Abstract

The goal of this article is to present lessons learned from the devastating effects of two specific natural disasters in Texas: Tropical Storm Allison, which flooded Houston in June 2001, and Hurricane Ike, which caused severe damage in Galveston in September 2008. When a disaster is predictable, good predisaster planning can help to save animals’ lives. However, as disasters are usually not predictable and tend not to follow a script, that plan needs to be easily adaptable and flexible. It should address all aspects of the program and include an evacuation strategy for the animals, data backup, and identification of emergency equipment such as generators and communication systems. Media communication must also be considered as the general public may become emotional about animal-related issues; adverse attention and public scrutiny can be expected if animals die. The psychological impact of the disaster on the lives of those it directly affects may require attention and accommodation in the postdisaster recovery period. Following an overview of each disaster we describe plans for recovery, impacts on research, business continuity programs, and planning and preparation strategies developed against future natural disasters. Long-term planning includes building design as an important factor in protecting both the animals and the research equipment. Lessons learned include successful responses, evaluation for improvements, and preparedness plans and procedures to guard against future disaster-related destruction or loss of facilities, research programs, and animal lives.

Key Words: business continuity; disaster planning; flood; hurricane; impact on research; natural disaster; preparedness; recovery

Overview

Tropical Storm Allison (Houston, 2001)

When Tropical Storm Allison formed 80 miles off the coast of Texas in early June 2001, no one expected that within 5 days it would go on record as one of the most devastating floods in the history of the United States. The heavy rains left Houston and the surrounding Harris County with 22 fatalities, 95,000 damaged vehicles, 73,000 damaged residences, 30,000 residents living in temporary shelters, and over $5 billion in property damage (Figure 1). The Texas Medical Center (TMC) alone incurred $2 billion of this damage (Hays 2001). Basement vivaria at TMC component institutions such as the Baylor College of Medicine, the Texas Heart Institute, and the University of Texas Health Science Center at Houston (UTHSC-H) suffered serious flooding.2

The 2001 UTHSC-H disaster plan was extensive and was written in accordance with the recommendations in the Guide for the Care and Use of Laboratory Animals (NRC 1996) and the UTHSC-H Center for Laboratory Animal Medicine and Care (CLAMC) program, but it could not be implemented because of the rapidity and sheer magnitude of the flooding. The standard operating procedures (SOPs) were of no help either, as the detailed plans for moving hundreds of animals to higher-level rooms in the UTHSC-H Medical School depended on advance warning and adequate time.

An online early flood warning system managed and operated by Rice University could not prevail against the enormous quantity of water dumped in such a short period. Most backup generators were in basements and flooding prevented their use. According to Philip Bedient, a flood expert at Rice University, “there is no current technology existing that could have provided adequate warning of what was coming,” saving the underground facilities from flooding (Schub 2002, 36).

1Abbreviations used in this article: ARC, Animal Resource Center; CLAMC, Center for Laboratory Animal Medicine and Care; HVAC, heating, ventilation, and air conditioning; TMC, Texas Medical Center; UTHSC-H, University of Texas Health Science Center at Houston; UTMB, University of Texas Medical Branch; UTPD, University of Texas Police Department

2Only the basement vivarium at the MD Anderson Cancer Center escaped flooding—the hole for the foundation of a new rodent vivarium at the Center became “a 20 million gallon retention pond,” saving the underground facilities from flooding (Schub 2002, 36).
especially when considering that this type of flooding statistically occurs only once every 500 years” (Schub 2002, 35).

The flash floods drowned thousands of laboratory animals and destroyed years of stored research data. Animals housed at ground level or above were not affected, but unfortunately over 50% of all research animals were housed in basement facilities. Although SOPs in the emergency response plans for each TMC research institution included measures for moving animals to safe locations along with other safety preparations, no animal facility staff were present because the flooding happened within just 3 hours in the middle of the night. Many animal care providers attempted to get to the facilities through waist-deep water and closed roadways, but they arrived too late to save any animals.

Other impacts of Tropical Storm Allison on the TMC complex in Houston were significant. At the UTHSC-H Medical School, over 1 million gross square feet of space for teaching, biomedical research, support functions, and animal care were out of service for many months and 3,200 faculty, staff, and students were displaced for more than a month. Ten million gallons of water inundated the Medical School basement, with total facility damage estimated at $52 million and total equipment loss estimated at $53 million. Sponsored research projects were negatively affected and more than 4,700 laboratory animals valued at $7.4 million drowned. Remediation of critical areas, including the totally demolished animal care center, the cyclotron, and the gross anatomy laboratory, was estimated to cost $68 million. The costs of emergency cleanup, business interruption, and temporary facilities were approximately $25 million, and the total impact of this devastating event was $205.4 million, of which only $50 million was covered by insurance (UTHSC-H 2001, 2).

A revised emergency response plan following the devastation of Tropical Storm Allison was nearly put to the test in September 2005 when Hurricane Rita was projected to strike the Gulf Coast of Texas (the hurricane made a last-minute turn to the east that spared Houston from a direct hit). The revised plan included the first-time use of “ride-out” teams of personnel (staff designated to remain on-site to implement emergency measures), new and improved communication systems, and revamped flood mitigation structures and programs.

Hurricane Ike (Galveston, 2008)

The revised UTHSC-H emergency response plan was truly tested in September 2008 when Hurricane Ike devastated the Gulf Coast in the Galveston area (Figure 2), some 50 miles southeast of Houston, and caused serious damage from high winds and torrential rain. The UTHSC-H buildings withstood the high winds, and flooding and power outages were avoided due in some part to the mitigation measures implemented after Tropical Storm Allison, but the University of Texas Medical Branch (UTMB1) location on the island of Galveston made it vulnerable to the ravages of the 2008 storm.
UTMB had had many close calls over the years. Hurricane Rita gave a big scare in 2005—coming just a month after Katrina, everyone knew how serious it could be. And the 2008 hurricane season was a busy one in the Gulf of Mexico; only 2 weeks before Ike, UTMB had gone to the highest alert level without a full shutdown as Hurricane Gustav passed nearby. So UTMB had a lot of practice and knew the drill. But was it enough? Hurricane Ike would be the worst in over 100 years, the “storm of the century.”

One of the authors (JCD) described the onset of the disaster:

The sinking feeling in the pit of my stomach would only get worse as the water in the streets continued to rise. This was only a Category 2 storm, yet the surge was already here 20 hours ahead of the storm. There was no wind or rain yet, just a slow relentless rise in water levels. I still had no idea on that Friday morning, 12 September, that our lives would be changed forever. I did comment in one of my emails that night as the waters swirled around the hospital and the winds started to pick up, that this was the one we have always worried about. And then the power and Internet went out.

