporary terminals were installed at key sites to allow operations to recommence before later reconstruction of more flood-resilient infrastructure. Travel demand management teams deployed alternative transport plans; buses were introduced to service ferry stops where other public transport options were not available. Ferry staff were deployed both in cleanup operations and in customer service, to help passengers access alternative transport. Ferry operations recommenced on February 15, 2013, on 15 of the 24 terminals in the ferry network. By March, some 21 terminals were back online, and by April, all but one were in service. The West End terminal, a key node in the CityCat system, was not back online until August 2013, after a previously planned major upgrade was completed; that terminal now can accommodate dual berthing (two vessels berthed immediately adjacent to the pontoon simultaneously). A first-generation terminal with spud barge at Gardens Point and the new flood-resilient design at Hamilton North Shore are pictured in Figure 2.

The new permanent terminals are being designed to be resilient to a 1-in-200-year flood. The ramps are not fully retractable but include fifth-wheel hinges that allow them to change angle with the floodwaters (by offering both up–down and left–right rotation, significantly reducing horizontal tension loading), and the pontoons have deflection structures at the upstream end and are more streamlined (*20*). These new designs are intended to reduce damage and cost and improve recovery time. Other key lessons learned from the experience include the need for better flood mapping and analysis and the need to plan for worst-case scenarios by learning what an operator or manager might need and which arrangements should be available. The city council has entered into specific arrangements that include standing offers, which allow fast-tracked appointments (e.g., of salvage teams, divers, and other skilled personnel as a priority and ahead of others) should a similar event occur in the future. Also under consideration are ways to minimize staff fatigue during a weather event or other crisis. For example, team members should become minimally proficient at tasks associated with other job titles to create skill redundancies; in this way, several staff members will be available to cover important positions during a crisis. The city council also has learned how teams across local and state governments can coordinate in the recovery phase. For instance, reconstruction of a ferry terminal may be combined with aspects of park and bikeway reconstruction at a location, and team approaches lead to improved outcomes.


**(a)**

**(b)**

FIGURE 2 CityCat ferry terminals: (*a*) first-generation terminal with spud barge at Gardens Point, low tide, 1996, and (*b*) new flood-resilient design at Hamilton North Shore, high tide, 2011.

## EAST RIVER FERRY AND HURRICANE SANDY

When Hurricane Sandy headed toward the U.S. Mid-Atlantic states, the storm already had wreaked havoc in Jamaica, the Dominican Republic, and Cuba from October 24 to 27, 2012. This Category 3 hurricane joined forces with another storm as it bore down on the metropolitan expanses of New Jersey and New York City. Residents in low-lying areas, including the New York Zone A coastal precincts, were evacuated from the expected area of storm surge and flooding as part of emergency planning. Hurricane Sandy landed on October 29 and swamped much of the city, killing 43 persons in New York City alone (*10*). The East River flooded into parts of lower Manhattan and Brooklyn as well as seven subway tunnels (*21*). Blackouts resulted, and millions were without power.

The ferry operator, BillyBey Ferry Co., received limited warning of the impending event, similar to what had occurred in Brisbane the previous year. But the operators were helped by having had recent experience with Hurricane Irene (August 27 and 28, 2011) and a strong legacy of emergency management planning provided by the terrorist attacks of September 11, 2001. The New York City Economic Development Corporation, which manages, subsidizes, and oversees day-to-day operations of the ferry system, suspended all operations by October 29. Operators decommissioned the seven East River Ferry terminals and another 12 to 15 landings and prepared for the storm. Figure 3 shows a typical East River Ferry terminal and vessel. Great efforts were made to ensure that power was disconnected and ramps were detached from the pontoons and barges. As in Brisbane, this preparatory work required at least 1 day to complete. The fleet was secured, but without the insurance issues that existed in Brisbane. The hurricane presented different challenges—high winds, but not swift-flowing water—because the East River is more of a tidal inlet than a major water catchment. At most terminals, damage was modest; however, landing areas were immersed, and infrastructure (e.g., ticketing machines) was destroyed.

The damage to the city's transport infrastructure became apparent as the storm passed. Road and rail tunnels were flooded, and the subway could not operate. Severe gridlock occurred at the street level, and fuel supplies ran critically low, but the city had secured diesel supplies for the ferries preemptively. Despite the devastation, some areas of the


FIGURE 3 East River Ferry terminal and vessel, 2012.

city returned to business remarkably quickly, and the ferries played a major role in its recovery. Some ferries were reintroduced as early as October 31, then the East River Ferry on November 1 and the Staten Island Ferry on November 2; ferries "quickly become a popular travel alternative" (*9,* p. 8).

The East River Ferry was the first public transport mode that enabled East River crossings between Manhattan and Queens and Brooklyn, New York. After service resumed, ridership doubled, and a fourth ferry was added to meet demand. Critical to this effort were effective human resources management and proactive steps taken by operators to refuel the vehicles of ferry staff who were on the water. Given the gas crisis that engulfed the city after the hurricane, staff would not have been able to work without then ability to drive to and from work, and ferry operations would have ceased. Also helpful in the recommencement phase was a smartphone app recently launched by the BillyBey Ferry Co. that allowed direct fare payment. Highly popular with regular users, this fare payment app significantly reduced the load on staff handling the additional passengers, especially given the destruction of most ticket machines.

