



NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities

Volume 2 – Study Documentation

THE MULTHAZARD MITIGATION COUNCIL

The *Multihazard Mitigation Council (MMC)*, a council of the National Institute of Building Sciences (NIBS), was established in November 1997 to reduce the total losses associated with natural and other hazards by fostering and promoting consistent and improved multihazard risk mitigation strategies, guidelines, practices, and related efforts. The scope of the Council's interests is diverse and reflects the concerns and responsibilities of all those public and private sector entities involved with building and nonbuilding structure and lifeline facility research, planning, design, construction, regulation, management, and utilization/operation and the hazards that affect them. In recognition of this diversity, the Council believes that appropriate multihazard risk reduction measures and initiatives should be adopted by existing organizations and institutions and incorporated into their legislation, regulations, practices, rules, relief procedures, and loan and insurance requirements whenever possible so that these measures and initiatives become part of established activities rather than being superimposed as separate and additional. Further, the Council's activities are structured to provide for explicit consideration and assessment of the social, technical, administrative, political, legal, and economic implications of its deliberations and recommendations. To achieve its purpose, the Council conducts activities and provides the leadership needed to:

- ◆ Improve communication, coordination, and cooperation among all entities involved with mitigation;
- ◆ Promote deliberate consideration of multihazard risk reduction in all efforts that affect the planning, siting, design, construction, and operation of the buildings and lifelines systems that comprise the built environment; and
- ◆ Serve as a focal point for the dissemination of credible information and sage counsel on major policy issues involving multihazard risk mitigation.

Board of Direction

Chair — Brent Woodworth, IBM Crisis Response Team (representing the building/facility owner community)

Vice Chair — Ronny J. Coleman, Commission on Fire Accreditation, International (representing the fire community)

Secretary — Ann Patton, City of Tulsa, Oklahoma (ex-officio member representing community interests)

MMC Members — Andrew Castaldi, Swiss Reinsurance America Corporation (representing the reinsurance community); Arthur E. Cote, P.E., National Fire Protection Association (representing the fire hazard mitigation community); Ken Deutsch, The American Red Cross (representing the disaster recovery community; resigned 2004); Ken Ford, National Association of Home Builders (representing the contracting and building community); Michael Gaus, State University of New York at Buffalo (representing the wind hazard mitigation community); David Godschalk, Ph.D., University of North Carolina at Chapel Hill (representing the planning and development community); George Hosek, Hosek Floodplain Management Consulting (representing the flood hazard mitigation community); Klaus H. Jacob, Ph.D., Columbia University, Lamont-Doherty Earth Observatory (representing the geological hazards research community); Gerald H. Jones, Kansas City, Missouri (representing the building code enforcement community); Howard Kunreuther, Ph.D., Wharton School, University of Pennsylvania (representing the economic statistics community; through March 2004); David McMillion, Consultant (representing the emergency management community); Michael Moye, National Lender's Insurance Council (representing the financial community); Dennis Mileti, Ph.D., Natural Hazards Center, University of Colorado at Boulder (representing the multihazard risk reduction community); Michael J. O'Rourke, P.E., Rensselaer Polytechnic Institute (representing the snow hazard mitigation community); Timothy A. Reinhold, Institute for Business and Home Safety, Florida (representing the insurance community); Paul E. Senseny, Factory Mutual Research (representing the fire hazard research community); Lacy Suiter, Naval Postgraduate School, Monterey, California; Alex Tang, P.Eng., C. Eng. Chair, ASCE Committee on Lifeline Earthquake Engineering, Mississauga, Ontario (representing the lifelines community); Charles H. Thornton, Ph.D., S.E., The Thornton -Tomasetti Group, Inc. (representing the structural engineering community); Eugene Zeller, City of Long Beach, California (representing the seismic hazard mitigation community)

