Appendix A
MMC AND ATC PROJECT PARTICIPANTS AND ATC INTERNAL PROJECT REVIEW TEAM ENDORSEMENT LETTER

MULTIHAZARD MITIGATION COUNCIL

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)

Members:
Andrew Castaldi, Swiss Reinsurance America Corporation (representing the reinsurance community)
Arthur E. Cote, PE, National Fire Protection Association (representing the fire hazard mitigation community)
Ken Deutsch, The American Red Cross (representing the disaster recovery community; through 2004)
Ken Ford, National Association of Home Builders (representing the contracting/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/development community)
George Hosek, Michigan Department of Environmental Quality (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, PE, Kansas City, Missouri (representing the building code enforcement community)
Howard Kunreuther, Ph.D., Wharton School, The University of Pennsylvania (representing the economic/statistics community; through 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, PE, Rensselaer Polytechnic Institute (representing the snow hazard mitigation community)
Timothy Reinhold, Institute for Business and Home Safety (representing the insurance community)
Paul E. Senseny, Factory Mutual Research (representing the fire hazard research community)
Lacy Suiter, Consultant, Alexandria, Virginia
Alex Tang, P.Eng., C. Eng. Chair, ASCE Committee on Lifeline Earthquake Engineering, Mississauga, Ontario (representing the lifelines community)
Charles H. Thornton, Ph.D., SE, CHT and Company, Inc. (representing the structural engineering community)
Eugene Zeller, City of Long Beach, California (representing the seismic hazard mitigation community)

Project Management Committee

Philip T. Ganderton, Ph.D., Professor and Chair, Department of Economics, University of New Mexico, Albuquerque
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, Boulder
Carol Taylor West, Ph.D., Professor, Department of Economics, University of Florida, Gainsville

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Carita Tanner, Communications Director, BSSC/MMC, Washington, D.C.

APPLIED TECHNOLOGY COUNCIL

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Community Studies Co-Leader: Craig Taylor, Natural Hazards Management, Inc., Torrance, California
Benefit-Cost Analysis of FEMA Mitigation Grants Leader: Adam Z. Rose, The Pennsylvania State University, University Park
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USC
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March 24, 2005

School of Policy,
Planning, and
Development

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Subject: Endorsement by the Applied Technology Council's Internal Project Review Team of ATC-61: *Independent Study to Assess Future Savings from Mitigation*

Dear Tom:

Thank you for providing the opportunity to participate as members of an Internal Project Review Team (IPRT) during the conduct of the effort leading to development of the subject report. As members of the team, it is our pleasure to provide this letter of final endorsement for this very significant piece of work.

The IPRT was asked to provide strategic and global input to the ATC-61 Project Team on project direction and on development of the major deliverables. We were also asked to ensure that the Project Team remain focused on the "target objectives."

To accomplish this task, the IPRT held seven conference calls over the course of the project and communicated frequently via email to transmit constructive input to you and the Project Team. Members of the IPRT carefully reviewed work product and provided written comments on deliverables; had lively discussions on technical issues needing resolution; and came to consensus on all significant issues. You should know that, in view of the complexity of the tasks involved in providing independent assessment of the benefits and costs of mitigation policies and programs and the critical importance of the results, the IPRT took this task very seriously.

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The IPRT is satisfied with all aspects of the ATC-61 *Final Report: Independent Study to Assess Future Savings from Mitigation*. Having been closely involved with project direction and key decisions affecting project outcomes, we stand by the results, and strongly endorse the report in the highest possible terms.

You and your entire Project Team, especially the core members, Ron Eguchi, Adam Rose, Elliott Mittler, Linda Bourque, Craig Taylor, and Keith Porter, should be very proud of this report, and we commend you for a job extremely well done.

Sincerely,

William J. Petak   David Brookshire   Stephanie A King

Dennis Mileti   Douglas J. Plasencia   Zan Turner

cc: Claret Heider
Tom Tobin
Christopher Rojahn

Appendix B
COMMUNITY STUDIES: DATA COLLECTION GUIDELINES AND QUESTIONNAIRE SPECIFICATIONS

The ultimate goal of the community studies was to help answer two questions: to what degree are mitigation costs beneficial and to what extent are there spin-off benefits that emanate from FEMA Hazard Mitigation Grant Program (HMGP), Project Impact, and the Disaster Mitigation Act of 2000 (DMA, 2000) mitigation activities? The critical elements in this approach may be broken down into five subjects: research method; the pilot community study; the selection of additional communities for study; data gathering procedures and protocols by which data are going to be processed and set-up for analysis; and estimating costs and benefits.

Congress proposed this overall study to find out whether mitigation funding by FEMA has led to future savings or reduced losses for either the federal government or community stakeholders and members who benefited from the mitigation activities. The research question can be rephrased as: what set of conditions would lead to high net savings?