And so began the Hurricane Ike ride-out at UTMB.

At the time, the Animal Resource Center (ARC) comprised eleven vivaria distributed across the campus. All animals—over 4,200 boxes of rodents, 50 sheep, and other species—in five of those facilities (totaling approximately 42,500 square feet), where ground floor animal rooms were deemed too low in elevation to withstand flooding, were evacuated to higher elevations.

Beginning shortly after midnight on Saturday, September 13, Ike devastated Galveston Island and the Bolivar Peninsula with 100 mph winds and a 17-foot storm surge that submerged 80% of the island. At least 20 deaths in the Houston Galveston area are attributed to Ike (Berg 2009). The Ike ride-out team found a very different city and campus in the daylight hours of Saturday as the storm winds slowed and floodwater began to retreat. From the outside, the campus looked normal and little external damage was evident. Yet virtually every building on campus, including 90% of the critical research facilities (according to the insurance estimate), had sustained damage except for the newly constructed Galveston National Laboratory. The ARC offices were inundated and destroyed (Figure 3), and critical documents and equipment ruined. UTMB lost over 750,000 square feet of ground floor space, and another 2 million square feet of floor space was unusable because of flooding on lower floors (Figure 4). The hospital lost the blood bank, pharmacy, radiology, and food service capabilities. Although the emergency room, a top-rated Level 1 trauma center, was spared, there was no infrastructure to support it. Power, water, and sewer services were destroyed.

Logistical concerns were often critical and complex. As described below, reconstruction has been slow and after almost 2 years life has not yet quite returned to “normal.”

**Recovery at UTHSC–Houston after Tropical Storm Allison**

**Early Measures: Sponsor Notification and Cleanup**

After an event has passed and human casualties and personnel safety have been assured by the occupational health and safety office, the next step for an institution’s management is immediate notification of government sponsors, regulators, and accrediting organizations. Within 48 hours after the storm passed, UTHSC-H officials contacted the US Department of Agriculture (USDA), the Office of Animal Welfare (OLAW) at the National Institutes of Health (NIH), and the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) International, followed by the sponsors of primary research grants.

The NIH Office of Policy for Extramural Research Administration states that it is very important to contact the appropriate scientific program officials and grants management
specialists, whether by phone, email, or fax, as soon as possible after a disaster to notify them of potential delays, possible research setbacks, or relocations of research. Within 2 weeks the initial reports should be followed up with written reports that include a detailed account of what happened and what plans are in place to prevent a recurrence. This is an important step to ensure the continuing support of animal research facilities that are registered, accredited, and accredited by regulatory and oversight organizations.

In the meantime, the University of Texas Police Department (UTPD) handled crowd control for gatherings of media reporters, concerned citizens, and research staff. The UTHSC-H Public Affairs Office coordinated communication with all of these groups and with academic operations personnel.

The next critical step in the recovery of the UTHSC-H Medical School was the removal of over 10 million gallons of water, 22 feet deep, from the basement and ground floor through the use of rented large portable pumping equipment (Figure 5). It took 72 hours to remove all the water, after which the occupational health and safety office permitted re-entry. Environmental health and safety experts conducted a complete hazard analysis and risk assessment to ensure that the area was safe for staff and recovery teams and that employees entering destroyed sections of the facility wore appropriate personal protective equipment (PPE). Basement facilities harbored some hazards such as chemical wastes and large numbers of decomposing animal carcasses and human cadavers from the anatomy laboratory. The animal care facility staff safely removed all animal carcasses and worked with recovery teams to salvage all usable equipment while ensuring that personnel were kept out of harm’s way.

Reimbursement Claims

Recovery resources for UTHSC-H included insurance claims, Federal Emergency Management Agency (FEMA) claims, Federal Emergency Management Agency (FEMA) reimbursement claims, and insurance claims. Federal Emergency Management Agency (FEMA) reimbursement claims were used to replace animal losses, repair research facilities, and provide temporary relocation funds, institutional administrative and financial support, no-cost grant extensions, and financial supplements from the NIH granting agencies on a case-by-case basis. But efforts to secure such assistance also constituted a major recovery challenge: the identification and substantiation of losses from the storm. The FEMA claim forms (www.disasterassistance.gov) required a great deal of detail and consistency to ensure that enough information was provided for agency approval of each claim (assistance was available from FEMA through a toll-free number). FEMA claims pay out at 75 cents on the dollar and do not reimburse for business interruption losses. To maximize and expedite reimbursement, claims should be prepared with the same amount of detail as an insurance claim and should include items slated for salvage (we found, however, that compiling a list of damaged or lost equipment and supplies often required a best guess of inventory counts).

In addition to an accurate animal census (numbers and breeds) with justification for the animals’ replacement and research value, it is very important that each department maintain a detailed inventory of fixtures and specialty items. Animal facilities often include unique requirements such as metal doors with viewing windows and kick plates, automatic light timers and watering systems, high-temperature and humidity alarms, security punch lock and card access systems, cleaning implement wall holders, eye wash stations, built-in modular cubicles, bumper guards, gas and reverse osmosis water lines, built-in casework, and surgery room lights, all of which must be identified and detailed on the reimbursement claim forms.

Animal losses are particularly difficult to document unless each animal is tracked individually, which is not realistic with thousands of mice. Methods to determine animal value included retrieval of animal purchase orders and receipts (many reimbursement rules for animals were published after Tropical Storm Allison and are still subject to revision). The replacement value for research animals was very difficult to determine and was based on the principal investigator’s (PI) resource allocations for each project and each animal. Considerations included the initial cost of the animal, experimental surgery procedures, chemicals or drugs used per approved protocol, physiological monitoring, behavioral data collection processes, and the number of months and even years each animal had generated per diem charges. But these calculations did not necessarily correspond to reimbursement amounts—one PI valued nonhuman primates on a long-term neuroscience study at $36,000 each, but reimbursement was limited to the commercial replacement value of $6,000 per animal.

In addition, immediate relocation expenses after a disaster include the costs of leasing space for animal housing, surgery, procedures, and storage at a sister institution; replacement, rental, or repair of equipment; leasing of cage wash machinery; and the renovation of vacant laboratories to accommodate animal housing and procedures. All of these measures are required to reinstitute animal-based research projects delayed or destroyed by the flooding.