MMC Organizational Members — American Forest and Paper Association, Washington, D.C.; American Institute of Architects, Washington, D.C.; The American Red Cross, Washington, D.C.; Association of State Dam Safety Officials, Lexington, Kentucky; Association of State Floodplain Managers, Inc., Madison, Wisconsin; Consortium of Universities for Research in Earthquake Engineering, Richmond, California; Council on Natural Disaster Reduction/American Society of Civil Engineers, Reston, Virginia; Earthquake Engineering Research Institute, Oakland, California; Factory Mutual Insurance Company, Norwood, Massachusetts; French and Associates Ltd., Park Forest Illinois; GE Global Asset Protection Service, Hartford, Connecticut; IBM, Woodland Hills, California; Institute for Catastrophic Loss Reduction, Toronto, Ontario, Canada; International Code Council; Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland; Multidisciplinary Center for Earthquake Engineering Research, State University of New York at Buffalo, New York; National Fire Protection Association, Quincy, Massachusetts; National Fire Sprinkler Association, Patterson, New York; National Institute of Standards and Technology, Building and Fire Research Laboratory, Gaithersburg, Maryland; Natural Hazards Center, University of Colorado, Boulder; Portland Cement Association, Society of Fire Protection Engineers, Bethesda, Maryland; State Farm Fire and Casualty Company, Bloomington, Illinois; Tennessee Building Officials Association, Murfreesboro, Tennessee; The Thornton - Tomasetti Group, Inc., New York, New York; Zurich U.S., Schaumburg, Illinois

MMC Affiliate Members — Baldrige & Associates Structural Engineering, Inc.; Corotis, Ross, Boulder, Colorado; Goettel and Associates, Inc.; Martin and Chock, Inc., Honolulu, Hawaii

MMC Staff — Claret M. Heider, NIBS Vice President, BSSC/MMC; Bernard F. Murphy, PE, Director, Special Projects; Carita Tanner, Communications Director



National Institute of
BUILDING SCIENCES

*The Multihazard Mitigation Council,
a council of the National Institute of
Building Sciences*

NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities

Volume 2 – Study Documentation

Prepared with funding from the Federal Emergency Management Agency of the U.S. Department of Homeland Security by the Multihazard Mitigation Council of the National Institute of Building Sciences with the assistance of the Applied Technology Council

National Institute of Building Sciences
Washington, D.C.
2005

NOTICE: Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency. Additionally, neither FEMA nor any of its employees make any warranty, expressed or implied, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, product, or process included in this publication.

This report was prepared under Contract EMW-2003-CO-0417 between the Federal Emergency Management Agency and the National Institute of Building Sciences. It is based on concept development and analytical work conducted under Contract EMW-1998 CO-0217. For further information, visit the Multihazard Mitigation Council website at <http://nibs.org/MMC/mmchome.html> or contact the Multihazard Mitigation Council, 1090 Vermont Avenue, N.W., Suite 700, Washington, D.C. 20005; phone 202-289-7800; fax 202-289-1092; e-mail mmc@nibs.org.

In Memoriam

The Multihazard Mitigation Council wishes to acknowledge James M. Delahay, PE, for his contributions to the Applied Technology Council's research/analysis efforts and his significant contributions to the profession of structural engineering and the nation's codes and standards development efforts. The built environment and all those who use it have benefited tremendously from his work.

PREFACE

The National Institute of Building Sciences through its Multihazard Mitigation Council is pleased to submit this report to the Congress of the United States on behalf of Federal Emergency Management Agency (FEMA) and the Department of Homeland Security. This report presents the results of an independent study to assess the future savings from hazard mitigation activities.

This study shows that money spent on reducing the risk of natural hazards is a sound investment. On average, a dollar spent by FEMA on hazard mitigation (actions to reduce disaster losses) saves the nation about \$4 in future benefits. In addition, FEMA grants to mitigate the effects of floods, hurricanes, tornados, and earthquakes between 1993 and 2003 are expected to save more than 220 lives and prevent almost 4,700 injuries over approximately 50 years. Hurricane Katrina painfully demonstrates the extent to which catastrophic damage affects all Americans and the federal treasury.