Prior to this study, there has been no systematic examination of what comprises a community's hazard mitigation program, how the program got started, why it got started, if and how it was sustained, and what quantitative impacts individual activities and the portfolio of all activities have made immediately and over time on reducing future community losses (see Mileti, 1999). The community studies were designed to provide data to address these questions, to find what may explain a specific outcome, in this case, future savings or reduced losses from natural hazards.

Guidelines issued to interviewers who conducted data collection interviews follow. The questionnaire used in the interview process is provided at the end of this appendix.

General Guidelines

Interview instructions are printed in all caps; this indicates text that should not be read out loud. Interviewers are to read everything that is not in all caps. To ensure consistency of data collection conditions and consistent meaning of data, it is important for interviewers to pay careful attention to distinguish between categories that are read aloud, and those that are not. The all-cap convention will help make this distinction more easily.

It is highly preferable that interviewers use blue ink. This shows up best against the black-and-white page, and helps speed the time and reduce errors for data entry. Do NOT complete the interview using red ink or pencil, and do not use whiteout.

Any changes to the interview should be initialed and dated. Cross the error out, and write the correction clearly next to the error. Any edits made after the interview is completed should be made in red ink, and also should be initialed and dated. This will allow us to easily track any changes made to the data.

Study Objectives

This study has two main objectives. The study is designed to first, determine the degree to which mitigation costs are beneficial, and second, the extent to which there spin-off benefits that emanate from FEMA HMGP, Project Impact, and DMA 2000 mitigation activities.

Data Collection Forms

There are four different data collection forms: (1) Contact Log, (2) Main Interview, (3) Mitigation Activities (Question 23 of the Main Interview), and (4) Referral Form.

The Contact Log is used to track all communication with potential and actual study participants. Separate Contact Logs may be completed for the same participant if more than one interviewer is contacting the individual. These may be transferred to the same log, or the logs may be stapled together. It is important that we record and enter complete data on all attempted and successful contacts with potential and actual participants.

The Main Interview is completed for each study participant. It includes general questions about efforts in the community to reduce the damage caused by natural disasters.

Question 23 (Q23) collects information about Mitigation Activities that are included in the National Emergency Management Information System (NEMIS); a separate Q23 is completed for each activity in the NEMIS database. It may also be used to collect information about spin-offs from FEMA activities, and other (non-NEMIS) mitigation efforts.

The Referral Form is used to collect information about other potential participants. We want to collect complete information on all individuals who are referred to us, so we will record ID#s and names of ALL referrals on the main interview, and contact information on actual NEW referrals on the Referral Form. This will allow us to link each participant will all of the individuals providing referrals.

Data Tables

The data set is entered in MS Access and includes six data tables: (1) Activities, (2) Communities, (3) Contact Log, (4) Main Interview, (5) Mitigation Activities, and (6) Participants. Each table can be exported to Excel and Statistical Package for Social Sciences (SPSS) software, as desired.

The Activities table records all of the mitigation activities that are asked for in Q23 for each community. This data set will serve as a reference for correctly coding and entering data for the Mitigation Activities in Q23. There is one record per mitigation activity per community.

The Communities table is used to document the ID# assigned to each community. This two-digit code is the first two digits of the participant ID#. There is one record per community.

The Contact Log table is used to document each contact with each potential and actual participant. This is a transactional data set. That is, there is one record per contact.

The Main Interview table collects all of the interview data excluding information about Mitigation Activities, Q23. There is one record per participant.

The Mitigation Activities table collects information for Q23 for each NEMIS activity, as well as for spin-offs and other mitigation activities mentioned, as time permits. There is one record per mitigation activity, per participant.

The Participant table collects information describing each participant including contact and referral information, as well as dates of major study milestones.

Data Entry Forms	There are five data entry forms: (1) Contact Log, (2) Dates, (3) Main Interview, (4) Mitigation Activities, and (5) Referral Form. The Contact Log form is used to enter information from the Contact Log. There is one entry per contact. A check mark written to the right of each entry of the Contact Log indicates that that contact has been entered. The Dates form is used to record the dates of major study milestones and is used to help internal monitoring of study progress. It includes dates of all Introduction and Thank You letters as well as appointment times and interview completion dates. There is one record per participant. The Main Interview form is used to enter data from the Main Interview, excluding Q23 on Mitigation Activities. The interview is initialed and dated on the bottom, right-hand corner to indicate that it has been data entered. The Mitigation Activities form is used to enter each NEMIS and spin-off or other activity discussed in Q23 and Q24, respectively. Each Q23 packet is initialed and dated on the bottom, right-hand corner to indicate that it has been entered. The Referrals form is used to enter contact information collected on the Referral form. There is one record for every person who is mentioned, regardless of whether or not they are pursued for interview. Contact information is initially entered the first time an individual is referred, and is confirmed and augmented during the actual interview with the participant. Thus, the referral data for each participant are entered once, and then updated later. Space is provided on the bottom of this form to indicate when and by whom initial and subsequent data entry has been completed.
Informant Questions Purpose	If the informant questions the purpose of the study, explain that the interview asks about knowledge of natural hazard mitigation programs and that the findings will be used to evaluate the benefits obtained from investment in mitigation activities.
Why This Informant	If you are asked why you are interviewing this particular individual, explain how he or she was referred to you, and that it is very important that we obtain information from the kinds of people she/he, this job title, represents. Indicate that for us to get a complete picture of the community, we need to talk to many different people.