Figure 5 Pumping out over 10 million gallons of water from the UT Medical School basement. (Photo courtesy of the University of Texas Health Science Center at Houston)
Emotional Impacts

Concerned citizens sent more than 125 letters extremely critical of the UTHSC-H programs for animal care and use, charging that the animal care staff “let the animals drown” and that they were incompetent, dumb, and unprepared lazy “Rednecks.” These insults were all the more painful as quite the opposite was true and the loss of so many animal lives was devastating for many staff members.

Dealing with this aspect of the tragedy required special attention to the mental and physical well-being of the animal care and use staff. The recognition of both physical and emotional loss was a key element of the personal recovery of dedicated staff members from both the CLAMC and research laboratories. Psychological counseling was made available and, about 5 months after the loss, a memorial service for the animals that died was attended by over 350 UTHSC-H faculty and staff. The memorial was a tribute to the animals that gave their lives to biomedical research without completing the goals and objectives of many long-term studies involving memory, learning, and autism. Each year on the anniversary of the storm a floral arrangement and tribute to the nonhuman primates that died during this disaster is presented by a nonhuman primate veterinary technician and displayed in the main lobby of the Medical School building (Figure 6).

Recovery at UTMB–Galveston after Hurricane Ike

As soon as it was safe to do so after the storm, ARC ride-out staff participated in assessment teams to complete floor-by-floor evaluations of campus buildings, documenting the condition of every room. Lab security was a primary concern; teams also noted any leaks, spills, broken glass, or other damage that might be dangerous to people entering facilities. The campus received daily updates on building status. Practical challenges were evident in the loss of utilities and infrastructure, arrangements for animal care and provisions, measures to address the emotional impacts on staff, and the need for adaptations in the absence of functioning elevators, lighted stairwells, and flushing toilets.

Utilities and Infrastructure

The UTMB ARC staff members were confident of the reliability and capacity of backup power on campus: during every hurricane season all generators are started weekly and run under full load conditions monthly with rare failures. But UTMB learned that reliability is relative as the storm surge devastated infrastructure. Failed city utilities included water, sanitary sewer, power, and phones; campus utilities that failed were steam, chilled water, some backup power, and the campus network.

A number of generators were lost directly to floodwaters and others were inoperable because switchgear flooded. This was the first storm where trailer-mounted auxiliary chillers and generators were prestaged and connected ready for use, but this equipment was flooded in the storm surge, requiring precious time for replacement and restored operation. A major natural gas line supplying Galveston from the mainland failed. It served UTMB’s only natural gas–powered generator (all the other emergency generators on campus were diesel fueled), which had been the most reliable generator on campus and provided emergency power to a large research facility. Decades of specimens stored in −80°F freezers were lost. Other generator failures were caused by a clogged fuel filter, an incorrectly positioned valve, a failed pneumatic control tube, and the rerouting of a fuel tanker truck by unknown officials to another location on the island (the fuel was eventually delivered to the generator, but not until the facility had been without power for 4 hours). One might ask why generators and electrical switch gear remained at low-lying elevations; mitigation plans were under way to raise this critical equipment to higher levels, but funding issues had delayed progress.

Communications infrastructure was disrupted, but office functions were restored by forwarding ARC office phones to staff members who had working home or cell phones. In
addition, UTMB effected a “work from home” strategy through measures such as streamlined purchasing procedures and virtual private networking, which proved invaluable for the purchase of supplies, payroll coordination, and census billing.

Last, because Galveston is an island, access is limited to the main causeway, a toll bridge on the west end, and the Bolivar Ferry on the east end. Damage to the ferry landings and to the roads on the west end left the causeway as the only possible access. While this was excellent for controlling entry and maintaining order, it made resupply and return of relief staff impossible for a few days. By day 3, the causeway was reopened for emergency personnel, including ARC staff, who had been designated “essential personnel” after Hurricane Rita and issued orange badges so that they could pass through the police roadblocks once the roads were clear; we included all office staff as well to provide a quicker return to normal business operations. Unfortunately, a typical 30-minute drive to the island took as much as 3 hours in the days after the storm as traffic jammed the freeway leading to the island.

Animal Care and Provisions

Often during times of stress, all effort with limited staffing must be focused on taking care of the animals. All of UTMB’s animals made it through the storm, but there were only seven people to provide care to the entire census—about 8,000 boxes of rodents plus other larger species—and without lights, water, air conditioning, or elevators (only our newest vivarium had adequate emergency power to maintain support to ventilated racks that were moved there from other buildings).

The first day after Hurricane Ike, staff checked each cage for food and water; the latter was a combination of prestaged filled water bottles, aqueous gel packs, and water obtained from reverse osmosis tanks. Because cages had been changed just before the storm as planned, only minimal cage changing was required in the first few days. As the cage changing load increased in the face of inadequate utility support services, disposable cages became indispensable.

By the third day, five more ARC staff members were able to return, and an on-site inspection of UTMB facilities by USDA veterinarians confirmed adequate animal care despite the less than optimum conditions. But it was obvious that maintaining the full census of animals would be extremely difficult under the continuing conditions.

Fortunately, help was out there. An informal “mutual aid” agreement, discussed earlier in 2008, established the willingness of sister institutions to assist each other in times of need. Now upper management was notified as soon as possible (given the severe damage to communications and other infrastructure), and the CLAMC executive director notified the UTHSC-H Animal Welfare Committee chair and institutional official and received verbal approval to take pigs and rabbits to Houston until UTMB facilities were restored. Under the authority of the facility directors at both institutions, an MD Anderson Cancer Center Veterinary Services transport truck from Houston escorted by UTPD made it to the island to accomplish the transfer (Figure 7). In the coming weeks, UTHSC-H also provided cage washing services, driving to Galveston to pick up dirty cages and returning them clean 2 days later.

Pallets of bedding and feed that had been moved to upper floors as a precaution were saved, but flooding of the main storage rooms on the ground floor of one of UTMB’s newest buildings destroyed many supplies, including a large stock of disposable caging. Vendors made extraordinary efforts to resupply the campus—an emergency shipment of disposable caging was requested and arrived just in time to complete cage changes on schedule. And when it was difficult to get trucks to the island, shipments were sent to an employee’s home and the employee brought them onto the island using the orange emergency pass. Innovative solutions and accommodations were necessary!

