LEARNING FROM HURRICANE HUGO:

IMPLICATIONS FOR PUBLIC POLICY

An Annotated Bibliography

prepared for the

FEDERAL INSURANCE ADMINISTRATION
FEDERAL EMERGENCY MANAGEMENT AGENCY
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INTRODUCTION

Between September 10 and 22, 1989, the storm that came to be known as Hurricane Hugo made its way across the Caribbean Islands and up the southeastern coast of the United States, and came ashore along the South Carolina coast. It resulted in 49 deaths, widespread damages and losses estimated to exceed $9 billion, the temporary displacement of hundreds of thousands of people, and disruption of the lives of about 2 million people. The long-term impacts of the disaster will be felt for years.

Like other natural disasters, Hugo spawned a large number of research investigations, post-disaster evaluations, case studies, assessments, conferences, journal articles, and similar documentation. This bibliography is a collection of citations and annotations to the material written about Hugo that has relevance to present or future public policy. Such a collection should assist both the public officials who must plan for or cope with hurricanes, and the researchers whose work helps them make their decisions.

Documents were reviewed and selected for this bibliography on the basis of two criteria. First, the document must have originated with a person or organization with recognized expertise in or official standing with regard to the subject matter. Second, the document had to include information from which something could be learned that would have implications for public policy, as opposed to the concerns of the private sector. Based on these criteria, most of the entries are the reports of scholarly or scientific studies, or are the work of local, state, or federal officials whose agencies have some responsibility for natural disasters like hurricanes. The following were not included: newspaper and magazine stories, victims' accounts of their experiences, letters to the editor, photographic essays, explanations of how particular businesses or industries survived the storm or its aftermath, news stories in trade journals, and the like.

The bibliography is organized by topic, and alphabetically by author's name within each topic. An index to authors' names appears at the end of the bibliography. Multi-topic works were entered under the heading that best describes their main focus. Copies of most of the materials listed in this bibliography are also entered in the Floodplain Management Resource Center database and library, which are maintained for the Association of State Floodplain Managers by the Natural Hazards Research and Applications Information Center at the University of Colorado. A companion document, *Learning from Hurricane Hugo: Implications for Public Policy*, lists key findings or lessons from the reports and studies reviewed for this project.

PHYSICAL CHARACTERISTICS OF THE STORM

Coch, Nicholas K., and Manfred P. Wolff 1990. Probable effects of a storm like Hurricane Hugo on Long Island, New York. *Northeastern Environmental Science* 9(1/2):33–47.

Hurricane Hugo and the 1938 hurricane that struck Long Island were similar in their shore-normal tracks and the types of devastation they spread far inland. Further, the geomorphology, coastal features, and degree of urban and suburban development in the Charleston area is similar to that on Long Island today. Taking the effects of the two storms and these background similarities, the authors project the damages that the New York coast would suffer at the landfall of a hurricane like Hugo. They recommend more stringent and restrictive setbacks and building codes; maintenance of dune height and continuity; unimpeded sand flow along the shoreline; a well-designed evacuation plan; and provisions for maintaining law and order after such a major disaster.

Garcia, A. W., B. R. Jarvinen, and R. E. Schuck-Kolben 1990. Storm surge observations and model hindcast comparison for Hurricane Hugo. *Shore and Beach* 58(4):15–21.

This article describes the extent and distribution of storm surge during Hurricane Hugo as deduced from tide gage data and high-water mark observations and compares them with hindcast results from SLOSH. The model results match the observed high-water marks quite closely at most sites and differ only up to 15% at others. Although the model does not reproduce Hurricane Hugo's initial water level rise, it did reproduce the time of arrival and elevation of the storm surge peak.

Marshall, Richard D. 1991. Lessons learned by a wind engineer. Pp. 160–69 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Surface wind speeds during the passage of Hurricane Hugo through the U.S. Virgin Islands and Puerto Rico are described in this article. Although damage to the affected areas was extensive, an assessment of relevant data indicates that the actual wind speeds were far lower than those reported by the news media. The consequences of overstating the wind speeds are examined and actions to improve the accuracy of measuring and reporting wind speeds are outlined.

Powell, Mark D. 1991. Meteorological aspects of Hurricane Hugo. Pp.11-40 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This paper discusses the meteorological aspects of Hugo that influenced the storm's track, the changes in intensity before landfall, and the surface wind distribution at various stages during the decay of the storm. The surface wind distribution is emphasized because of its effect on structural damage overland and its importance in forcing the storm surge and waves responsible for much of the coastal damage. Expansion of the surface observation network is recommended to improve data on surface wind fields in future storms.

Powell, M. D., and P. G. Black 1990. Meteorological aspects of Hurricane Hugo's landfall in the Carolinas. *Shore and Beach* 58(4):3-13.

Although meteorologists continue to learn about hurricane motion and track prediction, which should lead to improved future forecasts, little is known about predicting changes in intensity of storms like Hugo. A 24-hour forecast of intensity is especially important to emergency preparedness officials, because a more intense storm can result in a larger area of inundation, requiring preparedness and evacuation of a much larger population. This paper discusses the factors influencing Hurricane Hugo's storm track, the changes in intensity before landfall, and the surface wind distribution at various stages during the storm's decay. It concludes that Hurricane Hugo's rapid intensification (1 millibar/hour) over the six hours before landfall was associated with both low upper-level wind shear in the storm periphery and the passage of Hugo over the Gulf Stream. Determination of the surface wind field at landfall was hampered by lack of data, and expansion of the surface observation network and use of remote sensing instruments is recommended.

Rosenthal, Stanley L. 1990. Summary of the special sessions on Hurricane Hugo: 70th Annual Meeting of the American Meteorological Society. *Bulletin of the American Meteorological Society* 71(9):1339-42.

This article summarizes five special sessions about different aspects of Hurricane Hugo, beginning with a track of the storm's path, intensity, and speed. Forecast models used to predict the storm's movement from its origin off the coast of Africa until tracking stopped in the far north Atlantic two weeks later were compared for their accuracy. The impacts of the storm in the Caribbean and on the U.S. mainland were presented. Differences between flight-level winds and surface winds were discussed and suggestions for developing surface windfields from flight-level data were made. An analysis by a model known as HURISK computed the return period of a storm of Hugo's intensity as 430 years and the probability of having no hurricanes in the area for 25 years as 2%. Measurements of vertical electrical field, liquid water, and vertical velocity obtained by penetration of Hurricane Hugo's eyewall by National Oceanic and Atmospheric Administration's P-3 aircraft on September 15, 16, and 19 were presented. It was suggested that Hugo and other recent hurricanes signal the return to more intense Atlantic hurricane activity such as that of the 1950s and 1960s. The evolution of Hugo's precipitation structure based on radar reflectivity data was discussed, along with the reasonable accuracy of predicting Hugo's track and timing displayed by the ECMWF operational forecast model. Two other presentations described the in-flight emergency (loss of one engine) suffered by one P-3 during penetration of the storm and the

possibility that a small "suction" vortex, similar to that encountered in tornados, was responsible. A final segment was the presentation of several videos of satellite, infrared, color-enhanced, radar, and other imagery.

Schuck-Kolben, R. Erik 1990. *Storm-tide elevations produced by Hurricane Hugo along the South Carolina coast, September 21-22, 1989.* Open-file report 90-386. Columbia, S.C.: U.S. Geological Survey.

High-water marks produced by the storm tide from Hurricane Hugo on September 21-22, 1989, were identified, described, and level-surveyed along the South Carolina coast from North Myrtle Beach to Seabrook Island. Three hundred and fifteen marks are presented in tables with the latitude and longitude, quality of the mark, water surface elevation, and ground elevation noted. The marks and contours of approximate storm-tide elevations are plotted on 31 7 1/2-minute topographic quadrangle maps. The average elevation of the storm tide above sea level ranged from 7 feet at the North Edisto River mouth to 20 feet near Moores Landing.

Sparks, Peter R. 1991. The facts about Hurricane Hugo—what it was, what it wasn't and why it caused so much damage. Pp. 278-85 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

The wind and surge conditions during Hugo are described, and the extent of damage to buildings and utilities and the reasons for their poor performance are discussed. The paper concludes that there was a considerable amount of misinformation circulating about the conditions during Hugo; in general, the public was led to believe that the wind and surge conditions were more severe than they actually were.

IMPACTS ON HUMANS AND HUMAN SYSTEMS

Christian, Cora L. E. 1992. *Hurricane Hugo's Impact on the Virgin Islands*. Working Paper no. 73. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 66 pp. $ 4.50.

A research team from the Virgin Islands Department of Health conducted two surveys of the island population, one shortly after Hurricane Hugo, and another one year later. From the data obtained the researchers developed a demographic profile of the population before and after Hugo, assessed the effects of the storm on the physical and mental health of the residents, and ascertained possible long-term effects of Hugo on the psychological and social environment of the islands. Among the conclusions are that a portion of the population permanently left the islands after Hugo; that socioeconomic and educational differences among various segments of the population can exacerbate the impacts of a disaster; and that radio was the overwhelming means of alerting the public to the impending storm.

Hamm, Steven W. 1990. Battling disaster profiteering. *State Government News* 33(3):22-23.

Emergency ordinances barring price gouging, special price-gouging hotlines, and stern public statements by officials, such as the mayor of Charleston, all helped prevent the damage done by Hugo from becoming even more expensive for the affected citizens. Public information campaigns were mounted to advise consumers how to avoid being defrauded in attempts to get their property repaired promptly.

Hornig, Susanna, Lynne Walters, and Julie Templin 1990. Voices in the news: newspaper coverage of Hurricane Hugo and the Loma Prieta earthquake. Paper presented at the Association of Education in Journalism and Mass Communication Annual Meeting, Minneapolis, 1990. Reprints available from authors, Department of Journalism, Texas A&M University, 230 Reed McDonald Building, College Station, TX 77843-4111, (409) 845-4611.

This paper summarizes the results of a study of how newspaper coverage of the Loma Prieta earthquake and Hurricane Hugo used quotations from expert sources to construct claims about institutional needs and responsibilities. The study showed that specialized information used in newspapers usually comes from an appropriate expert source, although there was a strong tendency to obtain general comments or observations—rather than appropriately specific ones—from all types of sources, including experts. Elected officials and government agency representatives were the sources of 55% of all the quotations used. When experts were quoted, their general comments were almost as likely to be used as those based on their professional expertise. The authors conclude that their data support the assertion that the news stories were forums in which various interests competed to establish a public definition

of the disaster situation that recognized their own claims to primacy and to the resources necessary to accomplish their objectives.

Kaniasty, Krzysztof, and Fran H. Norris 1991. In search of "altruistic community": social support following Hurricane Hugo. Poster session presented at the Third Biennial Conference of the Society of Community Research and Action, Tempe, Arizona, June 1991.

Although many victims of catastrophic events receive substantial help (tangible physical or financial assistance, guidance, and emotional support) through altruistic communities that emerge after the disaster, not all victims participate or benefit fully. In a sample of 1,000 persons, 750 of whom resided in the Hugo impact area, it was found that several demographic factors—mainly age, education, sex, and network size—were consistently related to supportive behavior. Blacks, older, and less educated respondents were victims not only of disaster but also of a "pattern of neglect" in that they received proportionately less help than white, younger, and more educated victims.

Miller, Kristen S., and Catherine Simile 1992. "They could see stars from their beds": the plight of the rural poor in the aftermath of Hurricane Hugo. Paper presented at the Society for Applied Anthropology Annual Meetings, Memphis, Tennessee, March 1992.

This paper analyzes the impacts of Hugo on the housing situation of the rural poor of the Charleston area—an isolated, invisible population that rarely interfaces with outsiders. Three types of groups responded to their needs: church-based outreach programs, community service programs of businesses, and government programs. All three entities had both resources and personnel available to address the housing problems manifested by Hugo, but all were also limited to alleviating symptoms rather than finding solutions to long-term inadequacies in housing that were only exacerbated by the hurricane.

South Carolina Human Services Coordinating Council 1990. The State Human Services Agency Response to Hurricane Hugo. Columbia, S.C.: South Carolina Human Services Coordinating Council. 27 pp.

This is the report of a survey of the impact from Hugo on state human services agency operations, costs of the relief effort, barriers to restoring services, and recommendations for improving response in future disasters. Most agencies surveyed indicated that their liability insurance would cover most of the $5.1 million in damages. Some of the barriers impeding the relief effort were damage to facilities, power outages, lack of central authority and plans for coordination, stressed staff, and inconsistency of federal regulations for assistance. The report recommends better training on psychological trauma; a plan for specific staff assignments; a comprehensive public education and information dissemination network; and training of emergency personnel to assist clients with special needs, such as the elderly, disabled, and the homeless.

PSYCHOLOGICAL EFFECTS

Aptekar, Lewis 1991. *The Psychosocial Process of Adjusting to Natural Disasters*. 47 pp. Working Paper #70. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. $4.50.