Informant Questions Time Required for Interview	If the informant asks how much time will be required for the interview, state that the usual length is about an hour. Do not say that the interview will take only a few minutes.
Informant Questions Use of Tape Recorder	We will attempt to tape-record each interview so that there will be a back-up copy in the event that information is not written down, it is written down incorrectly, or the paper copy of the interview is inadvertently destroyed. The interviewer must: (1) ask permission to tape-record the interview prior to doing so, (2) document consent on the Interview, and (3) alert the informant whenever the tape recorder is being turned on or off. The tape recorder should be turned on just prior to reading the introduction on the top of page 2 (Q8), and should be turned off after the interview is completed and the final script is read, on page 17. The interviewer should label each tape with the date of the interview, the initials of the interviewer, and the informant ID#. Care must be used in safeguarding the tapes, and securing informant privacy. If an informant questions the use of a tape-recorder, explain that it is to help ensure that we obtain the best and most accurate information possible, that the tapes will be carefully guarded, and will be destroyed after the data have been analyzed.
Refusals	Our experience has been that few informants actually refuse to cooperate. However, if you have difficulty obtaining an interview, explain the purpose and importance of the study and stress the confidential treatment accorded to all information furnished by the informant. This should be done also at any point during the interview if the respondent should hesitate to answer certain questions. If the informant doubts that he/she has anything to contribute, restate the person(s) who identified the informant as someone important for us to talk to and reiterate that it is important for us to talk to many different people in order to get a complete picture of the community.
Your Manner	Your greatest asset in conducting an interview efficiently is to combine a friendly attitude with a businesslike manner. If an informant's conversation wanders away from the interview, try to cut it off tactfully—preferably by asking the next question on the

questionnaire. Over-friendliness and concern on your part about the informant's personal troubles or experiences may lead to your obtaining less information.

It is especially important in this interview that you maintain an objective manner.

Other Languages

All interviews will be conducted in English.

Note: Policy for "Don't Knows"

Whenever the interviewer receives a "don't know" response that is not pre-coded on the questionnaire (alternative answers to questions are not followed by "DON'T KNOW" with separate code number), the interviewer must write clearly the abbreviation "DK" in the right margin next to the response categories. These will be numerically coded following completion of the interview.

Clarifying Notes

Record any notes that may clarify informant responses in the interview margins.

Scales

Cards are not used in this interview because all of the scales are set up in a similar manner. Therefore, alternatives must be read to informants carefully. Circle the appropriate value on the scale. If the informant uses a half-number, ask him or her to choose the best whole number to represent his or her answer.

Probing

We have adopted standards on probing to assist interviewers. This will result in a much better interview.

Unless specified, all open-ended questions require probes to get complete, clear information. Please use the following standards: The probe, "anything else" should never be used. Instead, use, "what else?" It is too easy for the informant just to say "No" in response to this probe.

Never leave an open-ended question without an ending probe (e.g., What else?) that yields a final response, (e.g., "That's all.").
You may probe by repeating keywords (e.g., "Other relevant information?" repeating the question, asking for an example ("give me an example") or asking for explanation ("please explain").
4. Common probes for this interview include: "What else?" "Where else?" "Who else?" "How else?"

Final Probes

Unless specified, all open-ended questions must have a final probe. This is your way of ensuring that the informant has not further information on a subject.

Missing Codes	Missing Values for numeric fields will be distinguished by: (1) Don't Know, (2) Refused, and (3) Not Applicable or Skipped (Not Asked). The entire field width will be coded with 7s, 8s, and 9s, respectively. Thus, appropriate missing values for the 10-point scale items will be 77, 88, and 99. Remember to assign missing value codes for the entire width of the field to ensure that a missing value code is not mistaken for real data. Missing data for text fields shall be left blank.

Editing

Each questionnaire should be edited carefully as soon as possible after its completion, while it is still fresh in your mind. A thorough edit on your part is essential, so that editing at other stages can proceed quickly. The audio recording of the interview may assist you in filling in any gaps. The interviewer edit involves the following tasks: checking that handwriting is legible; no questions have been missed; all SKIP directions have been followed; all information in boxes is coded; code numbers are circled, unless otherwise specified. If you have circled the code for "other", check that you SPECIFY exactly what the "other" is. Remember, editing is more than "tidying up" the questionnaire. It is your way of providing a clear picture of the interview situation and the informant, and of what went on.

Data entry also will occur at this stage, and will be completed by the interviewer. Data entry for each interview will be reviewed by a second interviewer.