On day 6, 25 ARC staff reported to their workstations, providing much-needed relief for the ride-out teams. The staff had more offers of help than they could use due to the logistics of getting on the island and the fact that the rest of

Figure 7  Swine loaded on a truck for transport to the University of Texas-Houston Center for Laboratory Animal Medicine and Care. (Photo courtesy of Dr. William Masters, UTMB Animal Resources Director)
the UTMB staff were able to return in full force. But just knowing help was available tremendously assisted those working in these difficult conditions.

Emotional Impacts

As noted above, disasters place major stresses on the people who live through them. The UTMB ARC staff came to work despite losing their homes and belongings, and they all live with not only memories but also daily reminders of the sights, sounds, and smells of the storm and its aftermath—dead trees and plant life, scars on city buildings and throughout the campus, ground floors that remain closed or patched just enough to allow access to upper floors. (Residents of Galveston can sympathize with the survivors of Hurricane Katrina in New Orleans and Baton Rouge, who also continue to witness the destruction they experienced.)

Since it is inevitable that stress will accompany a major disaster, it must be recognized and managed. The UTMB employee assistance program provided group and individual counseling, and a month after Ike the human resources office began a series of workshops and seminars dealing with stress, loss, and changes brought about by the storm.

Operational Adaptations

Housing for the animal care staff and ride-out team was set up on the eighth floor of the main hospital building on campus. Meals were on the second floor of the prison hospital next door. All elevators were out of service. Providing animal care required carrying food, water, PPE supplies, and sometimes animals up and down dark stairwells, navigating with a flashlight. Even simple things like getting to lunch or dinner, or a midnight trip to the toilet, became a trial by stairway. On the second day, the use of scavenged water to flush toilets was banned because sewage pumps were out; portable toilets arrived the third day. Everyone’s stamina was tested.

Yet daily adjustments and changes to the work environment became normal. The arrival of auxiliary generators offered limited power to the animal floors. Staff found ways to add some light when the overhead fixtures were out (Christmas lights added a surreal effect in darkened hallways) and creative engineering got water upstairs when the normal sources were dry. An erasable marker board became an assignment and announcement center. Deionized water was bought in bulk since normal sources for clean water were not available. Flexibility and creativity were the order of the day.

And each day brought more progress. On day 5, a limited “look and leave” policy allowed PIs to check their labs to assess and report critical problems (but not to conduct any research). At a checkpoint set up in the main research tower researchers checked in and were assigned an escort from the environmental health and safety staff (Figure 8). This was a very traumatic time for many of our investigators as the loss of their research became apparent.

Day 16 marked the return of flushing toilets (the water supply was not safe to drink until a week later). Buildings on campus were added to the electrical grid almost daily, with full power restored to the priority animal buildings. But full services (utilities, heating, ventilation, and air conditioning), security and safety, and a stringent air quality test were required before a building could be returned to use. Chilled water and steam added to the availability of creature comforts, but the loss of equipment continued to hamper operations.

Also by day 16, the UTMB Institutional Animal Care and Use Committee (IACUC) was back in business, albeit in a streamlined capacity. Meeting weekly, the IACUC dealt with a number of issues, many of them involving policy decisions about investigator access, protocols up for renewal, and communication to emergency operations personnel about ARC facility needs.

The Very Slow Return to “Normal” Operations

By June 2009, 9 months after the hurricane, one of the last pieces needed for normal operations, a replacement quarantine facility, was activated (the previous quarantine facility was located in a building that was condemned and permanently closed because of the storm’s damage).

As of February 2010, however, there are still periodic outages of power, phones, or data lines as saltwater-saturated cables fail. Most ground floor space on campus remains vacant, stripped of sheetrock and awaiting remediation. Of the elevators on campus, 60% are in operation and 40 are locked down for replacement. The elevator in the main ARC building requires two people for operation, to manually open and close the doors.

In addition, somewhere in cold storage remain over 23,000 boxes of freeze-dried documents retrieved from flooded desks and file cabinets all over campus. Each document requires inspection and a decision to retain or destroy based on departmental and campus retention schedules; retained documents will require individual decontamination.
In short, UTMB is now essentially at pre-Ike status, with the exception of nonselect agent ABSL-3 space, but the loss of several facilities is still felt and full recovery is still very much a work in progress (Table 1).

**Impacts on Research Programs**

**UTHSC–Houston**

All animal-based research was delayed. Strains of genetically engineered mice bred to be susceptible to cardiovascular diseases, asthma, immune deficiency diseases, or neurological disorders were lost. UTHSC-H President Dr. James Willerson declared that “The development of improved diagnostic tools; more effective treatments and drugs; and preventive measures for heart disease, stroke, respiratory diseases, and other killers has been seriously delayed” (UTHSC-H 2001, 4).

The loss from drowning of 4,700 research animals included 78 nonhuman primates, 35 canines, 300 rabbits, and thousands of rodents. Other losses included adult nonhuman primates that were trained since infancy to perform specific behavioral tasks for assessments of cognitive function and evaluation of normal and abnormal brain development such as autism. All data were lost from studies with rabbits and rats that had been treated with new drugs for many months to determine the long-term effects of treatment such as gene therapy.

Fortunately, calls came in from around the country: “What can we do to help?” In one case, a colony of genetically engineered mice bred to study asthma and lung fibrosis was totally lost except for two aged females housed at New York University. The Jackson Laboratory in Bar Harbor, Maine, with a team of mouse breeding specialists, offered to help reestablish the line (Warren 2001). While the valiant attempt at breeding the geriatric females proved unsuccessful, the interstate cooperation demonstrates how the laboratory animal and research community pulls together in a time of need.

In addition to animal losses, other impacts on the UTHSC-H Medical School included the destruction of cell and tissue cultures and the loss of volumes of research data. Expensive new equipment—a 6-month-old magnetic resonance imaging instrument, computers, and diagnostic instruments housed in the basement—was unsalvageable. An estimated $105 million in sponsored research awards were compromised and the value of animal loss alone was approximately $7.4 million. About 400 faculty members, postdoctoral fellows, and graduate students were seriously affected and their research projects and/or graduate training programs significantly delayed.

**UTMB–Galveston**

Hurricane Ike disrupted $110 million in research projects at UTMB, including business costs estimated at $10 million and losses of more than $17 million in research equipment.

Of huge concern was the lengthy interruption of research on the campus. Faculty were locked out of buildings for nearly 60 days. Critical time was lost as schedules slipped and animals aged. A more structured approach was needed to determine which animals were most critical and which would still be useful in 30 to 60 days.