> This paper examines how victims and relief workers in two communities, one hit by Hurricane Hugo and the other by the Loma Prieta earthquake, responded to the disasters. The author identifies four phases—altruism, denial, anger, and final resolution—of psychological recovery from disasters. The demographic and political components of the communities, the differences between the two types of disasters, and the relationship between the victims and relief workers are all discussed in terms of how they affected victims' responses. The author recommends role-playing techniques to train relief workers to recognize and properly deal with the stress, denial, anger, frustration, and sense of loss that disaster victims experience.

Austin, Linda S., M.D. 1991. In the wake of Hugo: the role of the psychiatrist. *Psychiatric Annals* 21(9):520-24.

> A community-based disaster like Hugo is a different sort of stress from the individually experienced traumas that psychiatrists are accustomed to treating. Because the damages and losses are so widespread and evident, the community will naturally and spontaneously engage in mass group therapy to heal the emotional trauma of a hurricane. The psychiatrist will be called upon to facilitate this process using large-group interventions and the media.

Belter, R. W., S. E. Dunn, and P. Jeney 1991. The psychological impact of Hurricane Hugo on children—a needs assessment. *Advances in Behaviour Research and Therapy* 13(3):155-61.

> The researchers collected data through questionnaires administered to both parents and children in three elementary schools in the Charleston area about five months after Hurricane Hugo. The parents' responses at all three schools clearly revealed that the material, financial, and emotional impact of the hurricane on the families was enormous. About 90% of the children could be classified as experiencing "severe psychic trauma," according to the responses to the children's questionnaire. In contrast, the parental reporting of the children's emotional symptoms indicated that only about 69% could be so classified. Parents and children's responses both revealed that the hurricane was sufficiently traumatic to cause the overwhelming majority of children to be significantly distressed even five months after the storm. However, the overall global adjustment of the children (ability to function smoothly in their daily lives) was not adversely affected.

Boore, Judith A., Gina Earle, and Lewis Aptekar 1990. *Psychological Effects of Disaster on Children and Their Families: Hurricane Hugo and the Loma Prieta Earthquake*. QR#40. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 37 pp. $3.75.

> This study explores the relationship between resiliency and the psychopathology or emotional reaction of children in two major natural disasters. One to four weeks after the disasters parents and children were evaluated using interviews and checklists. The research indicated

that factors such as family dynamics and parental emotional state are important indicators of a child's resiliency. The authors also noted that outside aid in the form of food, clothing, money, housing, and insurance seemed to have a substantial positive effect on the parents' and children's morale and behavior; likewise, the presence of enthusiastic volunteer labor appeared to lift victims out of their helplessness and depression.

Norris, Fran H., and Krzysztof Kaniasty 1992. Reliability of delayed self-reports in disaster research. *Journal of Traumatic Stress* (in press).

In studies of traumatic stress, researchers often find themselves asking questions about an event and its aftermath long after the crisis has passed. This study assessed the reliability of these delayed self-reports. In January 1991, 65 Charleston residents were interviewed by telephone about their experiences after Hurricane Hugo, which had occurred 16 months before. The interview included assessments of disaster related losses, preparedness, social support received from others, and social support provided to others. In October 1991 (25 months after the event), the same persons were reinterviewed and asked the same questions. For reports of losses and preparedness, the accuracy of the later reports showed remarkable stability over time. There was a tendency to remember more social support as time passed.

Shaw, Darlene L., Pat Jarrell, John Freedy, and Cheryl Bene 1991. *Psychological Sequela of Hurricane Hugo: An Application of the Conservation of Resources Model of Stress*. QR#45. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 36 pp. $3.75.

This study aimed to generate empirical data to evaluate the applicability of the "conservation of resources model," which measures how stress reactions occur. The model is based on the supposition that people strive to retain, protect, and build four types of resources: 1) objects (property, material belongings); 2) conditions (marriage, job roles); 3) personal characteristics (self-esteem, sense of control); and 4) energies (time, money). The results of a survey of 1,200 faculty and 250 students at the Medical University of South Carolina about eight weeks after Hugo revealed that, in general, a significant proportion of both faculty and students suffered loss of resources, psychological distress, and changes in their health habits after Hugo. For both groups, higher losses of resources resulted in greater distress.

Sullivan, M. A., C. F. Saylor, and K. Y. Foster 1991. Post-hurricane adjustment of preschoolers and their families. *Advances in Behaviour Research and Therapy* 13(3):163–71.

Through questionnaires distributed to parents of 632 children in three preschools, this study assessed parental reports of the children's reactions 6–8 weeks after Hurricane Hugo. Preschoolers displayed significant changes in their behavior after the hurricane, including increases in the number of problem behaviors exhibited, and in the severity of those behaviors. Most behaviors remained in the normal range, however. The increase in behavior problems was attributed in part to pre-disaster behavior problems, total stressors experienced, and the parents' level of stress.

DEATHS AND INJURIES

Centers for Disease Control 1989. Medical examiner/coroner reports of deaths associated with Hurricane Hugo—South Carolina. *Journal of the American Medical Association* 262(22):3111-12.

> This article provides information about the demographic characteristics, cause, and circumstances of each of the 35 hurricane-related deaths reported between September 21 and October 6, 1989 in 25 South Carolina counties. During the storm, 13 people were drowned or crushed by falling objects. After the storm, 22 people died in house fires, from electrocution, from being crushed by falling trees, or from stress-related heart attacks. One death was the result of a chainsaw injury sustained during the cleanup. The article also discusses the definition of "hurricane-related death" and how the information was gathered through medical examiner/coroner systems.

Centers for Disease Control 1989. Update: work-related electrocutions associated with Hurricane Hugo—Puerto Rico. *Journal of the American Medical Association* 262(20):2806.

> Five of the six Hugo-related electrocutions in Puerto Rico were work-related. They involved linemen, a tree trimmer, and a meter-reader—all with many years of experience. The article describes the circumstances of the accidents and the recommendations that were made to health departments and electric companies to avoid future occurrences.

Morbidity and Mortality Weekly Report 1989. Deaths associated with Hurricane Hugo—Puerto Rico. *Morbidity and Mortality Weekly Report* 38(39):680-82.

> Nine hurricane-related deaths were reported by the Medical Examiner in Puerto Rico between September 18 and September 29, 1989. Seven were electrocutions and two were drownings of persons who refused to be evacuated to safer locations.

Philen, Rossanne M., Debra L. Combs, Lynn Miller, Lee M. Sanderson, R. Gibson Parrish, and Roy Ing 1992. Hurricane Hugo-related deaths: South Carolina and Puerto Rico, 1989. *Disasters* 16(1):53-59.

> Medical examiners and coroners contacted for this study identified 44 hurricane-related deaths in Puerto Rico and South Carolina from the day before Hugo struck the area to 12 days afterward. Among the dead were 32 men and 12 women, ranging in age from 1 year old to 94. There were eight drownings, eight instances of death by blunt trauma (falling trees and parts of buildings), eleven electrocutions, nine deaths in house fires started by candles, one asphyxiation under an uprooted tree, one chain saw laceration, and six stress-related heart attacks. The article concludes with recommendations for emergency managers on how to avoid similar deaths in future hurricanes.

UTILITIES AND TRANSPORTATION SYSTEMS

Cook, Ronald A. 1991. Hurricane Hugo vs. critical lifelines. Pp. 71–78 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

> Except for storm surge damage on the barrier islands, the primary causes of lifeline damage during Hugo were wind and wind-blown debris, particularly falling trees. The loss of electrical supply due to downed lines caused problems with other lifelines that relied on electricity. In general, the providers of lifeline services were prepared to cope with the damage that was expected from Hugo, but the actual damages were far more severe than anticipated.

Morris, Gregory L., and J. Hari Krishna 1991. *Hurricane Hugo and its Effects on Water Supplies in the U.S. Virgin Islands and Puerto Rico.* St. Thomas: University of the Virgin Islands, Water Resources Research Center.

> This paper documents the types of damages to water supply systems caused by Hugo. The principal supply problems were the loss of the electrical power needed to operate water supply infrastructure, damage to cistern systems and contamination of cistern water by wind-blown material, and damage to the electrical components of desalination systems by hurricane-driven rain and salt spray. Operational measures taken in the aftermath of the storm are detailed. Among the recommendations for mitigation are the use of underground power cables at least for essential services, the maintenance of redundant backup generators and similar equipment, and ensuring that cistern owners (residential cisterns are required by the Virgin Islands building code) take steps to protect their water supplies from contamination during a hurricane.

Nigg, Joanne M. 1990. Lifeline disruption in two communities: Charleston, South Carolina, Charlotte, North Carolina. Paper presented at the University of Puerto Rico Conference, Six Months After Hurricane Hugo, Mayaguez, Puerto Rico, March 12–14, 1990.

> This paper reports the preliminary results of a comparison of four lifeline systems (power, telephone, water, and sewage) in one inland and one coastal community in the aftermath of Hugo. Among the conclusions are that inland communities are less likely to take preparedness measures as a result of hurricane watches and warnings than coastal communities; few lifeline companies or agencies were prepared before Hugo for the possibility of a regional catastrophe; very little attempt is made to integrate representatives from lifeline organizations into the government's emergency response planning process; and the failure of the power system has direct effects on the ability of a community to begin recovering from a hurricane.

Peña, Hernan E., Jr. 1991. A post Hurricane Hugo transportation study. Pp. 230–37 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This article summarizes a study of the effects of Hurricane Hugo on Charleston's transportation infrastructure. The various transportation-related events of the storm are described, including the evacuation and recovery operations. Vehicle operating costs rose 35% in the aftermath of the hurricane, largely due to increased idling time and more stops and starts. The volume of traffic along selected arterials in Charleston increased by 20% immediately after the storm, and a 20% increase in accidents was found during the subsequent three months.

THE ECONOMY

Felts, Arthur A. 1990. The policy impacts of Hugo: the view from the lowcountry. *The South Carolina Forum* (April–June):32–33.

This brief article addresses some of the key local and state policies that were affected by Hugo's landfall in South Carolina. The biggest impact expected for 1990 was lost property taxes, because of the destruction and devaluation of a large amount of property throughout the state; the city of Charleston acted quickly to help compensate for this loss by increasing property taxes by 15% for one year. A local option sales tax was passed by the state legislature shortly after Hugo, allowing for a referendum on a local one-cent sales tax. The other principal policy issues center on coastal construction. The Beachfront Management Act was expected to receive serious challenge, and there was expected to be wide support for improved building codes and enforcement of them.

The Fontaine Company, Inc. 1991. An Analysis of the Damage and Effects of Hurricane Hugo and Status of Recovery One Year Later. Report prepared for the Governor's Office, Division of Intergovernmental Relations. Columbia, S.C.: The Fontaine Company, Inc. 200 pp.

This study analyzes the damage and effects of Hugo and the status of the recovery one year later in the 24 counties that had Presidential disaster declarations as a result of the storm. The work entailed collecting data and coordinating already-existing data, analyzing damages and recovery and economic forecasts of the area's economy with and without the storm, and making recommendations to facilitate economic recovery and development with regard to the economy itself, infrastructure, natural resources, housing, environment, and solid waste. Of the total $6.4 billion in physical damages in the state, it was calculated that all but $3 billion was "reimbursed" through insurance payments, public assistance, and salvage. Of the unreimbursed losses, about half was shouldered by residences, a problem that will affect the state's economy over the long run. The other half was accounted for by the forestry and agriculture sectors. Forestry was the big loser overall; of the estimated $1.2 billion in damages to timber, only about $150 million was recovered. Numerous recommendations are made for various sectors of the economy, including that long-term effects on the state's economy continue to be analyzed; that infrastructure within the disaster areas be monitored for long-term impacts; that state and local officials initiate a wildlife census in the disaster

counties; and that the state make local participation in state-funded projects contingent upon local passage of minimum building codes, particularly for manufactured housing.

Lord, J. Dennis, and Lee W. McConnell 1991. Property damage and retail sales impacts of Hurricane Hugo. *Area* 23.3:229-37.

The researchers tracked the sales of a do-it-yourself retail chain with stores both inside and outside the storm corridor and compared 1989 sales with those for the same months of the previous year. They also examined the geographic pattern of disaster aid paid by the Federal Emergency Management Agency to state and local agencies across the Carolinas. Both sets of data illustrated the path and relative intensity of the hurricane, with high per capita damage payments in the three Charleston area counties, a decline in damage payments inland, and a decrease on either side of the path of the storm's eye; damage extended much farther east of the path of the eye than to the west of it. Stores along the path of the eye experienced the largest increases in sales (some coastal stores had 200% or more increases for October and November after the storm) with the magnitude of the increases declining inland.