Checklist for Editing

Here are some things to check while editing:

- Questions are filled out completely.
- Days and dates in the call log agree with the interview.
- Your writing is legible.
- Skip rules have been followed correctly.
- Specify categories are included for all "Other" responses.

Study Timetable Deadlines

The pilot data community visit occurred the week of September 8th-12th, 2003. The due date for the pilot study report was October 8th, 2003. Timing will continue to be an important issue in this study. Therefore, it is essential that data be processed in a timely and efficient manner. Paper copies of the questionnaires and the accompanying cassette tapes should be forwarded to UCLA following data collection.

Contact Log

The Contact Log is used to document all attempted interactions with informants by telephone, email, fax, and regular mail. When multiple interviews are being scheduled or conducted, logging call activities will help avoid errors and confusion (Bourque & Fielder, 2003). It also will allow us to document our effort to reach informants, and possibly, to justify dropping a particular community.

Information on the Contact Log should be completed for each attempted interview, including contacts for those interviews that are not completed.

Call Script

The Call Script is used to ensure that each informant receives the same basic information about the study prior to agreeing to participate. For this study, we are using the content of the Introduction Letter as a script.

Main Interview

The vast majority of questions was drawn from a draft interview guide prepared by Elliott Mittler and submitted as Appendix 4-C of the July 22nd Community Studies Scoping Report. To assist in the development of the interview guide, Elliott Mittler reviewed two interview guides that were used in Project Impact and that were provided by Kathleen Tierney. These included the "Year III Community Interview Schedule", used for non-pilot communities, and the "Year IV Community Interview Schedule", used for non-Project Impact communities. The questions contained in the Project Impact Interview Guides were considered to be informative, but also to be too limited in scope to cover all of our areas of concern and too simplistic to collect the details we are seeking in the present study. Therefore, Elliott Mittler indicated that he drafted an interview guide appropriate for communities that did receive Project Impact awards, as well as those communities that did not receive such funds.

The interview guide prepared by Elliott Mittler contained four different schedules or sets of questions, with items focused differently for the four different types of respondents based on the respondent's likely familiarity with the content. Because of the large degree of overlap in these items, and also in an effort to simplify procedures, the content of the four interview guides was combined into one general outline of the interview content to be sought. The single interview approach also helps us avoid making a priori assumptions about what informants do and do not know. Additional items relating to project costs and cost-benefit analyses were provided by Stephanie Chang, and these were incorporated into the outline. The outline was included in the 9/22/03 version of the Community Studies Scoping Study as Appendix 4-A to provide members of the Project Management Team with a sense of the range of content areas under consideration. The outline also was used in the Pilot Study to guide interviews.

Next, the outline of potential topics was translated into a structured questionnaire. The structured questionnaire format includes specific wording of questions for each content category listed in the outline. Specific wording for probes, and response formats also were created. During a conference call on 9/15/03, having reviewed only the topical interview outline, the Internal Project Review Team (IPRT) expressed its strong support for the development of a structured questionnaire based on the topical outline. A few suggestions were recommended by the IPRT, and these were incorporated into the current version of the interview guide. A copy of the formatted questionnaire draft is included as an Appendix in the 10/15/03 Community Studies Pilot Study report.

Participant ID# is recorded on the top of pages 1 and 2.

Q1 Questions 1-5 should be completed before the interview, to the greatest extent possible.

Q1 is the name of the community that the interview describes.

Q2 Q2 documents the actual start and end dates of the interview.

Q3 Q3 documents the name of the interviewer; initials are entered in the data table.

Q4 Q4 documents whether the interview was conducted over the telephone or in person, and the number dialed or the location of the interview. Circle the appropriate code. If the interview is completed over the telephone, complete QA (phone number); if the completed in person, complete QB (location). If the interview is completed in person, record (999) 999-9999 in Q4A to indicate the item is not applicable.

Q5 Q5 documents the number and names of any documents provided by the informant prior to the interview. This documentation will help ensure that if a document received at such time is inadvertently misplaced, it will be sought and submitted and the information collected will be as complete as possible. Circle the appropriate code. If documents were provided, answer Q5A and fill in the number of documents provided and the document titles. To avoid confusion, use the exact title printed on the document. If Q5= “no”

(2), then Q5A=99.

Q6 — This records the start time of the interview. Fill in the time you start the interview, and circle "AM" or "PM."

Q7 — This asks the interviewer to review the referral form to make sure that contact information for the informant is complete and accurate. Be sure to confirm telephone number, email address, mailing address, and title, at a minimum. Circle 1 ("yes") or 2 ("no") to indicate if changes have been made to the Referral Form. Mark corrections directly on the Referral Form. The updated contact information will be re-entered following completion of the interview.

Q8-Q9 — These items ask about knowledge about state and local laws, ordinances, or regulations relating to hazard mitigation, respectively. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

Q10-Q12 — These questions ask the informant to rate the community's natural hazard risk, on a scale of 1-to-10, for earthquake, wind, and flood, respectively. On the scale, "1" represents "very low" and "10" represents "very high." Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

Q13 — Q13 asks about the informant's assessment of the community's natural hazard mitigation program. Record the response in the spaces provided. Try to use the informant's own words, and use quotation marks to indicate when you have done so. If there is not enough room, use Q40 to record the response.