The impact of a major disaster on a research program has both immediate tangible costs and less tangible, hidden costs. Research at UTMB was integrally tied to the clinical enterprise; Hurricane Ike closed the university hospital and caused a major disruption to the clinics, which significantly reduced UTMB’s income. As a result, a reduction in force went into effect in November 2008, cutting 20% of UTMB’s staff, mostly from clinical areas. Some researchers were included in the layoffs, and others left because they were unable to wait to restart their research projects.

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**Table 1 University of Texas Medical Branch (UTMB) Hurricane Ike impact and (partial) recovery timeline (September 1, 2008–May 15, 2009)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
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<tbody>
<tr>
<td>Sep 1</td>
<td>Hurricane Gustav skirts Texas and lands in Louisiana; Tropical Storm Ike forms in the Atlantic</td>
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<tr>
<td>Sep 4</td>
<td>Ike achieves Category 4 with 145 mph winds</td>
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<tr>
<td>Sep 9</td>
<td>Ike enters the Gulf of Mexico; ARC staff meet to initiate storm plan</td>
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<tr>
<td>Sep 10</td>
<td>UTMB releases nonessential personnel; ARC farm animals moved to central Texas</td>
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<tr>
<td>Sep 11</td>
<td>UTMB evacuates 471 patients from hospital; ARC evacuates animals from ground-level vivaria</td>
</tr>
<tr>
<td>Sep 12</td>
<td>7 AM street flooding begins; 9 PM tropical force winds begin; ARC ride-out team moves to hospital core</td>
</tr>
<tr>
<td>Sep 13</td>
<td>2 AM Ike hits with 17 ft. storm surge; 11 AM ride-out team begins campus damage assessment</td>
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<tr>
<td>Sep 16</td>
<td>USDA arrives to assess animal care</td>
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<tr>
<td>Sep 18</td>
<td>PI “look and leave” program</td>
</tr>
<tr>
<td>Sep 29</td>
<td>IRB and IACUC meet; full power and chilled water to vivaria; flushing toilets return to operation</td>
</tr>
<tr>
<td>Oct 6</td>
<td>Potable water returns</td>
</tr>
<tr>
<td>Oct 20</td>
<td>Research labs open with restricted hours</td>
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<tr>
<td>Nov 17</td>
<td>UTMB reduction in force begins; limited restart of rodent breeding</td>
</tr>
<tr>
<td>Dec 4</td>
<td>Limited restart of animal ordering</td>
</tr>
<tr>
<td>Dec 16</td>
<td>Unlimited rodent breeding authorized</td>
</tr>
<tr>
<td>Feb 15</td>
<td>ARC facilities return to pre-Ike accessibility</td>
</tr>
<tr>
<td>May 15</td>
<td>Quarantine and limited ABSL-2 space opens</td>
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*ABSL, animal biosafety level; ARC, UTMB Animal Resource Center; IACUC, institutional animal care and use committee; IRB, institutional review board; PI, principal investigator.*
Disaster Response and Management Planning

To paraphrase General Dwight D. Eisenhower, “it is the planning, not the plan.” Every institution with an animal care and use program must develop an emergency response/management plan, with the following overarching goals (Vogelweid 1998):

- Ensure animal welfare by minimizing the loss of animals and providing appropriate veterinary care and humane euthanasia if necessary.
- Support business continuity by enhancing the institution’s ability to restore and sustain operations, mitigating economic impacts from the disruption of operations, and enabling assistance from FEMA and state agencies in declared disasters.

The following sections illustrate the experiences and practices of UTHSC-H and UTMB in addressing these goals.

Animal Welfare

When disaster strikes an animal research facility, the highest priority must be saving human and then animal lives, and the plan should be designed to provide humane care for research animals even under adverse conditions. In the event that evacuation of research animals is necessary, the process should be designed to avoid risk to both humans and animals. Since elevators will likely not be operable, animals should be evacuated horizontally away from danger when possible. If animals must be moved to a different location, the sequence of movement, potential staging locations, and new housing locations should be predetermined by the program director or designee during the disaster planning process.

UTHSC–Houston

Long-term planning by the TMC administration after Tropical Storm Allison has focused on measures that will prevent similar impacts from possible future flooding. At UTHSC-H, animal evacuation is decided on a case-by-case basis, but normally according to the following species prioritization (UTHSC-H 2008):

1. nonhuman primates
2. canines
3. swine
4. rodents
5. rabbits
6. newly arrived rodents and rabbits in quarantine
7. fish

After the disaster, it may be more humane to euthanize surviving research animals than to allow them to go without food and water for sustained periods. At UTHSC-H, the institutional official and the IACUC have fully authorized the CLAMC executive director (attending veterinarian) or designated veterinary faculty member to approve and perform euthanasia.

In addition to minimizing animal (and structural) losses, each institution should make reasonable preparations to protect research assets by taking the following steps:

- Locate emergency generators in safe areas that will not be flooded.
- Ensure that an adequate supply of fuel is readily available ahead of the storm.
- Ensure that research staff maintain inventories of research laboratories and freezers, with a backup copy at a secondary location. The backup of all research data on off-site computers is vital; data can be backed up to either a secure network or to removable media such as Zip disks, CD-ROMs, or an external hard drive stored in a different location.
- Publish storm preparation strategies and procedures and make them readily available in an emergency response plan for use by all staff members.

UTMB–Galveston

In the days before Hurricane Ike, the ARC had already arranged to ship a large number of sheep and some nonstudy pigs back to the vendor in South Texas. This is standard procedure due to the low elevation of the holding area and the resources required to keep farm animals during emergencies. By September 10, 2008, the biocontainment facilities began their shutdowns and decontamination, and animal care preparations were completed by 7:00 PM on September 11. Now it was time to watch and wait. Staff were briefed regularly as they watched the storm follow almost the same path as the Great Storm of 1900, which killed over 8,000 people in Galveston and remains the most serious natural disaster in US history (Trumbull 2007).

Because vivarium evacuations had been planned and implemented in the past, 60% of the animal census was successfully moved to upper floors in other buildings on short notice and under emergency conditions, as shown in Figure 9. In addition, with the use of large rolls of clear plastic pallet wrap, entire racks complete with boxes were palletized, labeled with preplanned destination rooms, and moved by transport trucks. No animals were lost and there were no colony health breaks.