The success of the ferries during the crisis and their potential for rapid deployment encouraged the Economic Development Corporation to introduce a new ferry from Pier 11 in lower Manhattan to a temporary terminal in Rockaway, New York (108th Street and Beach Channel Drive), on November 12, less than 2 weeks after the storm. The temporary terminal effectively replaced the A train, which was out of service for 7 months because of the severely damaged Broad Channel railroad bridge and 1,000 ft of unusable track. The New York Department of Transportation then added ferry service from Great Kills, Staten Island, New York, to lower Manhattan on November 25 (*10*).

In other lessons learned, operators and managers have recognized the need for quick-disconnect systems to cut power rapidly to the terminals. Other changes to terminal design include raising the spud heights of barges to provide more resiliency. Also, as in Brisbane, fifth-wheel hinges already were being installed before the hurricane to allow a wide range of motion that improves the resiliency of the ramps.

Crises seem to provide an ideal testing ground for potential new services. The Rockaway Ferry, originally intended to remain for only 7 months, is still in operation at the time of this writing and is supposed to continue until at least January 2014. Given its patronage success, the service may continue long after that date. Launched on November 12, 2012, the service had carried more than 90,000 passengers as of mid-July 2013. Weekend service was added in May and also will continue. As of August 5, the Rockaway Ferry made additional stops at the Brooklyn Army Terminal in Sunset Park (58th Street Landing), which aided commuters disadvantaged by poststorm repairs on the R train service, which would be disrupted for 14 months. At the time of this writing, it is not known how long that service will operate.

## KEY LESSONS LEARNED

River ferry operators learned many lessons from the experiences studied in this paper. Suggested terminal design modifications include the following:

- Quick-disconnect systems for electricity,
- Removable ticket machines, and
- Resilient pontoons and barges (e.g., deflection devices, streamlining, higher piles designed to handle vertical movement in tidal surges, and fifth-wheel hinges for ramps).

Suggested planning and operations steps include the following:

- Prepare for an emergency disaster by planning for worst-case scenarios, and designate resources in advance;
- Ensure regulator understanding and preparedness to suspend key regulatory framework that could limit or prevent effective emergency response (e.g., establish processes to determine quickly which vessels may receive a waiver of safety regulations and any insurance implications);
- Train operator staff in the skill sets needed to provide rapid response in the event of an emergency and decommission terminals;
- Ensure that manager and operator staff have redundant skills that allow them to work together in a crisis and avoid staff fatigue;
- Obtain approvals and insurance to operate and secure vessels in appropriate locations;
- Arrange for fast-track approval that will ensure the appointment of key recovery personnel (e.g., salvage teams and divers);
- Consider how to assign ferry staff to cleanup and travel demand management duties during any extended suspension of operation;
- Determine locations where new temporary ferry services may be required if critical infrastructure (i.e., road or rail tunnels) is destroyed, which shoreline locations have sufficient water depth and infrastructure for emergency ferry services, and locations of vulnerable populations who may need ferry services;
- Back up ticketing data off site for quick reestablishment of fare payment services; implement cashless fare payment systems to avoid staff overload from additional passengers; and deploy redundant ticketing systems in case of lost power, mobile towers, or other facilities; and
- When recommencing operations, ensure logistics for key staff, including their travel to and from terminals.

## CONCLUSIONS

In agreement with previous research on disaster preparedness in the transport sector, the study findings highlight the need for preparation and emergency planning in advance of a disaster (*11–13*). Temporary ferry services can be deployed quickly if a fleet is effectively secured, the basic terminal infrastructure is resilient, and river navigation is safe. The East River Ferry's success in alleviating the postdisaster transport chaos of New York City by recommencing operation within 2 days of Hurricane Sandy clearly shows the value of ferries in a city's transport mix. Ferries can reconnect vulnerable or isolated populations and can replace other modes where bridges, tunnels, or key networks are unavailable. And ferries can do both tasks rapidly if a ferry fleet exists in the area already. With minimal infrastructure requirements—no roads, rails, or tunnels—ferries can be reintroduced rapidly after a disaster. Ferry introduction during or after emergencies can be aided by significant advance planning, for example, by identifying the locations where ferries may safely berth, and by testing scenarios to determine how they may best be deployed if other key transport links are severed. Cities that take such steps will optimize their emergency response efforts.

How ferry systems handle emergencies depends entirely on context. The river environs in Brisbane and the destruction of much of its terminal infrastructure put the ferries out of action for a modest period. Even then, the CityCats were running 4 weeks after the city's greatest disaster ever. The steps that the city of Brisbane is taking to make terminals more resilient suggest that recovery after any future flood will be quicker and far less expensive. Operators elsewhere may avoid significant damage and improve their own recovery from flood or storm surge if they heed the lessons shared by their peers in Brisbane and New York City. Modest investments in more resilient ramps and pontoons are cost-effective in the long term through avoided damage.

Future research may consider improved technical designs for ferry terminals (including spud barges and pontoons as well as landing areas) to better withstand flooding. Research may assist with identifying training needs for ferry operators to improve emergency response and in defining the current role and potential of ferries and other watercraft in humanitarian logistics. Given the rapid spread of linear river ferry systems to cities in developed and developing countries, the need to understand these systems better and learn how to make them more efficient and effective, in both daily operations and special events, is increasingly important.

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*The Ferry Transportation Committee peer-reviewed this paper.*