The MMC Board wishes to acknowledge the efforts of its subcontractor, the Applied Technology Council (ATC). Further, it applauds the innovative and painstaking work of the ATC research team under the guidance of Ronald T. Eguchi of ImageCat, Inc., the project technical director. The team members were: Adam Z. Rose of The Pennsylvania State University, leader of the benefit-cost analysis portion of the study; Keith Porter, Consultant, co-leader of that portion of the study; Elliott Mittler, Consultant, leader of the community research portion of the study; Craig Taylor of Natural Hazards Management Inc., co-leader of that portion of the study; Corey Barber of the University of California, Berkeley; Jawhar Bouabid of PBS&J; Linda B. Bourque of the University of California, Los Angeles; Stephanie Chang of the University of British Columbia; Nicole Dash of the University of North Texas; James Delahay of LBYD, Inc.; Charles Huyck, ImageCat, Inc.; Christopher Jones, Consultant; Megumi Kano of the University of California, Los Angeles; Karl Kappler of the University of California, Berkeley; Lukki Lam of the University of California, Berkeley; Rebecca C. Quinn, CFM, RCQuinn Consulting, Inc.; Archana More Sharma of the University of California, Los Angeles; Kenneth Strzepek of the University of Colorado; John Whitehead of Appalachian State University; Michele M. Wood of the University of California, Los Angeles; Kathryn Woodell of the University of California, Berkeley; and Bo Yang of The Pennsylvania State University. Thanks also go to the ATC Independent Project Review Team members William Petak of the University of Southern California, David Brookshire of the University of New Mexico, Stephanie King of Weidlinger Associates, Inc., Dennis Mileti of the University of Colorado, Doug Plasencia of AMEC Earth and Environmental, and Zan Turner of the City and County of San Francisco; to the ATC project staff including Thomas R. McLane and Christopher Rojahn; and to additional consultants engaged by ATC (James R. McDonald of McDonald-Mehta Engineers, Bruce Miya, and Douglass Shaw of Texas A&M University).

The MMC also offers its thanks to the Project Management Committee established to oversee the project on its behalf. The committee members have spent countless voluntary hours reviewing study materials and providing guidance to the MMC subcontractor conducting the data analysis effort, and the MMC Board thanks them very much for their extraordinary contribution of time

and expertise. Serving on the committee were: Philip T. Ganderton, Ph.D., Professor and Chair, Department of Economics, University of New Mexico; David Godschalk, Ph.D., Stephen Baxter Professor, Department of City and Regional Planning, University of North Carolina, Chapel Hill; Anne S. Kiremidjian, Ph.D., Professor of Civil and Environmental Engineering, Department of Civil and Environmental Engineering, Stanford University, Palo Alto; Kathleen Tierney, Ph.D., Professor and Director, Natural Hazards Research and Applications Center, University of Colorado; and Carol Taylor West, Ph.D., Professor, Department of Economics, University of Florida.

The MMC also is grateful to L. Thomas Tobin of Tobin & Associates, who worked closely with the Project Management Committee and served as technical liaison with the ATC researchers, and to the superb MMC staff. Further, the MMC wishes to thank the FEMA personnel and state and local officials who provided data and other information for analysis in this study. The MMC also wishes to express its gratitude to FEMA for having the confidence in the Council to give it the independence needed to conduct the study and prepare this report and especially to Maria Vorel and Margaret Lawless of FEMA for their insight and support.