IMPACTS ON NATURAL SYSTEMS

Bush, David M. 1991. Impact of Hurricane Hugo on the rocky coast of Puerto Rico. *Journal of Coastal Research* SI(8):49–67.

> In contrast to the entirely sandy and gently sloping coast of South Carolina, Puerto Rico's coastline is a series of sandy stretches separated by rocky stretches or headlands, with coastal lowlands that are narrow and relatively steep. Because Hugo was about the same intensity when it made landfall at both locations, a comparison of the response of both coastal types can be made. Intense damage in Puerto Rico was largely restricted to sand overwash, wave damage to structures on sandy beaches, and wave damage to structures at low elevations on rocky stretches of the coast. The steepness of the coastal areas limited the extent of inland penetration of the surge, and the rocky portions of the coast provided armoring and elevation. Poor construction and overcrowding of the coastal lowlands increased damage by putting large numbers of poorly built structures at risk.

Cely, John Emmett 1991. Wildlife effects of Hurricane Hugo. *Journal of Coastal Research* SI(8):319–26.

> Before extensive human settlement, hurricanes probably had only localized effects on wildlife populations. It is apparent from Hugo that, because the modern landscape consists only of isolated and fragmented pockets of wildlife habitat, unique, rare, and endangered species are at increasing risk from natural disasters. This study concluded that Hugo's dramatic alterations to coastal and forested habitats will be its primary effects on South Carolina wildlife. Much of the damaged habitat will require decades to recover, slowing repopulation by some species, especially gray squirrels and songbirds.

Gardner, L. R., W. K. Michener, B. Kjerfve, and D. A. Karinshak 1991. The geomorphic effects of Hurricane Hugo on an undeveloped coastal landscape at North Inlet, South Carolina. *Journal of Coastal Research* SI(8):181–86.

> In spite of its intensity, Hurricane Hugo had only a modest impact on the geomorphology of the undeveloped coastal landscape at North Inlet, South Carolina. Pre- and post-Hugo aerial photographs showed no change in the salt marsh creek network or the size or shape of sand bars. The changes were limited to the creation of several new, small washover fans around the inlet. The absence of significant impacts was probably due to the storm's perpendicular approach, the relatively light precipitation, and the fact that natural barrier systems are meant to cope with the wind and wave forces associated with severe storms.

Janiskee, Robert L. 1990. "Storm of the century": Hurricane Hugo and its impact on South Carolina. *Southeastern Geographer* 30(1):63-67.

> Hurricane Hugo's impacts on tourism, forestry, wildlife, and coastal resources management in South Carolina will be long term. This article summarizes damages and projects the impacts of Hugo on the state's economy, lumbering, agriculture, endangered species, fishing industry, and beachfront development. It concludes that the test of South Carolina's relatively new Beachfront Management Act posed by Hugo's destruction may be the most telling and far-reaching of Hugo's impacts.

Knott, David M., and Robert M. Martore 1991. The short-term effects of Hurricane Hugo on fishes and decapod crustaceans in the Ashley River and adjacent marsh creeks, South Carolina. *Journal of Coastal Research* SI(8):335-56.

> Trawl sampling in the Ashley River and lower Charleston Harbor after Hugo revealed that hurricane damage to the nektonic communities of the river channels and marsh creeks was severe and immediate, but short-lived. Hypoxia and salinity reduction resulted in extensive mortality along distinct geographic gradients, with the greatest impacts upstream. Organisms that did not succumb to the initial oxygen depletion migrated downstream. The most severely affected areas were repopulated within two months.

Marsh, Christopher P., and Philip M. Wilkinson 1991. The impact of Hurricane Hugo on coastal bird populations. *Journal of Coastal Research* SI(8):327-34.

> Large numbers of birds apparently were killed during Hugo, but this did not appear to reduce local shorebird populations drastically. The hurricane's impact may have been much greater on weaker flying species. The most obvious effect on local birds was the alteration of habitat. Three important nesting islands were seriously eroded.

Nelson, Douglas D. 1989. Factors effecting beach morphology changes caused by Hurricane Hugo, northern South Carolina. Unpublished paper. 45 pp. Copies available from author, Center for Marine and Wetlands Studies, Coastal Carolina College, P.O. Box 1954, Conway, SC 29526, (803) 347-3161.

> Hurricane Hugo caused beach erosion of two distinct styles within the area studied. The fine sand beaches of North Myrtle Beach did not change slope as a result of the storm, but eroded downward uniformly along the entire profile. Coarser sand beaches showed a decrease in beach slope and more washover deposition of sand. During the hurricane, littoral transport energy apparently overpowered the deleterious effects of seawalls and positive effects of local sources of sand. Erosion moved the high tide line an average of 10.4 meters landward. However, localized accretion also occurred near the inlets. Pre-hurricane beach surveys revealed that long wavelength waves generated by the approaching storm facilitated berm sedimentation and beach accretion throughout the study area for several days before the hurricane made landfall.

Remion, Michael C. 1990. Assessment of Hurricane Hugo damage on state and private lands in South Carolina. Pp. 41–47 in J. D. Greer, ed., *Third Biennial Conference on Remote Sensing Applications*. Bethesda, Md.: American Society of Photogrammetry and Remote Sensing. 488 pp. Reprints available from author, South Carolina Forestry Commission, P.O. Box 21707, 5500 Broad River Rd., Columbia, SC 29221.

> Over 18,000 miles of roads and highways were blocked by downed timber in South Carolina as a result of Hurricane Hugo, and the amount of timber destroyed was enough to build 660,000 new homes. A forest disaster was officially declared in the state. Besides the need for massive reforestation (1.3 million acres were totally destroyed), foresters must plan for invasions of damaged timber by insects and disease-causing organisms and for forest fires. Infrared aerial photography has been invaluable in helping private landowners, forest managers, and public agencies assess, analyze, and cope with various aspects of the hurricane's impact.

Shelfer, Richard B. 1990. Hurricane Hugo damage on the Francis-Marion National Forest. Pp. 33–40 in J. D. Greer, ed., *Third Biennial Conference on Remote Sensing Applications*. Bethesda, Md.: American Society of Photogrammetry and Remote Sensing. 488 pp. Reprints available from author, U.S. Forest Service, Francis-Marion Sumter National Forest, R8, 1835 Assembly St., Room 333, P.O. Box 2227, Columbia, SC 29202.

> Hugo caused more damage to the Francis-Marion National Forest in South Carolina than has ever been experienced by any forest in the nation's system. This paper documents some of the events that occurred during the storm, and describes plans for the forest's recovery. Remote sensing techniques and a geographic information system have been useful to the U.S. Forest Service in assessing the storm's impacts and setting priorities for future work. The post-Hugo status of the forest is compared to its cut-over, altered condition when it entered the national forest system in the 1930s. An interesting result of the storm is that, now that the forest canopy has been removed, evidence of previous land uses in the form of rice dikes, fence rows, and shell mounds is now visible in air photos.

Stauble, D. K., W. C. Eiser, W. A. Birkemeier, L. Z. Hales, and W. C. Seabergh 1990. Erosion characteristics of Hurricane Hugo on the beaches of South Carolina. *Shore and Beach* 58(4):23–36.

> Hurricane Hugo caused severe erosion of the beach and dune system along over 150 miles of the North and South Carolina coasts. Much of the protective dune disintegrated and several breaches in narrow barrier islands occurred as overwash inundated the low coastal areas. The mostly flat, fine-grained beaches were eroded down to old marsh surfaces in many locations. Many of the coastal protection structures were completely destroyed because they were not designed to withstand such an extreme event, especially smaller wood and concrete seawalls and stone revetments. Most inlet jetties were damaged at their seaward ends but maintained structural integrity.

Stauble, Donald K., William C. Seabergh, and Lyndell Z. Hales 1990. The initial impact of Hurricane Hugo on the beaches, dunes and inlets of South Carolina. Pp. 362–77 in Lawrence S. Tait, comp., *Beaches—Lessons of Hurricane Hugo, Proceedings of the 1990 National Conference on Beach Preservation Technology*. Tallahassee, Fla.: Florida Shore & Beach Preservation Association. Reprints available from authors, U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

> Hurricane Hugo made a lasting impact on a 140-mile stretch of the South Carolina coastal mainland, barrier island beaches, dunes, and coastal community infrastructure. Almost the entire primary dune line was eroded to base level. There was less damage to upland structures in the few areas where the dune survived. Beaches along the entire area suffered erosion of the subaerial beach. Eroded material was transported inland as overwash, offshore into a storm bar, and alongshore. Several breaches were cut across narrow sections of barrier islands and spits in the lower Grand Strand and Cape Romain areas. Within one week after the hurricane, sand was beginning to return to the lower foreshore, particularly along beaches that had been recently nourished.

Stauble, Donald K., William C. Seabergh, and Lyndell Z. Hales 1991. Effects of Hurricane Hugo on the South Carolina coast. *Journal of Coastal Research* SI(8):129–62.

> The combination of wind, waves, and surge from Hugo resulted in beach and dune erosion along a large portion of the central and northern coastal segments of South Carolina, including a wide variety of coastal morphologic types. Most dunes were reduced to a flat surface, while others were severely eroded. Most shore protection structures were seriously damaged or destroyed—only the largest remained intact. With the loss of the dunes and the protective structures, damage to coastal buildings was severe. Low-lying areas were overwashed during the height of the storm, and water, sand, and debris were carried up to 600 feet inland, in some cases completely over narrow barrier islands and spits. Numerous breaches were formed, creating cuts and new inlets. Existing inlets and associated navigation structures received only minimal damage, but all ocean fishing piers were demolished.

Thieler, E. Robert, and Robert S. Young 1991. Quantitative evaluation of coastal geomorphological changes in South Carolina after Hurricane Hugo. *Journal of Coastal Research* SI(8):187–200.

> Pre- and post-storm aerial videotape surveys were made of 51 kilometers of the barrier island coast of South Carolina from Garden City to Folly Beach. As a result of Hugo, the geomorphological classification of the coast changed from mostly dune fields and dune ridges to washover sheets. The study's conclusions about the protective effects of dunes provide a basis for predicting damage in other developed coastal areas in future storms. Among the findings are that the minimum width required for a dune field to survive Hugo and thereby protect buildings (providing it was not submerged) was 30 meters; 50% of all buildings completely destroyed or removed from their foundations were fronted by a "deadly" combination of dry beaches less than 3 meters wide and dune fields less than 15 meters wide.

U.S. House of Representatives 1990. Effects of Hurricane Hugo on Forest Resources. Hearings before the Subcommittee on Forests, Family Farms, and Energy of the House Committee on Agriculture. U.S. House of Representatives, 101st Congress, 1st session. November 6, 1989, Moncks Corner, S.C.

This is the formal record of hearings to review the effects of Hugo on forest resources in the Southeast. Prepared statements and question-and-answer sessions are included from the more than 30 witnesses. The materials describe the experiences of people affected by the storm's impact on forests, their activities to cope with damages, and their plans for restoration. Opinions and position statements were submitted by state and federal foresters and rangers, lumber companies, salvage companies, soil and water conservation districts, politicians, the National Wildlife Federation, and private citizens.

IMPACTS ON STRUCTURES

Leatherman, Stephen P. 1990. Aftermath of Hurricane Hugo. Pp. 165–67 in National Research Council, *Managing Coastal Erosion*. Washington, D.C.: National Academy Press.

A comparison of heavy damage and destruction in the Folly Beach area and the less extensive damage at Isle of Palms illustrates the importance of building structures in harmony with the natural dynamics of the beach system. The author emphasizes the need for better data on long-term shoreline change, public acceptance of the relevance of this information, and the institutionalization of conformance standards for setbacks.

Levinson, Nancy 1990. The costliest hurricane. *Architectural Record* 178(February):144,48

The consensus of selected architects, engineers, and geologists who viewed damages in the Carolinas and the Caribbean was that Hurricane Hugo's damage to buildings was widespread, varied, and complex. Roofing suffered extensively from high winds. Numerous inferior construction practices—in noncompliance with applicable codes—were uncovered. Historic buildings, because they had hipped roofs, protective shutters over windows, raised first floors, and generally sturdier construction, performed well overall.

Manning, Billy R., and Gary G. Nichols 1991. Hugo—Lessons Learned. Pp. 186–94 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum*. New York: American Society of Civil Engineers.

This paper is based on ground and aerial surveys of Hugo's damage to structures along most of the South Carolina coast, parts of the North Carolina coast, and in various inland areas. With special emphasis on wind damages, the authors describe the storm's impact on three categories of structures: those that were fully engineered (high rises, hospitals, and public buildings), those that were marginally engineered (low-rise motels, apartments, and offices), and those that were not engineered (most residences and small commercial buildings). Among the recommendations are that local sign codes be upgraded to include wind load requirements that comply with the building code, that a rating system be developed to assess the effectiveness of local code enforcement, and that closer inspections be made during the installation of roof coverings.