Q14 — This item asks for the informant's opinion on whether or not the community has a natural hazard mitigation program. Circle the appropriate code. If the informant indicates, "yes", ask Q15-16; if "no", skip to Q17. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

Q15 — This item asks the informant to rate the natural hazard mitigation program, using a 10-point scale, where "1" means "not very much" and "10" means "very much." Circle the appropriate value on the scale. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

Q16 — This item asks how long the community has had a natural hazard mitigation program. Record the number of years the community has had a program in the spaces provided. Use the blank space to record any information, as needed. Then ask Q21A, when the program started (in what year). Record the year in the spaces provided. For Q16 (YEARS), Don't Know, Refused, and Skipped are coded as 77, 88, and 99. For Q16A (year the program started), Don't Know, Refused, and Skipped are coded as 7777, 8888, and 9999.

Q17	This item asks who is responsible for administering the program. Record the response in the spaces provided. You are seeking both position titles and names, so probe, if necessary.
Q18	This item asks where the natural hazard mitigation program is housed, what department. Record the response in the spaces provided.
Q19	This item asks about the sources of funding for the community's natural hazard mitigation program. Circle all that apply. Probe as necessary. Write notes in margin to clarify. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, and Skipped, enter 7, 8, and 9 for each funding source.
Q20-Q21	These items ask the informant to rate the appropriateness and effectiveness of the community's hazard mitigation efforts for the community's needs using a 10-point scale, where "1" means "not at all appropriate" and "10" means "very appropriate." Circle the appropriate value on the scale. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.
Q22	This item asks the informant to rate how the community's program compares to natural hazard mitigation programs in other communities. Response options are: much worse, somewhat worse, about the same, somewhat better, or much better. Repeat the response options, if necessary, and circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.
Mitigation Activities Q23A-U	This item is to be completed for each mitigation activity that is listed in NEMIS, plus Project Impact, if applicable. Each Q23 is a separate, stapled packet. Record the Participant ID# in the space provided in the upper right corner on the first page of Q23 for each mitigation activity discussed. Prior to the interview, prepare a Q23 packet for each activity listed in NEMIS. (Each of the relevant NEMIS activities for each community should be entered in the Activities table.) Also include some blank Q23 packets for any spin-offs or other mitigation

activities mentioned in Q24.

QA classifies the activity as a NEMIS Project (1), NEMIS Process (2), Project Impact (3), Spin-off (4), Other Project (5), or Other Process (6) activity.

If QA is a NEMIS Project (1) or NEMIS Process (2) award, then record the disaster number and project number in the 8-digit space provided, and code the 2-digit space for the line number from Q24 as 99.

If QA is Project Impact (3), then record 9999-9999 and 99 in the spaces provided for the disaster, project, and Q24 line numbers.

If QA is a spin-off from Q24 (4), then record the disaster number and project number in the 8-digit space provided and record the line number from Q24 in the 2-digit space provided.

If QA is Other Project (5) or Other Process (6) activity, then record 9999-9999 in the space provided for disaster and project number, and code the line number from Q24 in the 2-digit space provided.

Write the project name and description in the space provided.

QB and C ask for the month and year the activity started and ended. Record responses in the spaces provided. Fill in leading zeros. Don't Know, Refused, and Skipped are coded as 77 and 7777, 88 and 8888, and 99 and 9999.

QD asks how the activity was funded. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all funding options.

QE asks about which natural hazards led to the mitigation activity. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all hazards.

QF asks about benefits provided by the activity. Read the entire list. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all benefits.

QF1 asks which of the benefits mentioned was the major objective of the activity. Read the list of all the benefits that were mentioned by the informant. Circle one major objective. Don't Know, Refused, and Skipped are coded as 77, 88, and 99. If the informant is unable to provide a single response, then circle the competing major benefits and enter the codes in the Notes section for Q23.

QG asks if a cost-benefit analysis was conducted. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", QG1 asks where a copy of the analysis can be obtained. If "No", QG2 asks why an analysis was not conducted. Record the responses as given.

QH asks whether the informant can provide any quantitative information about the benefits of the activity. Record response as given in the space provided.

QI asks whether the informant is aware of any studies, reports, or knowledgeable persons who can help describe and quantify the benefits of the activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", Ask QI1, where copies may be obtained or whom we should contact. Record response in space provided.

QJ asks if there are any cost data available about this activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask J1, where the information may be obtained. Record the response in the spaces provided.