The decision to move entire buildings of animals was not made lightly. Experience with previous storms provided ample evidence that storm tracks are unpredictable, so much thought and input went into the decision. Too early and you risk animal health and study results with a move. In this instance, the decision to move animals saved their lives but, because it came late, the protection of office equipment and documents was left as a normal Category 2 preparation. That plan did not include the possibility of massive storm surges,
which caused significant equipment losses and the destruction of years of documentation.

Business Continuity

Disaster and business continuity plans are designed to cover all possible disasters and focus on anticipated contingencies such as the loss of utilities or of a building. Both UTHSC-H and UTMB learned that a disaster reveals unexpected limitations and the need for flexibility, resourcefulness, and plan adaptations for future challenges.

UTHSC–Houston

Staying in business during the 6 years of recovery from Tropical Storm Allison was of paramount importance and required CLAMC staff to exercise considerable innovation and flexibility as UTHSC-H attempted to minimize catastrophic losses as quickly as possible.

Immediate measures. The first step toward business continuity was to identify alternate available space for animals and staff. Other TMC institutions were able to lease space to UTHSC-H for animal housing, cage washing, and experimental surgery (the leased space was reimbursed with FEMA funds for 3 years after the disaster). The establishment of temporary housing space in different buildings resulted in both a decentralization that increased travel time among seven locations on the TMC campus and the complete reorganization of animal care operations. In the UTHSC-H Medical School Building, 23 satellite housing rooms for various species were converted laboratories and had no lighting, HVAC, or temperature monitoring system controls. Oversight of these rooms was very labor intensive for the CLAMC staff, who nonetheless ensured compliance with all aspects of the Guide and the Animal Welfare Act and thus maintenance of AAALAC International accreditation and OLAW program assurance.

Laboratory remodeling required adequate heating, ventilation, and air conditioning (HVAC\(^1\)) and air pressures, sanitizable surfaces, and the installation of punch locks to ensure the security and safety of the animals. Permanent and leased cage wash machines were located throughout the campus, and temporary space in the basement was allocated for the storage of feed and bedding. Vivarium spaces in other buildings were maximized by increasing the number of racks and cages for animal housing. A BSL-3 rodent facility in the UTHSC-H Medical School was completed and became functional within 2 years after the storm.

Long-term planning. Looking to the future, improved flood-resistant construction of the vivarium and research buildings was the logical next step, with funding for the research replacement facility through two C06 grants from the NCRR, FEMA reimbursements, and State of Texas and benevolence funds. Key to the successful design and construction of a replacement building was the selection of competent and caring architects, engineers, vivarium planners, and project managers who were willing to listen to the users—this is a critical criterion for success in rebuilding a laboratory animal facility to withstand hurricanes and other weather-related disasters.

The 10-year plan calls for widening of the major drainage bayou in the area, the creation of large retention ponds, installation of an upgraded storm sewer system, and location of the new vivarium on the upper levels of a multistory building. Additional mitigation measures at the UTHSC-H Medical School, supported by FEMA and other funds, centered on protecting the building and its contents from future flooding. Such measures included flood doors and gates (“submarine doors”), elevated emergency exits, granite and glass retaining walls around the building, and the relocation of critical operations and systems to upper floors.

Construction was completed 9 years after the storm.

UTMB–Galveston

Because of UTMB’s location on an island in the Gulf of Mexico, its disaster and continuity plans tend to focus on storms. Before Hurricane Ike, actions in the UTMB plan were determined by the projected storm category or strength, based on wind velocity. Hurricane Ike was a Category 2 storm (i.e., with sustained winds of 96 to 110 mph).\(^3\) Because Category 2 storms are not typically associated with significant storm surges, the UTMB plan at that time would not have required moving animals to higher locations. Luckily, however, thanks to advance warning of the unusual nature of this storm (hurricane forecasters accurately predicted that it was pushing a

\(^3\)A new storm rating scale proposed by Powell and Reinhold (2007) would have rated Hurricane Ike greater than 5.0 on a 6.0 scale.
storm surge that had not abated from its previous Category 4 level), animals were removed from the lower levels of buildings (Figure 10) and so none were lost to rising water.

Two animal facilities survived with emergency lighting and limited air handling (no cooling or dehumidification). Buildings that survived the storm shared certain factors: they were built above 22 feet elevation and/or the critical electrical, HVAC, and elevator controls were located on the second floor or above. The main ARC building lost emergency power due to a flooded transfer switch from the emergency generator, but was otherwise intact.

Although campus buildings withstood the hurricane force winds, the floodwaters were devastating. Three animal facilities were destroyed, their building infrastructure irreparably damaged. Flooding also damaged the prestaged trailer-mounted building chiller unit and generator, preventing rapid cooling for the primary rodent building. To provide some moderation of temperatures, spot coolers were prestaged on the animal housing floor in the event system chilling was lost. These units, powered by the building’s penthouse-located generator, required staff to monitor them around the clock to remove the condensate that collected during operation (if condensate tanks filled to capacity the units would shut off).

Challenges persisted in the communications infrastructure. Landline phones and pagers failed, and cell phone service was spotty at best. The extreme load on the cell phone systems imposed by government and emergency response groups and the general public typically makes service unreliable during a catastrophe. Regulatory agencies complained that ARC phones were not answered in the days immediately after the storm but there were, in fact, no phones to answer. The rest of the country did not fully understand the gravity of our situation.

Furthermore, even with weekly testing of emergency generators, a clogged fuel filter on a critical generator knocked out the campus radio repeater system at the height of the storm. Until the radio repeaters were brought back online, campus emergency personnel had limited straight line radio contact and so used a line-of-sight relay system to pass information from one radio location to another. A rental radio system with a repeater and walkie-talkies was delivered the third business day after the storm and provided communication for animal care staff as they moved among the various buildings on campus.

**Stages of Disaster Preparation and Response**

During hurricane season (June 1 through November 1) it is imperative that all staff have a plan for their family, pets, and personal belongings. This is particularly important for members of the preparation and ride-out teams. Based on information from the National Weather Service, FEMA, and the American Red Cross, it is advisable to:

- Decide beforehand where to go if you must evacuate your home. Essential personnel, and particularly ride-out team members, should have plans for the shelter or evacuation of family and pets.
- Identify safe evacuation routes as well as alternate routes. Remember that roads will be crowded and that bridges and low-lying roadways could be underwater.
- Prepare a portable disaster supply kit of essential items if you live in an evacuation area.

Managers (or their designated representative) are responsible for ensuring that personnel remain in a secure area until it is safe to evacuate or until further instructions are received. They should also familiarize their staff with exits and procedures, and, when the time comes, ensure that employees leave through the exit nearest their work area and move away from the building for safety.