Rodriguez, Leandro, Carlos I. Pesquera, and Ricardo Lopez 1991. Hugo's structural damage in Puerto Rico. Pp. 93-102 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Wind damage to wood structures, industrial steel buildings, multistory reinforced concrete buildings, and poles in Puerto was assessed shortly after Hugo hit the island. The study corroborates that sound design and correct construction yielded good structural performance. The main structural elements of structures behaved very well, while facades did not fare well at all. The study concludes that the existing code does not need to be extensively revised, but it does need to be carefully enforced. Unfortunately, much of the repair and reconstruction was carried out in accord with pre-storm practices.

Wang, Hsiang 1990. Water and erosion damage to coastal structures—South Carolina coast, Hurricane Hugo, 1989. *Shore and Beach* 58(4):37-47.

This article documents the unusually severe water and erosion damage inflicted by Hurricane Hugo on waterfront and near-waterfront properties along a 120-mile stretch from Seabrook Island to North Myrtle Beach. The amount of damage was attributed to the high level of the storm surge, the density of pre-code structures, and the high rate of chronic erosion along the barriers (about 6 feet/year). Assessments were made by visual inspection and interviews.

PERFORMANCE OF STRUCTURES

Baird, W. F., B. L. Edge, O. T. Magoon, and D. D. Treadwell 1990. Cyril E. King Airport runway extension and vicinity at St. Thomas, U.S. Virgin Islands, damage during Hurricane Hugo. *Shore and Beach* 56(4):64-71.

Among the structures damaged by Hurricane Hugo were the shoreline protection systems on and in the runway extension at a St. Thomas airport. The 2,350-foot extension was completed in 1983 and was protected with an unreinforced concrete dolos armoring system composed primarily of 10-ton units. The adjacent shoreline was protected with 4-6-ton quarried stones. The article contains the observations of the American Society of Civil Engineers Committee on Rubble Mound Structures of the damages after Hugo, summarizes and discusses wind and wave data, and gives possible scenarios by which the damage may have occurred. The primary unexpected damage was localized mass slumping of the dolos layer and some associated breakage of individual units. The quarry stones used for armoring the adjacent shoreline were of a size expected to be displaced by waves generated by Hugo, and such displacement did occur.

Consulting Engineers Partnership, Ltd. 1989. Hurricane Hugo in Montserrat: Reconnaissance Report on the Structural Damage. Report to the United Nations Development Programme. Available from Consulting Engineer Partnership, Ltd., P.O. Box 625C, Bridgetown, Barbados, WI, Attn.: Rolf Stephanson at UNDP.

This report of a reconnaissance team that visited Montserrat soon after Hurricane Hugo describes the damage sustained; assesses the extent to which building design, workmanship,

materials, and lack of maintenance contributed to the damage; offers advice on improving design and construction standards; and recommends procedures to be followed during the reconstruction period. Recommendations include 1) designing all buildings and structures in accord with the Caribbean Uniform Building Code, 2) designing all electricity and telephone poles to withstand hurricane force winds, with particular attention to topographic effects, 3) designing all communication masts to withstand wind forces appropriate to critical facilities, and 4) immediately instituting a formal education program for the construction sector.

Cook, Richard L., Jr. 1991. Lessons learned by a roof consultant. Pp. 144–52 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

It is estimated that over 80% of the losses caused by Hugo were related to roof failures and the associated water damage. This paper reviews the wind measurement techniques and wind design criteria that are applied to roofing systems, analyzes the performance during Hugo of several components of roof systems, describes the role of and problems faced by roofing specialists and contractors during the recovery period, and makes recommendations for learning some roofing lessons from Hugo.

Harris, Gill 1991. Lessons learned from Hugo about building design trends. Pp. 207–23 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

An investigation of 100 metal system buildings was made to evaluate their resistance to Hugo's winds. The performance of these buildings compared to that of older ones indicated that current standards, codes, and designs provide better resistance to wind loads. The author suggests using peak gust measurements instead of fastest-mile wind speeds.

Hogan, Mark, and Anthony K. Karwoski 1991. Masonry performance in the coastal zone. Pp. 195–206 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This article summarizes the findings of a survey of coastal construction from Charleston to Myrtle Beach immediately after Hugo. The performance of selected masonry structures and masonry components is documented. In general, the findings substantiate the efficacy of existing design and construction recommendations. Principal areas of future concern are the performance of low-rise unreinforced masonry structures with light and heavy roof systems, the performance of high-rise masonry under suction loads, and the performance of roofs and foundations in relation to lateral support of masonry walls.

McDonald, James R., and Thomas L. Smith 1990. *Performance of Roofing Systems in Hurricane Hugo.* Lubbock, Tex.: Texas Tech University Institute for Disaster Research. 42 pp.

This report documents the findings of a study team dispatched into the area stricken by Hurricane Hugo to investigate the performance of various roofing systems subjected to the storm's high winds. They concluded that the wind speeds over most of the inhabited areas of South Carolina were below design value; that structural damage from wind was minimal; and that roofing systems performed poorly. Most property damage was due to loss of roofing materials and subsequent damage to the interior from wind and water. The report discusses damages to different types of buildings and styles of architecture, various roofing materials, and methods of connection.

Miehe, Ben K. 1991. Architectural lessons learned from Hurricane Hugo. Pp. 153-59 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This paper is a series of observations about the performance during Hugo of buildings on the naval base and in the Charleston area, and about the process of rebuilding damaged structures. Some of the conclusions are that most homeowners are unaware of laws, codes, or standard building practices that ensure quality structures; that roof designs need to be checked to assure that all attachments and/or penetrations are specifically detailed; that the use of old-fashioned wooden shutters may be the most effective way to protect windows and structures; and that the use of multiple codes can prove confusing to designers and builders.

Murden, J. A. 1991. Hugo 1989—the performance of structures in the wind. Pp. 51-62 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Wind speeds during Hugo in most areas of the Carolinas were below the design levels specified in the local building codes. Much of the damage was the result of failure to incorporate existing knowledge of wind loads in the building codes. Cladding and roofing system failures were the most widespread and expensive problems, even on professionally designed structures. The potential remains high for widespread wind damage from future storms below the design level.

National Conference of States on Building Codes and Standards (NCSBCS) 1989. Preliminary Report—Disaster Site Investigation of Manufactured Homes. Report prepared for the U.S. Department of Housing and Urban Development Office of Manufactured Housing and Regulatory Functions, Manufactured Housing and Construction Division by the National Conference of States on Building Codes and Standards. Washington, D.C.: Department of Housing and Urban Development. Available from HUD, 451 Seventh St., S.W., Washington, D.C. 20410, (202) 708-1920.

Several weaknesses in manufactured homes were identified as a result of investigations conducted after four disasters, including Hurricane Hugo. Problems were found with the improper installation and failure of tie-downs; loss of siding because negative wind pressure

was not incorporated into the design; inadequate connections for metal roofs; and possible shortcomings in the design criteria for wind loading of structures in hurricane zones.

Rhodes, Perry E. 1990. Lessons from Hurricane Hugo on designing shore protection structures. Pp. 199–202 in Association of State Floodplain Managers, *Challenges Ahead: Flood Loss Reduction Strategies for the '90s, Proceedings of the Fourteenth Annual Conference*. SP#23. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. $10.00.

Most of the protective structures from Folly Beach to Myrtle Beach State Park were damaged or destroyed by Hurricane Hugo. This is not surprising because Hugo was at least a 100-year flood event and because most of the structures did not meet the Federal Emergency Management Agency's crediting criteria for base flood protection. Examination of the structures (or what was left of them) showed that their failure was usually due to inadequate toe protection, insufficient height and/or backfill protection, inadequate landward returns at the ends, and undersized structures. Recommendations are made for the improved design and use of such structures.

Rogers, Spencer M., Jr. 1990. *Foundations and Breakaway Walls of Small Coastal Buildings in Hurricane Hugo*. QR#37. 6 pp. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. $1.50.

This survey of small coastal buildings in North and South Carolina after the Hurricane Hugo disaster assessed the performance of elevated foundations, breakaway walls, and foundation cross bracing. Background information on the building techniques, observations from the survey, and summaries of the most reliable techniques are included. Adequately embedded piling foundations were found to be generally effective. Masonry and cast-in-place concrete foundations were revealed to have major construction flaws and experienced widespread failures. There was also widespread failure of elevated masonry foundations with shallow footings; these were found to be inappropriate for areas subject to coastal flooding. Modified construction practices are suggested.

Rogers, Spencer M., Jr., and Peter R. Sparks 1990. Damage to buildings. *Shore and Beach* 58(4):48–52.

Documents the performance of buildings under Hugo's wind speeds, wave impacts, and flooding. Hugo exceeded design conditions in very few places; most buildings experienced significantly less than design conditions. Therefore, much of the damage to new construction could have been prevented using available construction techniques and at a reasonable cost. Proper enforcement of adequate building codes is the key to avoiding extensive damage.

Rogers, Spencer M., Jr. 1991. Performance of building resistance to water, waves and erosion. Pp. 63–70 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum*. New York: American Society of Civil Engineers.

The water, wave, and erosion damage inflicted by Hugo on buildings throughout the low-lying coastal areas of the Carolinas was widespread and severe. Most of the damage to

buildings occurred not because Hugo substantially exceeded design conditions, but because the buildings were not constructed to tolerate any storm conditions at all. As expected, well-constructed buildings performed acceptably during Hugo as long as design conditions were not exceeded. The keys to preventing damage are 1) understanding the hazards likely for the location, 2) providing sufficient floor elevation to avoid the structure's getting wet or hit by a wave, 3) using piling foundations to resist waves (where appropriate), and 4) using adequately embedded pilings to avoid undermining by erosion.

Sparks, Peter R. 1990. The performance of structures in Hurricane Hugo 1989—the Carolinas. Paper presented at the 22nd Joint Meeting of the U.S.-Japan Cooperative Program on Wind and Seismic Effects, Washington, D.C. and Charleston, S.C., May 16-21, 1990. 22 pp. Reprints available from author, Department of Civil Engineering, Clemson University, Clemson, SC 29634-0911, (603) 656-0488.

The performance of structures subjected to high winds during Hurricane Hugo is assessed in this paper. In most locations wind speeds were less than the design levels specified by local building codes, but failure to incorporate modern wind loading principles and to enforce the codes resulted in extensive damage, especially in South Carolina. Most of the damage was in the form of roof and wall cladding failures, which led to rain damage to the interior of the structure. Wood-frame construction performed well in general, while unreinforced masonry buildings performed very poorly, even in sheltered locations. Recommendations are made for improving the wind resistance of future construction.

Sparks, Peter R. 1991. Wind conditions in Hurricane Hugo and their effect on buildings in coastal South Carolina. *Journal of Coastal Research* SI(8):13-24.

This article analyzes the wind conditions in the coastal zone of South Carolina during Hurricane Hugo. The effect of wind on buildings is discussed and the damage is surveyed. Wind damage was observed along the coast from 50 kilometers south of Charleston to 160 kilometers north. Damage ranged from loss of roof and wall coverings to complete structural collapse. Some buildings performed satisfactorily where the wind speed recurrence interval was nearly 100 years while others were damaged in locations where the recurrence interval was less than 20 years. Reasons for the poor performance of buildings included the use of an inappropriate building code, difficulties in enforcement, and an unusually long interval since the last major hurricane.

Taylor, Jon Guerry 1991. Hurricane Hugo's effect on marina structures. Pp. 79-92 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

The author visited about 25 marinas in South Carolina and Puerto Rico immediately after Hugo and during the rebuilding period to assess the impacts of the storm on those types of facilities. Floating docks, fixed piers, breakwaters, drystacks, retaining walls, and fishing piers of various ages were evaluated. Although the performance of marina structures in the

hurricane was site-specific within the storm's path, patterns of performance can be related to the design, construction, and materials utilized. These data are useful in contributing to the improvement of future facilities.

URS Consultants, Inc. 1991. Flood Damage Assessment Report: Surfside Beach to Folly Island, South Carolina, Hurricane Hugo, September 21-22, 1989. Volume I, Damage Assessment of Flooded Buildings, and Volume II, Survey Forms. Reports prepared for the Federal Emergency Management Agency by URS Consultants, Inc., Paramus, N.J..

This report documents, with numerous photographs, a systematic inspection of structures damaged during Hurricane Hugo in order to assess the performance of building standards and practices under varying flood characteristics. Among several specific conclusions are that properly elevated structures on adequately embedded and structurally sound members are the key to reduced damages; that non-breakaway walls broke away from sound structural members with damage to the main structure; and that technical guidance is needed for storm-resistant residential roofing practices.

CONSTRUCTION PRACTICES AND CODE ENFORCEMENT

All-Industry Research Advisory Council 1989. *Surviving the Storm—Building Codes, Compliance, and the Mitigation of Hurricane Damage*. Oak Brook, Ill.: All-Industry Research Advisory Council. 70 pp. Single copies are free from the Council, 1200 Harger Road, Suite 310, Oak Brook, IL 60521, (708) 572-1177.