Brent Woodworth
Chair, Multihazard Mitigation Council

TABLE OF CONTENTS

PREFACE	iii
1.0 INTRODUCTION	1
1.1 Purpose and Background.....	1
1.2 Federal Mitigation Programs.....	2
1.3 Study Objectives.....	3
1.3.1 Benefit-Cost Analysis of FEMA Mitigation Grants.....	3
1.3.2 Community Studies.....	4
1.3.3 Types of Mitigation Activities.....	4
1.4 Study Characteristics.....	4
1.5 Organization of Report.....	4
2.0 PRINCIPLES AND DEFINITIONS	7
2.1 Benefit-Cost Analysis.....	7
2.1.1 Measures of Costs.....	9
2.1.2 Measures of Benefits.....	10
2.2 Loss Estimation Modeling.....	10
2.2.1 Basic Components.....	11
2.2.2 HAZUS [®] MH.....	12
2.3 Benefit Transfer Methods.....	14
2.4 Case Study Principles.....	14
2.5 Definitions.....	15
2.5.1 Process and Project Activities.....	15
2.5.2 Synergistic Activities.....	16
3.0 DATA COLLECTION, PROCESSING AND ANALYSIS	19
3.1 Existing Data Sources.....	19
3.1.1 FEMA NEMIS Database.....	19
3.1.2 Hazard Mitigation Grant Program and Flood Mitigation Assistance Grant Files.....	22
3.1.3 Project Impact Report Files.....	23
3.1.4 Other Files.....	24
3.2 Other Primary Datasets.....	24
3.2.1 Community Studies.....	24
3.2.2 FEMA Mitigation Grants.....	26

4.0	METHODS OF ANALYSIS	27
4.1	Parallel Study Components	27
4.2	HAZUS [®] MH and Other Loss Estimation Methodologies.....	28
4.2.1	Direct Property Damage (Stock Loss).....	28
4.2.2	Business Interruption (Flow Loss)	30
4.2.3	Societal Impacts	33
4.3	Supplemental Methodologies	37
4.3.1	Direct Property Loss — from Flood.....	37
4.3.2	Direct Property Loss — from Tornado	40
4.3.3	Business Interruption Loss— from Utility Outages.....	40
4.3.4	Environmental and Historic Benefits	41
4.3.5	Grants for Process Mitigation Activities	41
4.3.6	Other.....	44
4.4	Community Studies Analysis	44
4.4.1	Purposive Sampling Techniques	45
4.4.2	Field Research.....	47
4.4.3	Interview Guides	50
4.4.4	Benefit-Cost Analysis for Community Studies	50
4.5	Methodology for Benefit-Cost Analysis of FEMA Mitigation Grants.....	50
4.5.1	Stratified Sample	50
4.5.2	Calculating Benefit-Cost Ratios for Sample Activities.....	52
4.5.3	Extrapolating Benefits and Costs from Sample to Population	52
4.5.4	Potential Future Savings to the Federal Treasury.....	53
4.5.5	Analyzing Model Sensitivity and Uncertainty	55
5.0	COMMUNITY STUDIES RESULTS.....	59
5.1	Sample Communities	59
5.2	Community Descriptions.....	62
5.2.1	Freeport New, York.....	61
5.2.2	Hayward, California	67
5.2.3	Horry County, South Carolina.....	75
5.2.4	Jamestown, North Dakota	79
5.2.5	Jefferson County, Alabama	84
5.2.6	Multnomah County, Oregon.....	89
5.2.7	City of Orange, California.....	93
5.2.8	Tuscola County, Michigan	97
5.3	Mitigation Activities Undertaken.....	103
5.3.1	FEMA-Funded Mitigation Activities	103
5.3.2	Synergistic Activities or Effects.....	103
5.4	Benefit-Cost Results.....	106
5.4.1	Hazard Mitigation Grant Program Grants	107

5.4.2	Project Impact Grants	112
5.4.3	Spin-Off Activities Resulting from Hazard Mitigation Grant Program Grants	115
5.4.4	Cost-Effectiveness Analysis of Grants for Process Mitigation Activities.....	117
5.5	Non-Quantifiable Benefits	118
5.6	Comprehensiveness Factor	119
5.7	Summary	120
6.0	BENEFIT-COST ANALYSIS OF FEMA MITIGATION GRANTS	123
6.1	Project Selection.....	123
6.2	Stratified Sample	124
6.3	Sample Results	125
6.3.1	Sampled Grants for Project Mitigation Activities.....	125
6.3.2	Sampled Grants for Process Mitigation Activities	133
6.4	Extrapolation of Sample Results to Population.....	135
6.4.1	Breakdown of Results	137
6.4.2	Deaths and Injuries.....	138
6.4.3	Net Benefits to Society.....	139
6.4.4	Impacts on the Federal Treasury	139
6.5	Sensitivity Analysis.....	142
6.5.1	Grants for Earthquake Project Activities.....	142
6.5.2	Grants for Wind Project Mitigation Activities	143
6.5.3	Grants for Flood Project Mitigation Activities.....	144
6.6	Other Sensitivity Analyses	145
6.7	Combining Sampling Uncertainty and Modeling Uncertainty.....	146
6.8	Conclusions	146
7.0	STUDY FINDINGS.....	149