The major stages of hurricane or tropical storm preparedness are shown in Table 2, and Box 1 provides a useful checklist for the beginning of hurricane season. The following
sections offer detailed descriptions of responsibilities and steps for each phase and for veterinary, animal care, and other staff.

**Preparation**

As soon as the threat of a disaster is imminent, it is essential to establish communication with the campus emergency response components, including the occupational health and safety office (OHS) and campus police, and to provide OHS with a list of all essential personnel who will be involved with animal care during the disaster, to ensure accountability for the health and safety of these staff members.

The preparation team—veterinarians, veterinary technicians, husbandry managers and supervisors, facility managers, and husbandry staff—is responsible for reviewing the emergency situation response plan, which should include a list of the required supplies and equipment, show where the items are located, and explain procedures for moving equipment away from windows to protected locations.

**Alert (96 to 72 Hours Out)**

When a unit moves to alert status, directors and managers meet with all personnel and brief them on the emergency plan. The members of the preparation and ride-out teams meet to receive specific instructions, review the emergency response procedures, and establish the chain of command to be followed during the storm. They also determine when the ride-out team will be released to make personal preparations (e.g., for their families and/or personal property) and when they will be expected to return to the facility to ride out the storm in designated buildings. As members of the ride-out team return to the facilities, members of the preparation team are permitted to leave.

**General Tasks**

- Verify the accuracy of phone numbers for all personnel and ensure that staff know how to contact their managers during and after normal work hours.
- Distribute list of employees’ responsibilities and tasks during the emergency.
- Decide which supplies and equipment are needed and the quantities required.
- Provide all employees with printed call-down lists (“telephone trees”) for use during evacuation.
- If necessary, decide on the relocation, security, and/or euthanasia of any biohazardous, farm, or nonhuman primate research animals.
- Arrange for the delivery of critical supplies from vendors, including feed, bedding, and euthanasia supplies such as barbiturate solutions and CO2 gas cylinders.
- Cancel expected animal shipments.
- Ensure that fuel and water tanks are topped off in departmental vehicles.

**Tasks for Veterinary Staff**

- Consult with veterinarians about modifying treatment schedules for very sick animals.
- Cancel routine physicals and surgeries.
- Prepare instructions for care of PI-maintained animals and ensure that managers have access to satellite facilities and are trained in the proper methods of care for the animals in them, especially with species (e.g., zebrafish) that are new to the program or require special handling.

**Tasks for Animal Care Staff**

- Change out all cages/pens.
- Do thorough observation checks and submit all animal health concerns to veterinary staff.
- Immediately report any animal health emergencies (e.g., moribundity, bleeding) to veterinary staff.

**Box 1 Checklist for beginning of hurricane season**

- Assign ride-out team from roster of essential personnel.
- Create list of critical supplies/equipment, locations, and staff responsible for restocking.
- Keep at least a 1-month supply of feed and bedding on hand throughout the season.
- Review internal departmental call list and, as necessary, update procedures for contacting employees.
- Provide departmental hurricane preparedness refresher training.
- Develop departmental communications plan and hierarchy of departmental decision makers.
Watch (72 to 24 Hours Out)

Directors and managers meet with all personnel and brief them on the emergency plan. Program director (or designee) notifies facilities planning and engineering director (or designee) with names of essential personnel available for storm preparations and recovery. The ride-out team is sent home to secure personal property, with specific instructions on return reporting time and location.

General Tasks

- Prepare sign-in/-out sheets for emergency entrance points.
- Charge batteries for radios and walkie-talkies; charge cell phones and put fresh batteries in pagers.
- Ensure that dumpsters are empty.
- Receive and process incoming animals as quickly as possible.
- Help facilities maintenance team seal gaskets on flood gates as requested.
- Stage extra feed, bedding, and clean equipment in clearly designated locations.
- Cremate all carcasses.

Tasks for Veterinary Staff

- Notify essential personnel of procedures for reporting to work for recovery operations after the storm.
- Conduct final review with staff and essential personnel concerning all health issues for research animals.

Tasks for Animal Care Staff

- Rodents: Top off feed; replace water bottles; change all wet cages, reduce overcrowded cages, and clean any excessively soiled cages.
- Large animals: Move to clean pens; clean and prepare vacant large animal pens for future use.
- Make sure all bottles, carboys, and drums are filled with potable water.
- Place a water bottle on every cage that receives automatic watering and place two full bottles on rabbit and guinea pig cages.

Warning I (24 Hours Out)

Directors and managers meet with personnel and brief them on the emergency plan.

- Place satellite facility keys in a designated location.
- Walk through all animal relocation spaces with ride-out team members.
- Provide husbandry and veterinary teams with the list of all rooms where animals are located and with the personnel assignments for both health care and husbandry.
- Fill water barrels on wheels with chlorinated water for rodents and tap water for large animals.
- Stage PPE (including eye protection), hard hats, head lamps, trash bags, and flashlights with new batteries at emergency entrance points.

Warning II (8 Hours Out)

Directors and managers meet with personnel and brief them on the current emergency situation.

- Order the securing of facilities.
- Issue master keys and reliable communication devices (e.g., satellite phone, two-way radios) to ride-out team members.
- Ensure the availability of dry ice in designated freezers in case of power loss.
- Notify police, facilities, and the OHS personnel with a list of all authorized ride-out team members, their mode of communication (e.g., satellite phone, two-way radios), and their locations in the buildings (especially sleeping quarters).
- Ensure that all buildings are evacuated.
- Coordinate with police that all doors are secured.

Ride-out

During ride-out, it is essential to monitor animal housing areas for signs of significant temperature changes, flooding, and any other detrimental conditions. If any of these conditions threaten, the program director in charge (or a designee) must determine measures to reduce their impact. If the assistance of the facilities maintenance team is required, they should be contacted immediately through the facilities service desk or by cell phone, pager, or email. Walkie-talkies should also be available for communication as all other means of contact may be inoperable. Research buildings must be locked externally until deemed safe to reenter after the storm. (At UTMB, ride-out is not permitted in animal facilities with the exception of the GNL; ride-out team members stage in the main hospital facility for the duration of the storm.)