This study reports on the increase in people and property at risk from hurricanes along the U.S. coast and reviews the evidence on how the strength of local building codes and the level of compliance with them have made a difference in the amount of damage sustained in recent hurricanes, including Hugo. The report analyzes the wide variations in building codes in effect along the Gulf and Atlantic coasts, and highlights states and organizations that have paid special attention to wind resistance requirements in building codes. The cost implications of constructing new homes with stronger wind resistance are detailed. Comments made by coastal building officials and inspectors about the challenges of improving enforcement are summarized.

Brooks, Christopher 1991. Hurricane Hugo and the South Carolina Coastal Council. Pp. 259-62 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum*. New York: American Society of Civil Engineers.

The South Carolina Coastal Council's hurricane disaster plan, which had been prepared in advance of Hugo, enabled that agency to respond to the governor's directive to get the coastal economy rolling as soon as possible after the storm and still administer the provisions of the state Beachfront Management Act. The agency implemented a streamlined permitting system, allowing repairs to proceed quickly; had protected most of its computer equipment and files; and had video and hardcopy documentation of pre-storm coastal conditions.

Coastal Hazards Advisory and Mitigation Project 1989. Recommendations for Rebuilding after Hurricane Hugo. 8 pp. Available from the Coastal Hazards Advisory and Mitigation Project, 110 Lowry Hall, Department of Civil Engineering, Clemson University, Clemson, SC 29634-0911, (803) 656-0488.

> Numerous relatively new buildings were demolished by Hugo's strong winds, indicating that community building codes are not adequate to withstand events of this magnitude. This short publication makes recommendations to legislators, building owners, architects, engineers, and building officials on ways to correct past mistakes and ensure that future structures are better able to withstand the high winds and storm surges of events like Hugo. It recommends that ANSI A58.1 be used as a guide to better structural design.

Curry, Bobby L. 1991. Structural engineering lessons learned from Hurricane Hugo. Pp. 139-43 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

> The majority of the damage to the U.S. Navy's structures at the Charleston naval station were caused by wind and water after the buildings were torn open by high winds. Government structures, both old and new, suffered considerable damage even though they were designed, constructed, and inspected under strict guidelines. However, most of the failures occurred because the design criteria were not properly addressed or enforced. The vast majority of the navy's structures sustained little, if any, structural damage. Hugo showed that structures built to present Navy Design Criteria, which use ANSI A58.1 criteria for wind, will withstand hurricane wind forces. More attention should be paid, however, to the choice and installation of cladding and cladding fasteners, particularly along roof edges, corners, and eaves, and at the ends of walls.

Deegan, Daniel E., and Wayne D. Lasch 1990. Analysis of coastal flood hazards following Hurricane Hugo. Pp. 354-61 in Lawrence S. Tait, comp., *Beaches—Lessons of Hurricane Hugo, Proceedings of the 1990 National Conference on Beach Preservation Technology.* Tallahassee, Fla.: Florida Shore & Beach Preservation Association. Reprints available from authors, Greenhorne & O'Mara, Inc., 9001 Edmonston Rd., Greenbelt, MD 20770, (301) 982-2800.

> A revised flood hazard analysis was performed for four localities in which Hurricane Hugo caused relatively large amounts of wave-associated damage to structures located in areas designated as zone A on FIRMs. The inclusion of wave set-up and more up-to-date beach profile data resulted in an average increase of 2-4 feet in BFEs along the open coast and an increase in the width of the V zone of from 100 to 1,000 feet. The study concludes that in general the methods now applied to evaluate coastal flood hazards are reasonable.

Mahoney, Michael 1990. The effects of coastal construction standards in reducing damages from Hurricane Hugo. Pp. 195-98 in Association of State Floodplain Managers, Inc., *Challenges Ahead, Flood Loss Reduction Strategies for the '90s, Proceedings of the Fourteenth Annual Conference.* SP#23. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. $10.00.

> Although there was considerable destruction in the wake of Hurricane Hugo, some structures survived with little damage. This paper discusses the role played by building regulations in

determining which buildings did not survive intact, namely those inadequately elevated, those with inadequate foundation embedment, improper use of foundation materials, overloaded foundations, or inadequate structural connections. Among other ideas, the author recommends more restrictive building requirements in areas subject to wave damage, a statewide building code, and more rigorous enforcement of codes.

Manning, Billy R. 1989. Surviving the storm: building codes, compliance and the mitigation of hurricane damage. Pp. 18-20 in National Committee on Property Insurance, *America's Imperiled Coastlines: A New Concern for the Property Insurance Industry*. Boston: National Committee on Property Insurance. Available from the National Committee on Property Insurance, Ten Winthrop Square, Boston, MA 02110, (617) 423-4620.

Buildings that were professionally designed and engineered came through Hurricane Hugo better than those without such attention. In fact, buildings that were designed and constructed in total accordance with current code provisions withstood the wind forces with minimal damage. Signs created many of the problems in the Charleston area by acting as missiles, damaging buildings and power and utility lines. A system is needed to evaluate and rate the effectiveness of local code enforcement, and wind and flood insurance premiums should then be based on that rating.

Miller, H. Crane 1990. Hurricane Hugo: Learning from South Carolina. A Report to the Office of Ocean and Coastal Resources Management, National Ocean Service, National Oceanic and Atmospheric Administration. Washington, D.C.: U.S. Department of Commerce. 41 pp.

The author analyzed 3,700 Hugo damage claims on policies written by the South Carolina Windstorm and Hail Underwriting Association, which revealed a wide spectrum of building and management practices in South Carolina from excellent to extremely poor. This report discusses the success or failure of hurricane-resistant building design and construction practices, traces the development of building codes in the state, and examines how homeowner's, flood, and wind insurance acted as mitigating agents for disaster recovery. Appendices present damage data for much of the state's coastal zone and a synopsis of construction code legislation. The author observes that neither lending institutions nor property and casualty insurance companies exert their considerable leverage over the real estate market to ensure that migitative measures are implemented to reduce wind damage.

Mittler, Elliott 1991. *Building Code Enforcement Following Hurricane Hugo in South Carolina*. QR#44. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 11 pp. $1.75.

This project investigated how building codes were enforced in the city of Charleston and neighboring South Carolina cities and counties during the initial recovery period after Hurricane Hugo. Most local governments did not have adequate resources to deal with such widespread damage through the normal building review process and had to make choices about which buildings required inspection; no community attempted to enforce the building code on all structures damaged by the hurricane. In many cases, permit fees were waived or reduced to enable homeowners to more easily repair their structures. At the same time,

local officials were careful to enforce the guidelines of the Federal Insurance Administration—especially elevation standards—for repairing and rebuilding damaged structures.

Mittler, Elliott 1991. The plight of state legislation mandating building codes in South Carolina. Pp. 263–77 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Since 1968, counties in South Carolina have exercised their individual options to adopt and enforce building codes, and at the time of Hugo, only 17 of the 46 counties in the state had chosen to adopt codes. Legislation to establish a statewide building code was introduced in the 1989 legislative session as a result of concern by building officials, civil engineers, and others that the health and safety of the state's citizens were being jeopardized by the lack of mandatory standards. The bill did not reach the floor of either the house or the senate in that session. This paper summarizes the bill's progress in the state legislature before and after Hurricane Hugo.

Saffir, Herbert S. 1991. Hurricane Hugo and implications for design professionals and code-writing authorities. *Journal of Coastal Research* SI(8):25–32.

Throughout the Caribbean and the Carolinas Hugo inflicted damage to structures that could have been avoided by adherence to existing design and construction guidelines. The author explains various modes of building damage and how they could have been avoided. Florida's coastal building provisions are used as an example of proper accounting for the inevitable force of hurricanes.

Sparks, Peter R. no date. Damages and Lessons Learned from Hurricane Hugo. Unpublished paper. 16 pp. Available from author, Department of Civil Engineering, Clemson University, Clemson, SC 29634-0911.

This paper reviews the wind and storm surge conditions during Hurricane Hugo and discusses their relationship to the extent and nature of damages. In general, building damage was related to local construction practices rather than to the relative severity of the storm. The disruption of the electrical supply is contrasted with the much better performance of the telephone system. The paper concludes that the extensive damage resulted in general not from unprecedented storm conditions but from the failure to use available knowledge in the selection of building and utility systems.

Sparks, Peter R. 1991. Development of the South Carolina coast 1959–1989: prelude to a disaster. Pp. 1–7 in Benjamin L. Sill and Peter R. Sparks, eds., *Hugo One Year Later, a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Although reasonable design standards for wind and storm surge conditions could have been established before the intensive development, control of construction along the South Carolina coast over the last 30 years was left in the hands of local jurisdictions, resulting in considerable variation in the quality of control, including no control at all. The result of this

has been shortcomings in the building code, enforcement problems, and actions by the construction industry, lenders, insurers, and homeowners to produce buildings inadequately resistant to hurricanes, as demonstrated by Hugo.

Sparks, P. R. 1990. The Risk of Hurricane Wind Damage to Buildings in South Carolina: A White Paper. Charleston, S.C.: South Carolina Sea Grant Consortium. 19 pp. Available from South Carolina Sea Grant Consortium, 287 Meeting St., Charleston, SC 29401.

Written a year before Hurricane Hugo, this paper, issued after the hurricane with minor changes, provides a painful demonstration of the accuracy of many points made about the inadequacy of the state's hurricane mitigation measures. Comments are offered on the accuracy of design wind speeds, building codes and their enforcement, the evolution of building design standards in South Carolina, and ways to improve building design and construction standards in the state. The author contends that mandatory implementation of ANSI A58.1 would drastically improve the capability of buildings to withstand hurricane winds; that the construction industry influences building code policies too much; that enforcement is almost as important as the adoption of stringent standards; and that the state has an inventory of buildings along its coast that its decentralized laissez-faire system of building control deserves.

INSURANCE

Berry, Skip 1989. The CAT teams. *Insurance Review* 50(12):20-24.

> In the wake of Hurricane Hugo and the San Francisco earthquake, platoons of experienced insurance adjusters were deployed from around the country to settle claims and advise disaster victims. This article describes briefly some of the preparations made for the teams in anticipation of Hurricane Hugo's landfall and the operational difficulties some of them overcame.

Coughlin, H. Joseph, Jr. 1990. Hurricane Hugo and federal flood insurance. *Common Ground* 1990 (March/April):9-10.

> Insured losses to condominiums during Hugo were only a small part of the total number of losses, primarily because such multi-family structures are typically constructed to newer, stricter building regulations and are generally in compliance with them. This article, directed to associations of condominium owners, describes the National Flood Insurance Program, the construction standards that reduce flood damage in multi-family structures, and the value—both to the insureds and the general public—of full flood insurance coverage.

Flood Insurance Producers National Committee 1990. Notes on a hurricane. *Flood Insurance Producers National Committee Bulletin* IV(1):1-3.

> A Florida insurance agent provided onsite assistance to another agency in the Charleston area soon after Hugo's impact. His observations include the disorganization evident everywhere, the widespread destruction and accompanying claims for losses, the apparent lack of planning for such a contingency on the part of the agency, the ignorance on the part of employees about basic crucial information such as whether or not a policy covered debris removal of trees, and the problems with using out-of-town adjusters. Recommendations are made for insurance agencies and companies to avoid repeating mistakes made during Hugo.

Friedman, D. G. 1989. Is Hugo a forerunner of future great hurricanes? Paper presented at the National Committee on Property Insurance Annual Forum, December 13, 1989. 81 pp. Available from National Committee on Property Insurance, Ten Winthrop Square, Boston, MA 02110, (617) 423-4620.

> There is speculation among climate scientists that adverse impacts from anticipated global warming could encourage the formation of powerful "super hurricanes." It is also claimed that the appearance of these storms could begin during a transitional climate phase (1990-2010), as global warming starts to accelerate. This paper attempts to quantify these

shorter-term effects, utilizing presently available information that is consistent with the current state of knowledge about regional storm characteristics (frequency, severity, location); their natural disaster production characteristics during the present climatic regime; and likely effects of a global atmospheric warming on these storms and their catastrophe-producing potentials. Results of the analysis suggest that the overall damage-producing potential of winter storms could decrease during the period of climatic transition. For severe local storms, it would increase slightly. For hurricanes, the increase in damage potential could be substantial. The estimated effect of various degrees of warming is expressed in three scenarios, and a new coding system, called the catastrophe index, is introduced to define the damage-producing potential for each.

Journal of American Insurance 1990. What Hugo taught us. *Journal of American Insurance* 66(Winter):1-13.