QK-M are scale items that ask about familiarity with, involvement in the design, and involvement in the implementation of the activity. Circle the appropriate whole number on the scale. These questions should always be asked for every participant, even if the participant is not familiar with the activity. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

Q29N asks about the informant's roles and responsibilities in the activity. Circle all that apply. If you are not sure how to categorize a role, record the informant's response in the margin. If the informant was not really involved in the activity, circle the appropriate code (7). This question should always be asked for every participant, even if the participant is not familiar with the activity. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all roles.

QO-P are scale items that ask the informant to rate the community's success in achieving the major objective with and without the activity. Circle the appropriate whole number. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

QQ asks if there are any documents like grant announcements, grant applications, or reports that could help describe the activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask Q1, where copies can be obtained. Record the response in the space provided.

QR asks if this was a partnership activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then ask QR1-R6. If "No", go to QS.

QR1 asks what resources were provided through this activity. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all resources.

QR2 asks why this partnership formed. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all reasons.

QR3 asks about indicators of this partnership's success. Record response in space provided.

QR4 asks about indicators of this partnership's failure. Record response in space provided.

QR5 asks about what contributed to making this partnership successful. Record responses in the space provided.

QR6 asks about what contributed to making this partnership unsuccessful. Record responses in the space provided.

QS is used to document if this activity is Project Impact. If "Yes", then ask QS1-S2. If "No", then skip to QT. QS1 asks what else the community did for Project Impact. QS2 asks how Project Impact activities fit into the overall hazard mitigation program. Record responses in spaces provided.

QT asks what else the informant can report to help us understand the activity. Record the response given in the spaces provided.

QU asks if this activity lead to any new hazard mitigation activities. Circle the appropriate response. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then ask QU1, what spin-offs resulted from this activity. If "No", then return to the beginning of Q23, and ask items for the next NEMIS activity until all activities have been completed.

Q24

This item asks about other natural hazard mitigation activities in the community with which the informant is familiar. QA asks for a name or brief description of the activity.

QB asks if this activity was initiated as a result of a FEMA activity. Circle the appropriate code (1=Yes, 2=No). Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then complete QC.

QC documents the Disaster Number and Project Number for the FEMA activity that initiated the spin-off. Don't Know, Refused, and Skipped (not a spin-off) are entered as 7777-7777, 8888-8888, and 9999-9999.

For each spin-off, and for each other mitigation activity, complete Q23, as time permits. Then go to Q25. This study is focused on spin-offs, so it is important that we get complete data for every spin-off possible.

Q25

Complete the box at the top of page 15, prior to Q25; do not read the item in the box aloud. The box asks whether the informant is a community partner. If "Yes", ask Q25. If "No", skip to Q26. Don't Know is coded as 7. Q25 asks if the informant's agency (or the informant if not affiliated with any agency) has any plans for future involvement in hazard mitigation activities? Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

If "Yes", answer A and B. If "No", answer C. Q25A asks how the informant's agency decides what activities to become involved with. Q25B asks why the agency has chosen the hazard mitigation activities they plan to participate in. Q25C asks why the agency is not going to be involved in future hazard mitigation activities. For questions 25A-C, write responses in the space provided.

Q26

This item asks if the community plans to expand its natural hazard mitigation activities. Circle the correct code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask QA-B; if "No", skip to QE.

QA asks for more detail about the community's plans to expand its natural hazard mitigation activities.

QB asks if cost-benefit analyses are performed on each potential project. Circle the correct code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If QB= "Yes", then ask QC and D. If QB="No", then skip to Q27.

QC asks who performs the cost-benefit analysis. Record the response in the space provided.

QD asks how the cost-benefit analyses are conducted. Record the response in the space provided.

QE asks why the community is not planning to expand its natural hazard mitigation activities. Record the response in the spaces provided.

Q27 — Q27 asks for additional contacts, that is, individuals we might be able to interview and who could help us understand the community's natural hazard mitigation activities. For each person suggested, record the name in the side margin, and complete a Referral Form for each name given. Write the corresponding ID#s in the spaces provided following the interview, after ID#s have been assigned. Don't Know, Refused, and Skipped are coded as 7777, 8888, and 9999. When the informant indicates that he/she does not know of any other appropriate referrals, the first blank would be coded as Don't Know, with subsequent blanks coded as Skipped.

Q28 — This item asks if we may contact the informant for additional assistance in the future. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

Q29 — This item records the end time. Circle "AM" or "PM."

Read the script at the bottom of page 17. After thanking the informant, announce that you are turning off the tape recorder, and do so.

Q30-40 — Q30-40 are to be completed after the interview is conducted.

Q30 — This item documents the number of sittings it took to complete the interview. Don't Know is coded as 7.

Q31 — This item documents the length of the interview in minutes. Combine the length of time for each sitting.

Q32 — This item documents whether or not the informant was given a copy of the interview guide. Don't Know is coded as 7.

Q33 — This item records the number and names of any documents provided by the informant at the time of the interview. This documentation also will help ensure that the data collected are as complete as possible. Circle the appropriate code. If documents were provided, fill in the number of documents provided for QA and the document titles for QB. To avoid confusion, use the exact title printed on the document. If Q33 is “No”, QA (number of documents) is coded as 99.