- Assign personnel to walk through the facility every few hours to check for problems (e.g., leaks, breakage of windows, electricity failure) and report these to the husbandry manager on duty, who should in turn report to the program director and the facility maintenance team.
Shortcomings That Quickly Became Apparent

- While preparations at UTMB started early, it was not early enough. A 36-hour window was though sufficient, but staff learned that 96 hours before projected landfall is advisable to see preparations through to completion. The downside of early preparations is that current forecasting methods cannot tell at 96 hours where the storm will land.
- Prestaging equipment in harm’s way created additional problems at UTMB.
- Perform rounds to check the animals’ condition, ensuring that all have food and water.
- Rodents: Perform necessary change-outs if conditions allow.
- Large animals: Wash down cages and runs if the situation allows and/or utilities are adequate.
- Periodically check all equipment to ensure proper functioning.
- If power is lost and animals die, double-bag carcasses with lime and safely transport them to designated storage areas.
- As necessary and at the discretion and under the direction of the program director, attending veterinarian, or designee, euthanize animals according to the emergency response policy approved by the institutional official and the IACUC.

Lessons Learned

Disaster plans may not be effective because of unexpected or catastrophic events or because the disaster occurs quickly and there is no time to react effectively. UTHSC-H and UTMB learned many lessons from the events associated with Tropical Storm Allison and Hurricane Ike, especially as UTMB learned many lessons from the events associated with Tropical Storm Allison and Hurricane Ike, especially as there is no time to react effectively. UTHSC-H and UTMB have alternate off-site web hosting capabilities, enabling the distribution of campus information to a widely dispersed staff. Ensure the availability of a

Animal Care

- Ensure that the ride-out team has enough staff to deal with the physical demands of providing care at all animal facilities.
- Designate all animal care staff, including office staff, as “essential” to enable their faster return to the site.
- Shrinkwrap racks of caging for evacuation and movement to new locations, and be prepared to shift staff and processes to other facilities or institutions.
- In multistory facilities, stage supplies on each floor in the event of elevator failure.
- Use disposable cages and prepackaged animal water to enable continued operations without cage wash facilities.
- Follow existing animal handling SOPs. An SOP-driven operation can support animal health even during a disaster through the use of off-site office operations and a reconstituted “lean and mean” IACUC that can make decisions quickly as conditions change.
- Most important of all, have a dedicated animal care staff willing to work in the most difficult conditions for days providing care and support for the research animals.

General Staff and Logistical Considerations

- Recognize and address complacency and denial early.
- Establish a checkpoint for returning employees.
- Allow employees to take “adverse weather leave” or to work from home when the normal worksite is not available. Provide additional leave for staff unable to return to work immediately because of personal issues such as a destroyed home.
- Ensure the availability of employee assistance program and other resources to address emotional impacts on staff.
- Provide “red folders” to key staff members with emergency contacts for staff and vendors as well as all the information required to handle time keeping, payroll, purchasing, and contracts, including forms for manual processing in case online systems are not available.
- Provide daily information to staff on-site and identify alternatives to communicate with the outside world. UTMB and UTHSC-H have alternate off-site web hosting capabilities, enabling the distribution of campus information to a widely dispersed staff. Ensure the availability of a
functional campus website, email capability, and phones for key personnel.

**Going Forward: The Long View**

- Encourage all researchers to cryopreserve or to collaborate with others around the country to ensure the survival of rare lines. Since Hurricane Ike, there is more interest in pursuing these techniques at many institutions located in coastal areas. “Freezing your assets” is good advice for researchers who use genetically engineered rodents. As new lines of transgenic and knockout mice are created, they should be housed in different physical locations throughout the institution so that founder animals will be available if another disaster strikes.

- Ensure that remediation contractors are ready to respond quickly with repairs and/or supplies when the event is over.

- Negotiate with insurance companies to ensure adequate coverage for catastrophic losses.

- Revise the emergency response plan, as necessary, in conjunction with animal care management, the office of environmental health and safety, fire safety specialists, and the university police soon after any disaster.

**Summary and Conclusions**

For 118 years UTMB has faced the threat of hurricanes and recovered quickly from them—until Hurricane Ike in 2008 completely changed the way the institution approaches hurricane preparation. Sweeping changes to infrastructure and building planning will make future storms less destructive to the campus. A $657 million 4-year mitigation project scheduled to begin in the first quarter of 2010 will address infrastructure needs. The construction of reinforced facilities with critical services at elevations above projected storm surge levels will decrease downtime to allow investigators to get back to work quickly and preserve ongoing research.

But achieving prestorm functionality should not be confused with recovery. UTMB has resumed many of its pre-Ike activities, but not necessarily in the same ways. The medical students are back, but classroom space is limited. The hospital has reopened, but with most of the ground floor closed off and food service provided from temporary buildings. The emergency room reopened in September 2009. Many offices remain makeshift and scattered.

Plans for a new hurricane season are being reviewed and updated. The process of planning is crucial for acquiring the insights necessary to follow through, adjust midstream, modify, or perhaps scrap the plan if conditions warrant. It truly is not the plan, but the planning.

Staff members must practice implementing the disaster plan to ensure that they know their roles and responsibilities. The designation of all ARC staff as essential personnel is an integral part of disaster planning.

Up-to-date contact lists are also essential, and when the power is off and cell phone networks and paging systems go down, the disaster plan must include provisions for alternate means of communication.

According to the Director of Major Capital Projects and Planning at Baylor College of Medicine, “the cost of remediation far exceeds the cost of well-planned mitigation efforts. Therefore, the cost of construction will be small when compared to the costs associated with animal loss and loss of research productivity” (Christina Durovich, quoted in Schub 2002, 36).

UTHSC-H’s safety expert advises that the early involvement of research personnel in disaster preparedness can help to minimize the damage from a disaster (Schub 2002, 36). One means of accomplishing this is to educate them about flood insurance, especially about what is and is not covered, and deductibles, which are often very high. To ensure a rapid response for beginning the recovery process after a disaster, each institutional department should have its own specific emergency response plan and contact list and should not plan on immediate assistance from facility maintenance personnel.

During the reconstruction period, management teams should be willing to consider and approve numerous changes, should not compromise on the requirements for state-of-the-art HVAC requirements, and should consider the installation of interstitial spaces between floors for all mechanical equipment and controls.

The lessons learned from these significant storms can assist all animal care and use programs in designing preventive programs for future events of this magnitude. And beyond the practical specifics, staff at UTHSC-H and UTMB learned that good management and flexibility are key, that team loyalty was paramount to achieving departmental goals and objectives during the years-long recovery period, and that, above all, patience and persistence were the greatest attributes during the recovery from Tropical Storm Allison and Hurricane Ike.

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