Hugo's impact rejuvenated the property/casualty insurance industry's catastrophe programs, reaffirming some successful approaches and redirecting others that did not work as well. This article describes the insurance industry's response to Hugo, from an analysis of the rationale for the "surplus" catastrophe funds to individual agents' heroic actions in the aftermath of the storm. Reminders of key aspects of pre-disaster planning for both agents and policyholders are given, clarifications of distinctions between federal flood insurance and coverage of homeowner insurance are provided, and checklists itemize safe construction techniques and disaster claim procedures.

Watermark 1990. Storm shatters NFIP records for number of claims, payouts. *Watermark* 1990(Fall):1-2.

In addition to the sheer volume of damage claims after Hugo, the National Flood Insurance Program faced other obstacles, including the inaccessibility to adjusters of many damaged properties and the uncertainty among the public, the media, and some officials about what kinds of damages were covered by what kinds of policies. The new "claims coordinating office," which assigned claims for both wind and flood damage to one adjuster, helped relieve the latter difficulty. The disaster also demonstrated an advantage of the NFIP's "write your own" program (under which flood insurance policies are written by private insurers): the private companies were able to draw on their own resources to provide the over 6,000 adjusters needed in the areas hit by the storm—a number that a purely governmental insurance program would not likely have been able to produce.

EMERGENCY MANAGEMENT

PREPAREDNESS

Powicki, Christopher R. 1990. The calm before the storm: a hurricane preparedness plan. *Operations Forum* (March):24–29.

A comprehensive emergency preparedness plan at the Plum Island Wastewater Treatment Plant at Charleston Harbor minimized damages and allowed operations to resume soon after Hugo devastated the area. This article clearly summarizes the steps taken by the plant's managers and personnel from the first hurricane watch to the critique of their performance a month after the storm passed. An interesting description of the state's procedure for testing water for contamination after Hugo is included.

United Nations 1991. Hugo: a case study. *UN Chronicle* 28(2):50–51.

The cyclical nature of hurricanes, volcanic eruptions, and other natural disasters in the Caribbean, coupled with the relative isolation of the various islands, has made it essential for planners to view disaster preparedness there as part of economic development and environmental assessment. The Pan Caribbean Disaster Prevention and Preparedness Project, managed by the United Nations Disaster Relief Organization, has worked to help develop local capabilities to prepare for disasters. This article highlights the Project's successes in the aftermath of Hugo.

Forecasting and Warning

McKinney, Stan M. 1991. Preparations for the storm. Pp. 8–10 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This short article, compiled by the Division of Public Safety Programs of the South Carolina Governor's Office, lists chronologically the steps taken by the State Emergency Preparedness Division as Hugo approached the mainland. The emphasis is on use of the forecasts and computer models, the process of deciding whether and when to order evacuation of certain areas, and mobilizing the various local emergency response units.

Sparks, Peter R. 1990. Wind speeds in the Carolinas during Hurricane Hugo. *The Wind Engineer* 4(2):1,8.

> The experience in Hugo is a clear example of the problem of recording and reporting wind data in the United States. In South Carolina there was an area of over 7,000 square miles in which the winds were almost certainly gusting to over 100 mph but within which there was not one reporting station. Many official anemometers throughout the Hugo impact area were improperly sited, either in height above the ground or in relation to adjacent objects, such as buildings or forests. These deficiencies posed significant problems to forecasters of the National Weather Service who were attempting to obtain information during the storm. A properly located and calibrated grid of anemometers, adhering to an already-established international format, would greatly assist both the meteorologist and the wind engineer.

U.S. Department of Commerce 1990. *Hurricane Hugo, September 10–22, 1989: Natural Disaster Survey Report*. Silver Spring, Md.: National Oceanic and Atmospheric Administration, National Weather Service. 71 pp.

> Compiled by a post-disaster survey team, this report chronicles the storm's course, presents pertinent meteorological information, summarizes preparedness actions and National Weather Service (NWS) warning services, evaluates the interpretation and dissemination of NWS information, and discusses public response to the storm and the benefits of NWS services. Findings and recommendations include 1) a comprehensive evacuation study has not been undertaken for Puerto Rico and the Virgin Islands; 2) in its advisories, the National Hurricane Center did not sufficiently emphasize the impacts that inland high winds might have for the Carolinas; 3) construction of future NWS offices in hurricane-prone areas should have hardened hurricane-proof areas that can preserve foodstuffs, provide temporary sleeping quarters, and include minimal personal hygiene facilities; 4) the public continues to receive most of its warning information from the media; and 5) in both the Caribbean and the Carolinas, emergency managers coordinated frequently with their local NWS offices.

Evacuation

Baker, Earl J. 1990. *Evacuation Decision Making and Public Response in Hurricane Hugo in South Carolina*. QR#9. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 16 pp. $2.00.

> The effective evacuation of South Carolina's residents during Hurricane Hugo can be attributed to up-to-date weather information and timely decisions by public officials. This paper evaluates various evacuation study tools (surge maps, clearance times, and decision aids); public response to evacuation; and evacuation rates, timings, and destinations. Inundation maps and evacuation clearance time calculations produced in pre-storm studies proved useful and generally accurate. It is noted that, in many areas, evacuation was not as complete as is widely believed.

Federal Emergency Management Agency and the U.S. Army Corps of Engineers 1990. *Hurricane Hugo Assessment: Review of Hurricane Evacuation Studies Utilization and Information Dissemination*. Prepared for the U.S. Army Corps of Engineers South Atlantic Division and the Federal Emergency Management Agency Region IV by Post Buckley, Schuh and Jernigan, Inc., Tallahassee, Florida. Copies are available from FEMA Region IV, 1371 Peachtree St., Atlanta, GA 30309, (404) 853-4302.

> Before Hurricane Hugo, comprehensive hurricane evacuation studies—jointly funded by the Federal Emergency Management Agency, the Corps of Engineers, the state governments, the National Weather Service, and the South Carolina Coastal Council—had been completed for North and South Carolina, and a study for Georgia was almost done. This report evaluates whether these studies were being used by local and state officials, whether the data from the studies were reliable, and which study products were the most useful to officials. The report covers hazards, vulnerability data, behavioral characteristics of evacuees, shelters, transportation and clearance time data, evacuation decision making, and public information. Findings suggest that 1) more than half the evacuees from all areas went to the homes of friends or relatives; 2) very few evacuees went to public shelters; 3) roughly a fifth reached their destinations in less than 30 minutes; 4) very few respondents interpreted the evacuation notices as being mandatory; and 5) over 90% of respondents felt that officials had handled the evacuation well.

Sexton, M. C. 1990. Hurricane Hugo: evacuation and repair. Pp. 355-58 in *Compendium of Technical Papers: Institute of Transportation Engineers 60th Annual Meeting*. Washington, D.C.: ITE. 470 pp. Reprints available from author, Wilbur Smith & Associates, Analytical Laboratory, Bankers Trust Tower, P.O. Box 92, Columbia, SC 29201, (803) 738-0580.

> The minimal loss of life in South Carolina during Hurricane Hugo can be attributed to the evacuation before landfall of most of the population at risk. This article analyzes the evacuation process, detailing the density of automobile traffic in the hours preceding the storm; damage to highways, roads, signalling equipment, and signs; and the impacts of power outages on traffic management. Recommendations are given for minimizing the impacts of a future hurricane on local and regional transportation systems.

RESPONSE

Badolato, Edward V. 1990. *Hurricane Hugo: Lessons Learned in Energy Emergency Preparedness*. Clemson, S.C.: Clemson University, Strom Thurmond Institute of Government and Public Affairs. $8.50.

> The report discusses the problems caused when Hugo knocked out electrical power in widespread areas for extended periods, including the effects of the prolonged disruption on community health, safety, commerce, industry, and recovery efforts. The author recommends that emergency planners prepare for the worst; coordinate their responses with federal, state, and industry responders; establish and sustain pre-emergency planning; create an energy emergency preparedness group to work at the state and local levels; familiarize themselves with the role of the military; and better utilize their communications systems.

Berke, Philip, and Dennis Wenger 1991. *Montserrat: Emergency Planning, Response and Recovery Related to Hurricane Hugo*. College Station, Tex.: Texas A&M University, Hazard Reduction Recovery Center. 84 pp.

This is the report of an investigation of the emergency planning, response, and long-term recovery activities carried out by government and nongovernmental organizations as they coped with Hugo's impact on Montserrat. The authors analyzed the island's disaster plans, communication systems, organization, budgetary status, and health care systems to determine what factors contributed to or detracted from effective response and recovery from the hurricane. Specific disaster response activities, such as provision of shelter, damage assessment, distribution of aid, handling of the dead, and emergency medicine are also discussed. Among the recommendations are that the National Disaster Plan be updated based on the Hugo experience, that the roles of government agencies be more clearly spelled out, and that training and public education be enhanced.

Brooks, Jim 1990. Lessons from Hugo: San Juan mayor writes a booklet. *Nation's Cities Weekly* 13(January 15):4.

Although Hugo left San Juan, Puerto Rico, with 4,000 refugees in 32 emergency shelters, not one life was lost. The city's mayor headed the crisis management team, and summarized the lessons he learned, foremost of which was that a written emergency plan cannot anticipate every variable and that common sense and personal leadership are invaluable. Other lessons include that any emergency plan must be tested periodically; onsite quarters should be provided for key employees; the lines of communication and chain of command should be kept clear; communication with the public should be carried out through the mass media; and as recovery begins, key symbolic events, such as summer festivals or the opening of public schools, should be held on schedule.

Drabek, Thomas E. 1991. Microcomputers and disaster responses. *Disasters* 15(2):186–92.

Microcomputers have transformed the operations of many private-sector and governmental organizations. This article surveys the use of microcomputers in the disaster preparedness and response activities of 11 state and local agencies involved in two floods, two hurricanes (including Hugo), a fire and toxic chemical threat, and a nuclear power plant exercise. Specific examples are given of shortcomings in the use of the computers and associated software, in improvisational use of the technology, and in the unexpected impacts the computers had on other aspects of the organization's response. The author concludes that computer technology has improved the ability of the organizations to coordinate the complex systems involved in a disaster, that some agencies were further along in the effective use of their computers than others, and that most agencies have not really come to grips with the subtle ways in which the computer has and will continue to affect their procedures and policies.

Griswold, J. S., T. L. Lightle, and J. G. Lovelady 1990. Hurricane Hugo: effect on state government communications. *IEEE Communications* 28(6):12-17.

> The state of South Carolina is the largest user and fourth-largest provider of telecommunications services in South Carolina, with about 50,000 lines. Although the state system did enable critical communication between Charleston and the capitol in Columbia to be maintained during Hurricane Hugo, there were some deficiencies, including tremendous competition for local and long distance access and loss of power and lack of backup generators in the days soon after the storm. The State Division of Information Resource Management (DIRM) began emergency preparedness activities in the week before Hurricane Hugo, firming up contacts with private companies supporting the network, protecting equipment, and gathering repair supplies. As a result of the storm, the state is developing an emergency disaster recovery communication network that includes several layers of communications, diverse facilities, alternate communications devices, and infrastructure protection to ensure that the network functions during a disaster. South Carolina is also one of the states selected for development and implementation of the National Communications System/Telecommunications Services Priority model plan for emergency restoration of telecommunication services, administered by the National Communications System for the Federal Communications Commission.

Hudak, Mary 1991. Lessons learned by the federal government. Pp. 251-53 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

> The scope and intensity of Hugo's impact occasioned many unprecedented situations that had to be resolved by the Federal Emergency Management Agency in its attempts to provide assistance to state and local governments both before and after the storm. The agency learned many "lessons" about its response organization and structure, staffing levels, management of donations, and operational details, among others. This short article details a few of the more generally applicable discoveries.

Jesitus, John 1990. Still standing: South Carolina duo shares hard lessons. *Communications News* 27(April):30.

> The Charleston County, South Carolina, telecommunications manager and assistant manager spent 48 hours preparing for Hugo, and rapidly rounded up additional vital telephone lines and mobile radios in the days after the storm. The county's long-term relationship with Southern Bell and Motorola speeded acquisition of extra phone lines and mobile radios. The local Motorola supplier worked all night to get the mobile radio system up and running, which was crucial to the cleanup effort after the hurricane. Thirty cellular phones and 50 additional pagers were also provided by vendors. The Hugo experience has helped Charleston County plan its new disaster-preparedness facility.

Lindbergh, Charles 1991. Inspection of damaged buildings. Pp. 121–28 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

Volunteer engineers and architects helped expedite South Carolina's recovery from Hugo. They augmented state and local government organizations, assessed damage to public facilities, and provided contingency engineering and construction repair services to municipalities. The paper reviews the initiation, continued development, and utilization of the group, Volunteer Technical Assistance Group (VOLTAG). It concludes by recommending the institutionalization of such groups to assist during future disasters.

Morbidity and Mortality Weekly Report 1990. Surveillance of shelters after Hurricane Hugo—Puerto Rico. *Morbidity and Mortality Weekly Report* 39(3):41–43.