Q34 — This item records the number and names of any documents promised by the informant at the time of the interview. This documentation also will help ensure that the data collected are as complete as possible. Circle the appropriate code. If documents were provided, fill in the number of documents provided for QA and the document titles for QB. To avoid confusion, use the exact title printed on the document. If Q34 is “No”, QA (number of documents) is coded as 99.

Q35 — This item asks if the interviewer is already acquainted with the informant. Circle the code for “Yes” if any of the interviewers present during the interview is already acquainted with the informant. If “Yes”, ask QB, length of acquaintance. Fill in the number of months and/or years of the acquaintance in the spaces provided. The information collected in this item may be used to answer questions regarding potential interviewer bias.

Q36 — Use the 10-point scale to rate how cooperative the informant was, with “1” meaning “not at all cooperative” and “10” meaning “extremely cooperative.” Circle the appropriate response.

Q37 — Use the 10-point scale to rate how knowledgeable the informant was, with “1” meaning “not at all knowledgeable” and “10” meaning “extremely knowledgeable.” Circle the appropriate response.

Q38 — Use the 10-point scale to rate how biased the informant seemed, with “1” meaning “not at all biased” and “10” meaning “extremely biased.” Circle the appropriate response.

Q39 — This item asks if there was anything unusual about this interview. If “Yes”, explain in space provided for QA.

Q40 — This item provides space for any additional comments or explanations pertaining to the interview. Use the space provided to record notes.

ID# ____ ____ ____ ____

QUESTIONNAIRE

COMPLETE BEFORE INTERVIEW:

1. COMMUNITY NAME______________________________ COMMUNITY ID ___ ___

2. INTERVIEW DATE ___ ___ / ___ ___ / ___ ___ ___ ___ / ___ ___ / ___ ___
START DATE END DATE

3. INTERVIEWER ____

4. INTERVIEW TYPE

TELEPHONE...................COMPLETE A................. 1
FACE-TO-FACE.............COMPLETE B................ 2

A. NUMBER DIALED: (___ ___ ___) ___ ___ ___ - ___ ___ ___ ___

B. INTERVIEW LOCATION ____

5. WERE ANY DOCUMENTS RECEIVED FROM THIS INFORMANT PRIOR TO THE INTERVIEW?

YES .... ANSWER A & B...................... 1
NO... 2

A. HOW MANY DOCUMENTS? ____ ____

B. LIST DOCUMENT TITLES:
1) ____
2) ____
3) ____
4) ____
5) ____
6) ____

ID# ____ ____ ____ ____

6. INTERVIEW START TIME: ___ ___ : ___ ___ AM / PM

7. REVIEW REFERRAL FORM.
IS CONTACT INFORMATION COMPLETE AND ACCURATE?

YES	1
NO , UPDATE CONTACT DATA............................	2

CONSENT FOR TAPE (CIRCLE): YES...1, OR NO...2.

I'm going to turn the tape-recorder on now. TURN ON TAPE RECORDER. Thank you for agreeing to talk to us about hazard mitigation activities in <COMMUNITY>. I want to start by asking you some general questions about the community.

8. As far as you know, are there any state laws, ordinances, or regulations relating to hazard mitigation in <COMMUNITY>?

YES ....ASK A	1
NO	2
INFORMATION ALREADY OBTAINED..............	9

A. Please tell me about them.

1) ____

2) ____

3) ____

9. As far as you know, are there any local laws, ordinances, or regulations relating to hazard mitigation in <COMMUNITY>?

YES ....ASK A	1
NO	2
INFORMATION ALREADY OBTAINED..............	9

A. Please tell me about them.

1) ____

2) ____

3) ____

I want to ask you some questions about your assessment of <COMMUNITY'S> natural hazard risk.

10. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for earthquake?

    1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

    Very Low ... ***Very High***

11. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for wind?

    1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

    Very Low ... Very High

12. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for flood?

    1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

    Very Low ... Very High

Now I want to talk about the community's overall natural hazard mitigation program.

13. What is your assessment of the community's overall natural hazard mitigation program?

    ____

    ____

    ____

    ____

    ____

    ____

14. In your opinion, does the community have a natural hazard mitigation program?

YES	CONTINUE	1
NO	SKIP TO Q17	2

15. On a scale of one-to-ten, where 1 means "not very much" and 10 means "very much", how much do you know about <COMMUNITY'S> natural hazard mitigation program?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not very Much ... Very Much

16. How long has <COMMUNITY> had a natural hazard mitigation program?

____ YEARS: ____ ____

A. When did the natural hazard mitigation program start? ___ ___ ___ ___

17. Who is responsible for administering the program?

____

____

____

18. Where is the program housed, what department?

____

____

____

19. What are the sources of funding for <COMMUNITY'S> natural hazard mitigation program?
CIRCLE ALL THAT APPLY

HMGP/FEMA...	1
PROJECT IMPACT....................................	2
OTHER FEDERAL FUNDING....................	3
STATE FUNDING	4
PRIVATE ORGANIZATIONS	5
OTHER..	6