APPENDICES

A.	MMC and ATC Project Participants and ATC Internal Project Review Team Endorsement Letter	151
B.	Community Studies: Data Collection Guidelines and Questionnaire Specifications.....	157
C.	Demographic Characteristics of Communities	195
D.	Assumptions and Limitations.....	201
E.	Casualty Estimation Methodology	207
F.	HAZUS [®] MH Injuries and the Abbreviated Injury Scale.....	213

G.	Property Loss Estimation – Flood.....	221
H.	Property and Casualty Loss Estimation – Tornado.....	239
I.	Business Interruption Benefits – Electricity and Water Utilities.....	241
J.	Environmental and Historic Benefit Estimation.....	245
K.	Process Grant Benefit Estimation.....	247
L.	Base-Isolated Buildings Loss Estimation.....	255
M.	Debris Flow Damage Estimation.....	257
N	Four Methods to Select Sample and Scale-Up Benefit.....	259
O.	Community Selection Process.....	265
P.	Bibliography of Community Documents.....	275
Q.	Project Impact.....	305
R.	Combined Sampling and Modeling Uncertainty.....	339
S.	Validation and Quality Control.....	349
	REFERENCES.....	355
	GLOSSARY.....	363

LIST OF FIGURES

Figure 2-1	HAZUS [®] MH Modules.....	12
Figure 3-1	FEMA mitigation grants by region: (a) number and (b) total cost.....	21
Figure 3-2	Mitigation activities by year of declaration.....	22
Figure 3-3	Data collection process for community studies. “A” denotes archive.....	25
Figure 4-1	Schematic of floodplain showing how the point in the channel center closest to the property is determined.....	38
Figure 4-2	Variables used to calculate flood depths.....	38
Figure 4-3	Illustration of geocoding error in flood analysis.....	39
Figure 4-4	Overview of community studies methodology.....	45

Figure 5-1	Activity Chronology for Freeport, New York (unless otherwise indicated, activity dates above show start date).....	68
Figure 5-2	Activity Chronology – Hayward, California (unless otherwise indicated, activity dates above show start date).....	74
Figure 5-3	Activity Chronology – Horry County, South Carolina (unless otherwise indicated, activity dates above show start date)	80
Figure 5-4	Activity Chronology – Jamestown, North Dakota (unless otherwise indicated, activity dates above show start date)	85
Figure 5-5	Activity Chronology – Jefferson County, Alabama (unless otherwise indicated, activity dates above show start date)	90
Figure 5-6	Activity Chronology – Multnomah County, Oregon (unless otherwise indicated, activity dates above show start date)	94
Figure 5-7	Activity Chronology – City of Orange, California (unless otherwise indicated, activity dates above show start date).....	98
Figure 5-8	Activity Chronology – Tuscola County, Michigan (unless otherwise indicated, activity dates above show start date).....	104
Figure 6-1	Contribution to benefit-cost ratio by factor for (a) earthquake, (b) wind, and (c) flood	137
Figure 6-2	Sensitivity of benefit to uncertainties (grants for earthquake project mitigation activities)	143
Figure 6-3	Sensitivity of benefit to uncertainties (grants for wind project mitigation activities)	144
Figure 6-4	Sensitivity of benefit to uncertainties (grants for flood project mitigation activities)	145
Figure G-1	Illustration of flood-loss calculation	221
Figure G-2	Four methods of simulating X	223
Figure G-3	Illustration of elevation differences X used in Hermite-Gauss quadrature for flood loss	225
Figure G-4	Sketch showing definitions of various parameters of interest in flood studies.....	230
Figure G-5	Plot showing various flood levels for a sample profile from a flood insurance study	237