Even though 10,300 evacuees were housed in 161 temporary public shelters in Puerto Rico from about September 25 to October 3, 1989, surveillance by the Puerto Rico Department of Health detected no serious disease outbreaks or other public health problems in the shelters. Only a few minor health problems were identified. The article describes how the Health Department surveyed the shelters and recommends such action by other public agencies in similar situations.

Moss, Bill 1989. A post-Hugo evaluation. *Public Management* 71(12):15–17.

When Hurricane Hugo struck the South Carolina coast, the city of Myrtle Beach had just finished revising its disaster preparedness plan. This enabled the local government to respond swiftly and decisively to the disaster. Among other details, the article describes the usefulness of having city employees be prepared to stay at work for up to three days, some communications successes and failures, and some early-recovery problems.

Pan Caribbean Disaster Preparedness and Prevention Project 1989. *Case Report: Hurricane Hugo, September 1989, Caribbean.* Publication no. 89/21. Available from the Office of the United Nations Disaster Relief Coordinator, Palais des Nations, CH-1211, Geneva 10, Switzerland.

Hugo caused $365 million in damages on Dominica, Montserrat, Antigua/Barbuda, the British Virgin Islands, and St. Kitts/Nevis. Overall coordination of the response and relief operations was provided by the Pan Caribbean Disaster Preparedness and Prevention Project (PCDPPP). This report was prepared by the PCDPPP to inform the international community of the subsequent activities that were undertaken to promote disaster preparedness and to improve the efficiency of future relief operations. Seventy-six comments are offered dealing with hurricane preparedness measures, regional and telecommunications planning, public awareness, training of emergency personnel, the response to Hugo, the coordination of both internal and external responses, and implications for PCDPPP activities. The rest of the document contains the United Nations Disaster Relief Organization information and situation reports.

Piacente, Steve 1989. In the eye of the storm. *Government Executive* 21(12):24-33.

Federal response to the Hurricane Hugo and Loma Prieta earthquake disasters is described in this feature article, along with criticisms of those efforts levelled by state officials and legislators. Some of the hindrances faced by the Federal Emergency Management Agency and the shortages in funds and personnel that the agency overcame are detailed.

Shields, Bobbie 1991. Lessons learned by local government, Charlotte, North Carolina. Pp. 254-58 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

The City of Charlotte and the Mecklenburg County governments worked cooperatively in the aftermath of Hugo to provide emergency services, response, and recovery assistance. This article summarizes a local official's impressions of the roles played by the local governments, their interaction with their citizens, and the more helpful aspects of the response effort.

Shook, Marie and Don Steger 1989. How to handle a disaster: a study in teamwork. *Public Management* 71(12):10-14.

The joint Emergency Management Office of Charlotte, North Carolina, and Mecklenburg County, North Carolina, followed its standard all-hazard plan to cope with Hurricane Hugo. Both city and county public health, safety, and other departments cooperated in immediate response activities to help the area respond to the storm. The article describes the various steps taken and cooperative methods used by the EMO personnel.

U.S. House of Representatives 1991. Federal Emergency Management Agency's Response to Natural Disasters. U.S. House of Representatives, Hearings before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, 101st Congress, 2nd Session, May 1-2, 1990, Washington, D.C. 357 pp.

About six months after Hurricane Hugo and the Loma Prieta earthquake, hearings were held to evaluate the accomplishments of the Federal Emergency Management Agency (FEMA) in its role as provider and manager of the Federal Disaster Assistance Program. The subcommittee sought answers to the following questions: Was FEMA's response sufficient? Was it proactive in supplying needed information and resources to state and local officials and to disaster victims? What more would have been useful? How well did FEMA coordinate the relief effort among various government agencies and nonprofit ones? Was the military used wisely? Was FEMA's staffing adequate? How well did its system of using paid reservists work? Were they well trained for the jobs they were required to perform? How timely, accurate, and fair were FEMA's assessments of damages and needs, and was relief swift and forthcoming? Testimony and prepared statements from witnesses and four members of Congress, along with reprinted documents, letters, and articles provide insights to FEMA's response to the two natural disasters.

Virginia Department of Emergency Services 1991. Coastal hurricanes pose severe threats to inland jurisdictions. *Update* 1991(September):1.

This brief article recounts the experience of the Director of Public Safety and Civil Defense for Sumter County, South Carolina—a county 100 miles inland that was nevertheless seriously affected by Hugo. Some of the problems included a nine-day power outage, blocked roads, loss of mass communications, broken water mains and sewer lines, and hundreds of injured residents.

Wagar, Linda 1990. Hugo and the earthquake: lessons learned. *State Government News* 33(3):10-14.

Confusion among government agencies at all levels slowed efforts to get South Carolina communities back on their feet after Hugo. This article describes some of the misunderstandings and ad hoc decisions that were made in the wake of the hurricane in attempts by local, state, and federal officials to respond to the crisis. Some comparisons are made to the response to the Loma Prieta earthquake in California.

Wilson, Carol and Ann Lindstrom 1989. Survival of the network. *Telephony* 217(October 23):38.

The telephone system in the Carolinas remained intact and working during the Hurricane Hugo disaster, due mainly to modern electronic switching, fiber optic trunking, and buried cables. About 90-95% of all Southern Bell customers had telephone service throughout the crisis. North Carolina had received $1 billion and South Carolina $781 million worth of telecommunications modernization in recent years.

RECOVERY

BCD Council of Governments 1990. Disaster Analysis and Recovery Tracking System (DARTS): Project Description. Charleston, S.C.: BCD Council of Governments. 32 pp.

The BCD (Berkeley, Charleston, Dorchester) Council of Governments developed a disaster and recovery tracking system to provide local policymakers in stricken communities with maps and data to guide their recovery decisions. This report describes the system, including the methods used to analyze hurricane damage by neighborhood; a regional tracking system for local facilities reconstruction; information needed to plan for economic development, transportation, housing, emergency medical services, and other local government responsibilities; and the planning-oriented land-use and mapping system for the region, which is designed for a microcomputer. BCDCOG is producing community studies for each of the affected areas, damage assessment profiles, and planning practice manuals, as well as documents dealing with other specific aspects of the system, all described in this report.

Beatley, Timothy 1990. *Managing Reconstruction along the South Carolina Coast: Preliminary Observations on the Implementation of the Beachfront Management Act Following Hurricane Hugo.* QR#38. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 27 pp. $2.75.

> South Carolina's 1988 Beachfront Management Act prohibited rebuilding heavily damaged structures that were close to the ocean—specifically within 20 feet of the natural duneline in the so-called "dead zone." This paper describes the law, examines the mechanisms for managing reconstruction, and relates lessons learned from South Carolina's Hurricane Hugo experience. Although the state Coastal Council was reasonably well prepared to deal with damage assessment, reconstruction permitting, and administrative rulings, many specific issues had not been foreseen and support for the existing law even before the storm was by no means universal. The author recommends that additional research and thinking be done—before the next hurricane—about equitable and feasible mechanisms for moving development back from the ocean in the aftermath of such storms.

Berke, Philip, and Dennis Wenger 1991. *Linking Hurricane Disaster Recovery to Sustainable Development Strategies: Antigua, West Indies.* College Station, Tex.: Texas A&M University, Hazard Reduction Recovery Center. 30 pp.

> This is the report of an investigation of the emergency planning, response, and long-term recovery activities carried out by government and nongovernmental organizations as they coped with Hugo's impact on Antigua. The intent was to develop recommendations for a successful recovery planning program that will make reconstructed localities less vulnerable to future disasters while improving local capability to undertake sustainable development activities. Among the findings are that the Antigua disaster planning program failed completely during Hugo; that the Disaster Relief Committee, which was established outside of existing governmental organizations, was a successful vehicle for assessing damage data and distributing and monitoring housing aid; that, in some instances, recognition of the legitimacy of Antiguan authorities by foreign donor organizations was low; and that most of the housing recovery work was not developmental in nature.

Berke, Philip, and Dennis Wenger 1991. *Linking Hurricane Disaster Recovery to Sustainable Development Strategies: St. Kitts and Nevis, West Indies.* College Station, Tex.: Texas A&M University, Hazard Reduction Recovery Center. 41 pp.

> This is the report of an investigation of the emergency planning, response, and long-term recovery activities carried out by government and nongovernmental organizations that coped with Hugo's impact on St. Kitts and Nevis. The intent was to develop recommendations for a successful recovery planning program that will make reconstructed localities less vulnerable to future disasters while improving local capability to undertake sustainable development activities. Among the findings are that the pre-disaster awareness programs and planning proved very effective; that some organizations used Hugo as an opportunity to initiate development activities not directly related to the disaster; that private insurance companies were able to provide accurate and rapid damage assessments and housing recovery aid; and that many opportunities to make rebuilt homes less vulnerable to hurricanes were missed,

partly because of the lack of adequate building codes and procedures in place before the storm.

Dowd, Millard W., Jr. 1990. Recovery from Hurricane Hugo—Debris Removal and Channel Shoaling. *Shore and Beach* 58(4):53-56.

Debris removal was a major component of the disaster recovery operations after Hurricane Hugo, accounting for about 36% of FEMA's total approved recovery funding. An estimated 15.5 million cubic yards of debris was removed by the combined efforts of municipalities, the military, the Corps of Engineers, and private citizens, at a cost of about $5.90 per cubic yard. It is hypothesized that the absence of shoaling in the navigation channels around Charleston Harbor (as would be expected after a hurricane) is the result of the presence of jetties at the entrance to the Charleston harbor and harbors northward. The funnel-shaped jetties may have allowed higher velocities in storm water exiting the estuaries, enabling the flow to scour channel bottoms and thus remove any shoals.

Kana, Timothy W., F. David Stevens, and Gered Lennon 1990. Beach and dune restoration following Hugo. *Shore and Beach* 58(4):57-63.

After Hugo, the federal government and the state of South Carolina made a commitment to restore the beach/dune system in the most seriously affected areas. The emergency work included beach scraping and dune shaping, beach nourishment, and dune revegetation. For the work at 7 sites (one of which was 65 miles long), $9.8 million was spent and 1.2 million cubic yards of sand were placed on the beach from external sources and accreted shoals. It is anticipated that the recovery of the beaches will continue for more than a year, and that the new dunes will be stabilized by natural accretion.

Katuna, Michael P. 1991. Effects of Hurricane Hugo on the Isle of Palms, South Carolina: from destruction to recovery. *Journal of Coastal Research* SI(8):263-73.

Damage to the Isle of Palms beachfront houses, private development, public facilities, and beach after Hugo was considerable. A significant amount of sand was eroded from the island's beach-dune system. The most noticeable effects were the erosion of the primary dune ridge and the reduction in width and slope of the beach. Most of the sediment removed from the beach and dunes was transported and deposited offshore in ridges or in tidal inlet channels. At the time of the survey, much of the displaced sand was migrating back onshore and naturally replenishing the beach. Beach scraping and revegetation were initially successful in restoring the shoreline.

Rhodes, Perry E. 1990. Federal emergency work on South Carolina beaches following Hurricane Hugo. Pp. 26–35 in Lawrence S. Tait, comp., *Beaches—Lessons of Hurricane Hugo: Proceedings of the Third Annual National Beach Preservation Technology Conference*. Tallahassee, Fla.: Florida Shore & Beach Preservation Association.

> After Hurricane Hugo, the Federal Emergency Management Agency made public assistance grants available for, among other activities, restoration of the beach nourishment project at Myrtle Beach and the construction of a 17.3-mile-long emergency protective berm from the Stono River to the North Carolina border. The Corps of Engineers was contracted to build the emergency berm with eroded sand reclaimed from the surf zone. The paper describes the eligibility of sandy beaches for grants for both permanent and emergency work, and summarizes the eligible areas in South Carolina. The emergency work on South Carolina beaches, which cost about $2.5 million in federal funds, is described.

Rubin, Claire B. 1990. *Report on trip to Charleston County, South Carolina, after Hurricane Hugo*. QR #33. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 7 pp. $1.50.

> This report analyzes the intergovernmental aspects of recovery from Hurricane Hugo, including intergovernmental relationships; state, county, and city emergency management capabilities; the Federal Emergency Management Agency Section 409 requirements and the mitigation grant option under Section 404; the use of hazard mitigation tools and multihazard mitigation; assistance to the large number (50,000) of displaced persons; political reactions to the disaster; training, education, and preparedness; and coastal zone management. Needs for further research are identified.

Rubin, Claire B., and Roy Popkin 1991. *Disaster Recovery after Hurricane Hugo in South Carolina*. Working Paper #69. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. 91 pp. $4.50.

> This paper explores response and early recovery problems confronting South Carolina's municipal, county, and state governments; the Federal Emergency Management Agency; and the Red Cross after the hurricane. These agencies' organizational and functional problems with preparedness, response, recovery, and mitigation are discussed in detail. In addition, the authors examine how existing educational and training processes have failed to teach local emergency managers to manage disaster recovery efforts. The findings suggest that 1) problems existed in all four phases of emergency management; 2) post-hurricane response problems were both organizational and functional; and 3) serious mitigation planning problems were found with both hurricanes and potential earthquakes. An appendix presents a new explanatory model of recovery that demonstrates the many levels of effort, commitment, and cost connected with recovering from a major natural disaster.

URS Consultants, Inc. 1991. Follow-up Investigation Report: Repair Efforts 9 Months after Hurricane Hugo, Surfside Beach to Folly Island, South Carolina. Volume I, Damage Assessment of Flooded Buildings, and Volume II, Survey Forms. Reports prepared for the Federal Emergency Management Agency by URS Consultants, Inc., Paramus, N.J.. 56 pp.

Nine months after Hugo, many homes along the South Carolina coast were either just beginning to be repaired, had been abandoned, or were awaiting a contractor. This report documents, with numerous photographs, both the progress in repair and rebuilding and the adherence to National Flood Insurance Program building standards and other hazard-resistant design criteria. The report concludes that, in general, most of the coastal construction would fare better today in a storm of Hugo's magnitude than it did during Hugo. Most homeowners were able to see for themselves the value of properly built elevated construction.

Wells, John T., and Jesse McNinch 1991. Beach scraping in North Carolina with special reference to its effectiveness during Hurricane Hugo. *Journal of Coastal Research* SI(8):249-61.

Biweekly surveys of 1-kilometer stretches of scraped and adjacent unscraped beaches at Topsail Beach, North Carolina, for one year after Hugo revealed that 1) the scraped beach had lost 25% less sediment than the unscraped beach, 2) the dune from the unscraped section retreated 1 meter more, and 3) scraping had no obvious impact on the recreational beach because only a small percentage of sediment was removed. Despite higher erosion rates in the scraped section after Hugo, it can be argued that sediment losses would have been even greater during Hugo without scraping.

MITIGATION

Coch, Nicholas K., and Manfred P. Wolff 1991. Effects of Hurricane Hugo storm surge in coastal South Carolina. *Journal of Coastal Research* SI(8):201-26.

Structural damage along the South Carolina shoreline due to Hugo's storm surge was a function of location with respect to the eye, elevation, exposure, foundation types, and bracing. In some lowlying areas groin fields amplified the surge levels. High dunes were the most effective surge barriers. Incorporating what was learned about surge damage into the emergency management programs of coastal states can help decrease the damage and loss of life when another large storm inevitably hits an even more urbanized section of the coast.

Faupel, Charles E., and Susan P. Kelley 1991. Individual and Household Response to Hurricane Hugo. Final report to the National Science Foundation. 128 pp. Single copies are available for $4.00 from Susan Kelley, Department of Behavioral Sciences, Charleston Southern University, P.O. Box 10087, Charleston, SC 29411.

Under a grant from the National Science Foundation, the researchers examined whether participation in disaster education programs enhanced appropriate preparedness activities or reduced the level of stress experienced by disaster victims. It was found that, in general, disaster education is an important factor in appropriate preparedness behavior, particularly household planning, even if the type of disaster for which persons were trained is not the

same as the one that eventually befalls them. However, the earthquake education workshops conducted by Charleston Southern University themselves did not have a significant impact on household planning or adaptive response. Stress levels were found to increase as a result of participation in disaster education programs, but the authors point out that this stress may not be dysfunctional. The report discusses the implications of these findings for hazards education.

Gayes, Paul T. 1991. Post-Hurricane Hugo nearshore side scan sonar survey; Myrtle Beach to Folly Beach, South Carolina. *Journal of Coastal Research* SI(8):95-111.

Hurricane Hugo significantly modified the nearshore system of the northern half of the South Carolina coast. There was massive offshore transport of sand and construction debris. The nearshore response to the storm and post-storm topography varied along the coast and may have been influenced by coastal development. The system's recovery was rapid in water less than 4 meters deep; storm-related structures were reworked and debris was buried. This was aided in several areas by emergency beach renourishment projects. Recovery in deeper water was slower.

Hall, Mary Jo, and Susan D. Halsey 1991. Comparison of overwash penetration from Hurricane Hugo and pre-storm erosion rates for Myrtle Beach and North Myrtle Beach, South Carolina, U.S.A. *Journal of Coastal Research* SI(8):229-35.

A comparison of detailed pre-storm erosion rates with post-hurricane onsite inspection and aerial photographs showed that zones with higher pre-storm erosion rates were also areas of greater overwash penetration during Hugo. Other factors also significantly increased the overwash penetration, namely the presence of low-elevation areas landward of the beach, and large open stretches of pavement such as parking lots and streets perpendicular to the beach. In contrast, where buildings were well back from the beach with fronting dunes, overwash was not significant. Because the locations of overwash are predictable, relatively low-cost hazard mitigation measures can be taken to reduce their occurrence and severity.

Interagency Hazard Mitigation Team, Region IV 1989. Hurricane Hugo: Interagency Hazard Mitigation Team Report. FEMA-843-DR-SC. Atlanta, Ga.: Federal Emergency Management Agency. 39 pp.

Hurricane Hugo affected an estimated 1.8 million people—20 persons died, 264,500 were evacuated, 270,600 were temporarily unemployed, 60,000 were left homeless, and about 54,000 had registered for disaster assistance six weeks after the storm. This report contains recommendations for improved recovery and hazard mitigation that were proposed by a regional Federal Emergency Management Agency mitigation team that investigated the stricken area in the hurricane's aftermath. The report addresses issues that South Carolina should consider in future emergency plan development. It offers a general description of the disaster and the response to it, addressing government and regulatory structures, hurricane preparedness, damage, initial reaction, and long-term reconstruction. It recommends improvements in the use of South Carolina's emergency operations centers, in floodplain and coastal zone management procedures, in emergency communications, and in the

implementation of a mandatory statewide building code that provides structural protection from both hurricane-force winds and earthquakes.

Lennon, Gered 1991. The nature and causes of hurricane-induced ebb scour channels on a developed shoreline. *Journal of Coastal Research* SI(8):237–46.

Of the various types of storm-induced erosion, ebb-scour channels were particularly evident after Hugo on Folly Island, South Carolina. Water flowing in these channels carried vast amounts of debris offshore, wrecked buildings and seawalls, and undermined roads and water lines. A one-mile segment of Folly Island was studied to determine what processes were responsible for the creation of the channels. The study concluded that several factors encourage or inhibit channel formation, including streets laid perpendicular to the shoreline, wind direction, open drainage areas, public access, and existing bodies of water. The author recommends two individual actions to help prevent channel formation in future storms: keeping as much of the beach area as fully vegetated as possible, and maintaining shoreline armoring in as strong a condition as possible. He cautions that this is *not* a recommendation for the use of more and larger seawalls, but only a note that the stronger, already existing ones did seem to deter channel formation.

Lindstrom, Ann 1990. One year later—Hugo changes network approach. *Telephony* 219(September 17):14.

The state of South Carolina has announced the establishment of a private emergency preparedness telecommunications network that will operate only in a disaster like Hurricane Hugo. The network has four tiers and is built around an electronic tandem network that includes seven voice and data switching nodes connected by a DSI backbone and an independent fiber optic ring around the state. Since Hurricane Hugo, all telecommunications companies have increased the percentage of buried cable in their networks. Most of the cleanup costs after Hugo were absorbed by each company's stockholders, including $50 million for Southern Bell and $20.1 million for GTE.

Pilkey, Orrin H., David M. Bush, Rodney Priddy, Kathie Dixon, Amber Taylor, and E. Robert Thieler 1990. *Recovering from Hugo: Preparing for Hilda—Hurricane Damage Mitigation Field Trip Guide from Folly Island, South Carolina to Bogue Banks, North Carolina.* Durham, N.C.: Duke University Program for the Study of Developed Shorelines. 110 pp. Photocopy available for $12.00 from Program for the Study of Developed Shorelines, Department of Geology, Duke University, Box 6729 College Station, Durham, NC 27708, (919) 684-5847.

This guidebook for a three-day automobile trip along the North and South Carolina coast includes a section on basic principles of property damage mitigation, a mile-by-mile itinerary, detailed descriptions of natural and engineered features of the coastline and what happened to them during Hugo, and useful appendixes summarizing pertinent coastal legislation. The objectives of the field trip were to foster a new way of thinking about hurricane recovery, to wit, taking active steps to repair the islands themselves and to enhance the protective characteristics of the natural setting. The authors suggest principles for reducing hurricane

property damage in light of anticipated accelerated rates of sea level rise, increasing barrier island migration, and increases in both frequency and intensity of Atlantic hurricanes.

Platt, Rutherford H., Timothy Beatley, and H. Crane Miller 1991. The folly at Folly Beach and other failings of U.S. coastal erosion policy. *Environment* 33(9):7-9, 25-32.

The concept of relocating a structure back from an eroding shoreline has been widely advocated in the United States but is seldom achieved in practice. Instead, the prevailing response has been either to ignore it or to safeguard coastal development with a variety of "hard" protection structures, which are of varying effectiveness and can have detrimental side effects. Five strategies for responding to coastal erosion have been pursued by the federal government: shoreline protection, direct federal regulation, public ownership, incentives for state planning, and insurance and mitigation of erosion losses. The failure of federal and state policies to cause beachfront development in South Carolina to move landward after Hugo demonstrated the strength of political pressure and the irrelevance to erosion problems of some of the otherwise effective federal policies. The authors make detailed recommendation for changes in federal policy to remedy the situation.

Richardson, Thomas W. 1990. Panel discussion: technological preparedness and response to severe storms. *Shore and Beach* 58(4):75-77.

This article is the report of a panel discussion at a special conference sponsored by the U.S. Army Corps of Engineers, the American Shore and Beach Preservation Association, and Sea Grant, which focussed on recommendations of ways to reduce the potential property damage, physical injury, and death from severe coastal storms like Hurricane Hugo and to improve our ability to cope with the consequences of such storms when they strike. The recommendations include those related to predicting effects of storms, assessing conditions, reducing damages, public education, and interdisciplinary communication.

Sill, Ben L. 1991. Lessons learned from Hurricane Hugo and future mitigation activities. Pp. 286-89 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

This paper summarizes the more salient observations made during a symposium held one year after Hugo. In general terms, it gives lessons learned about the kinds of structures damaged during the storm and the kinds of damage that were common, the performance of utility systems, the effectiveness of the evacuation, and the response effort, among other issues. The paper concludes that if all that was known about mitigating hurricane disasters had been properly put into practice, Hugo's damage would have been reduced by several billions of dollars. A summary of two major mitigation projects in North and South Carolina is also presented.

Sill, Ben L., and John S. Fisher 1991. Advisory and mitigation activities in the Carolinas. Pp. 129-32 in Benjamin L. Sill and Peter R. Sparks, eds., *Hurricane Hugo One Year Later, Proceedings of a Symposium and Public Forum.* New York: American Society of Civil Engineers.

> After Hugo it was obvious that the magnitude of the disaster and the recovery time could have been substantially reduced through improved planning, education, engineering, and construction. Several programs in the Carolinas have been launched that are aimed at long-term mitigation of the impacts of hazardous occurrences. This paper outlines several principal efforts, including the South Carolina Multi-Hazard Mitigation Program, the Coastal Hazards Advisory and Mitigation Project, and the University of North Carolina's research and education program under the Center for Disaster Reduction.

Wilson, Susan, Michael Mahoney, and Cynthia Keegan 1990. Post-Hurricane Hugo mitigation issues for reducing flood losses in South Carolina. Pp. 203-206 in Association of State Floodplain Managers, Inc., *Challenges Ahead, Flood Loss Reduction Strategies for the '90s, Proceedings of the Fourteenth Annual Conference.* SP#23. Boulder, Colo.: University of Colorado, Natural Hazards Research and Applications Information Center. $10.00.

> This article identifies a number of short- and long-term mitigation strategies that could be implemented after Hurricane Hugo as part of local, state, or federal floodplain management programs to reduce future losses. They focus on improvements in coastal construction codes, mapping, building repairs, wind design, manufactured housing, using Section 1362, and making additions to the Coastal Barrier Resources System. Although the details of the recommendations are specific to Hurricane Hugo, they can be effectively utilized after virtually any hurricane.

Wood, William L. 1990. Coastal management alternatives for reducing storm impacts at a coast. *Shore and Beach* 58(4):72-74.

> This article is a general discussion of the management alternatives identified in the wake of Hugo for reducing coastal storm impacts, the recommended objectives of such approaches, and the political, economic, and technological hindrances to action. The author recommends further education of the public of the consequences of coastal development and an improved system of gathering oceanographic data during severe storms.

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