LIST OF TABLES

Table 3-1	Status of Applications in NEMIS (as of 5 June 2003).....	20
------------------	--	----

Table 3-2	Number and Cost of Funded Grants by Hazard Type.....	21
Table 4-1	Distribution of Grants in the NEMIS Database	29
Table 4-2	Major Types of Mitigation Projects Designed to Reduce Casualties — by Hazard.....	35
Table 4-3	Cost of Injuries (Urban Institute, 1991).....	36
Table 4-4	Casualty Values Mapped into HAZUS [®] MH	36
Table 4-5	Relationship between Flood Depth and Recovery Time in Days	37
Table 4-6	Communities Selected for Analysis.....	47
Table 4-7	Typical Search Protocol for Community Studies	48
Table 4-8	Distribution of Grants in the Stratified Sample	51
Table 4-9	Federal Government Relief and Mitigation Categories	54
Table 4-10	Federal Tax Revenue Categories Affected by Hazard Mitigation	54
Table 4-11	Sensitivity Parameters for Project Mitigation Activities	57
Table 5-1	HMGP and FMA Grants Awarded to Freeport, New York.....	63
Table 5-2	Project Impact Activities Initiated by Freeport, New York.....	65
Table 5-3	FEMA Hazard Mitigation Grants Awarded to Hayward, California.....	70
Table 5-4	Projects Approved for the City of Hayward Funded Under the State of California Earthquake Safety and Public Building Rehabilitation Bond Act of 1990	71
Table 5-5	FEMA Hazard Mitigation Grants Awarded to Horry County, South Carolina	77
Table 5-6	FEMA Hazard Mitigation Grants Awarded to Jamestown, North Dakota.....	81
Table 5-7	FEMA Hazard Mitigation Grants Awarded to Jefferson County, Alabama.....	88
Table 5-8	FEMA Hazard Mitigation Grants Awarded to Multnomah County, Oregon	92
Table 5-9	FEMA Hazard Mitigation Grants Awarded to the City of Orange, California	96
Table 5-10	FEMA Hazard Mitigation Grants Awarded to Tuscola County, Michigan	102

Table 5-11	Summary of FEMA Hazard Mitigation Grant Program Grants for Communities Studied.....	105
Table 5-12	Project Impact Costs for Five Communities	106
Table 5-13	Summary of Synergistic Activities or Effects.....	106
Table 5-14	Summary of Costs, Benefits, Benefit-Cost Ratios and Ranges by HMGP Project Grant Activities and by Community	107
Table 5-15	Downside Factors Used in Uncertainty Calculations for Table 5-14	109
Table 5-16	Upside Factors Used in Uncertainty Calculations for Table 5-14	110
Table 5-17	Summary of Costs, Benefits, Benefit-Cost Ratios and Ranges by Project Impact Activity and Community	113
Table 5-18	Upside Factors Used in Uncertainty Calculations for Table 5-17	113
Table 5-19	Downside Factors Used in Uncertainty Calculations for Table 5-17	114
Table 5-20	Net Benefits for Spin-off Activities Not Covered in Table 5-17	116
Table 5-21	Cost-Effectiveness Estimates for Process Activities	118
Table 5-22	Basic Estimates Used in Deriving a Comprehensiveness Factor.....	119
Table 6-1	Mitigation Efforts and Sample Size by Hazard (in 2004 dollars).....	124
Table 6-2	Methods Used to Estimate Benefits for Grants for Project Mitigation Activities	126
Table 6-3	Mitigation Benefits and Sample Size by Hazard (in 2004 dollars).....	136
Table 6-4	Scale-Up of Results to all FEMA Grants (all \$ figures in 2004 constant dollars).....	136
Table 6-5	Summary of Benefits and Costs by Hazard	137
Table 6-6	Summary of Benefits and Costs by Type of Mitigation Activity	137
Table 6-7	Estimated Reduction in Casualties by Grants for Both Project and Process Mitigation Activities.....	139
Table 6-8	Annual Potential Savings to the Federal Treasury.....	140
Table C-1	Demographic Characteristics of Eight Communities in the Community Studies Sample.....	198
Table C-2	Demographic Characteristics of Study Communities that Received FEMA Grants for Earthquakes Only (Communities 01 and 08) as Compared to those with Similar Sample Criteria	198

Table C-3	Demographic Characteristics of Study Communities that Received FEMA Grants for Floods Only (Communities 05 and 07) as Compared to those with Similar Sample Criteria	199
Table C-4	Demographic Characteristics of Study Communities that Received FEMA Grants for Floods and Wind (Communities 02, 04 and 06) as Compared to those with Similar Sample Criteria	199
Table E-1	Input Variables for HAZUS Casualty Module in Relation to Damage State	207
Table E-2	Injury Rates Used for Tornado Estimation.....	212
Table F-1	HAZUS®MH Injury Classification Scale	214
Table F-2	HAZUS®MH Level-1 Injuries and Related AIS-Coded Injuries.....	215
Table F-3	HAZUS®MH Level-2 Injuries and Related AIS-Coded Injuries.....	217
Table F-4	HAZUS®MH Level-3 Injuries and Related AIS-Coded Injuries.....	218
Table F-5	Two Options for Mapping from HAZUS®MH to AIS Injury Levels.....	219
Table G-1	Flood Depth h_n Given Return Period and Site Elevation	226
Table G-2	Annualized Losses Y_{ann} for Each Site Elevation X	226
Table K-1	Conclusions on Likely Benefit-Cost Ratio for Process Grant Categories	253
Table O-1	Distribution of Communities and Quota Limits Set for the Sample by the Pattern of FEMA Awards Received by a Community.....	268
Table O-2	Distribution of Communities and Quota Limits Set for the Sample by Being at High Risk of Earthquake, Flood or Wind Hazard	269
Table O-3	Distribution of Communities and Quota Limits Set for the Sample by Population Size	270
Table O-4	Distribution of Communities and Quota Limits Set for the Sample by FEMA Region.....	271
Table O-5	Communities that Were Accepted for the Sample and Communities that Were Rejected Because One or More Limit Had Been Reached by Stage of the Draw	272
Table O-6	Communities Selected for the Sample by Community Size, Pattern of FEMA Awards Received, and Whether They Were Selected to Be in the First, Second or Third Set of Communities	274
Table Q-1	Project Impact – Matrix	308

Table Q-2	Project Impact Reporting Documents Collected During Visits to FEMA Regional Offices and Communities	315
Table Q-3	Project Impact Activities Initiated by Freeport.....	319
Table Q-4	Benefit Cost Analysis of Completed Project Impact Activities in Freeport, New York	320
Table Q-5	Project Impact Activities Initiated by Jefferson County	323
Table Q-6	Benefit Cost Analysis of Completed Project Impact Activities in Jefferson County, Alabama.....	324
Table Q-7	Project Impact Activities Undertaken by Multnomah County.....	327
Table Q-8	Benefit Cost Analysis of Completed Project Impact Activities in Multnomah County, Oregon	328
Table Q-9	Project Impact Activities Initiated by Jamestown.....	331
Table Q-10	FEMA and Local Shares and Partners of Project Impact Activities.....	332
Table Q-11	Benefit Cost Analysis of Completed Project Impact Activities in Jamestown, North Dakota.....	333
Table Q-12	Project Impact Activities Initiated by Horry County	335
Table Q-13	Benefit Cost Analysis of Completed Project Impact Activities in Horry County, South Carolina	336
Table R-1	Combined Sample Uncertainty and Modeling Uncertainty	341
Table S-1	QC Form (Track B Reports)	350