SPECIFY: ____

20. On a scale of one-to-ten, where 1 means "not at all appropriate" and 10 means "very appropriate", how <u>appropriate</u> do you consider these efforts for the community's needs?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not at all Appropriate — Very Appropriate

21. On a scale of one-to-ten, where 1 means "not at all effective" and 10 means "very effective", how <u>effective</u> do you consider these efforts?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not at all Effective — Very Effective

22. In your opinion, how does this community's program compare to natural hazard mitigation programs in other communities? Would you say that it is:

much worse,..	1
somewhat worse,...	2
about the same, ...	3
somewhat better, or..	4
much better?..	5

COMPLETE QUESTION 23 FOR EACH ACTIVITY INCLUDED IN THE NEMIS DATASET, AND FOR PROJECT IMPACT, IF APPLICABLE.

23. Now I want to find out about specific hazard mitigation activities that have been conducted in <COMMUNITY>.

A. WHAT TYPE OF ACTIVITY IS THIS? (CIRCLE ONE)

- NEMIS PROJECT.................... 1 __ __ __ __ - __ __ __ __
- NEMIS PROCESS .... 2 __ __ __ __ - __ __ __ __
- PROJECT IMPACT 3
- SPIN-OFF (Q23U, Q24) .... 4 __ __ __ __ - __ __ __ __; Q23A1#: __ __
- OTHER PROJECT (Q24) .... 5 Q23A1#:__ __
- OTHER PROCESS (Q24)......... 6 Q23A1#:__ __

First (Now) I want to know about ____.
ACTIVITY TITLE OR DESCRIPTION

B. When did < ACTIVITY> start? That is what month and year? ___ ___ / ___ ___
MONTH YEAR

C. When did it end? ___ ___ / ___ ___
MONTH YEAR

D. How was <....> funded? CIRCLE ALL THAT APPLY

- HMGP/FEMA.............................. 1
- PROJECT IMPACT 2
- OTHER FEDERAL 3
- STATE FUNDS............................ 4
- COMMUNITY FUNDS 5
- PRIVATE FUNDS 6
- OTHER... 7
  SPECIFY:______________________

E. Was <...> done because of:

CIRCLE ALL THAT APPLY

- Flood,... 1
- Wind, or....................................... 2
- Earthquake? 3

F. Which of the following benefits were provided by < ...>? Would you say:

F. CIRCLE ALL THAT APPLY.	F. BENEFITS	F1. MAJOR OBJ.
Reducing deaths, injuries, and illnesses	1	1
Reducing stress and trauma	1	2
Reducing property damage	1	3
Reducing infrastructure damage	1	4
Reducing emergency response and management costs	1	5
Reducing residents' disruption and displacement	1	6
Reducing business disruption	1	7
Reducing government disruption	1	8
Reducing environmental damage	1	9
Reducing damage to historic sites	1	10
Reducing insurance premiums	1	11
Improving emergency response capacity	1	12
Improving disaster mitigation capacity	1	13
Stimulating private sector mitigations	1	14
New knowledge about hazards and their impacts	1	15
Public education about risks and risk reduction options	1	16
Increase in property values	1	17
Environmental benefits	1	18
What other benefits were provided? SPECIFY: ______	1	19
What other benefits were provided? SPECIFY: ______	1	20
What other benefits were provided? SPECIFY: ______	1	21

F1. In terms of providing the benefits you mentioned, what was the major objective of this activity?

READ ANSWERS GIVEN BACK TO RESPONDENT. RECORD IN F1, ABOVE. CIRCLE ONLY ONE.

G. Was a cost-benefit analysis done for <...>?

YES...............ASK G1.................. 1
NO................GO TO G2............. 2

G1. Where can we get a copy of the cost benefit analysis?

____
RECORD AS GIVEN

G2. Why wasn't a cost benefit analysis done?

____
RECORD AS GIVEN

H. Can you provide any quantitative information about the benefits of this activity? PROBE: Any estimates of benefits in either physical (e.g., lives saved) or monetary terms?

____
RECORD AS GIVEN

I. Are you aware of any studies, reports, or knowledgeable persons that can help us describe and quantify the benefits of this activity?

YES.......ASK I1 1
NO.........GO TO J...................2

I1. Where could we get copies of these reports or whom should we contact?

____
RECORD AS GIVEN

J. Are there any cost data available about this activity?

YES.......ASK J1 1
NO.........GO TO K 2

J1. Where could I get this information?

____
RECORD AS GIVEN

K. On a scale of 1 to 10, where 1 means "not at all familiar" and 10 means "extremely familiar," how <u>familiar</u> are you with this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Not at all Familiar — Extremely Familiar

L. On a scale of 1 to 10, where 1 means "not at all involved" and 10 means "extremely involved," how involved were you in the <u>design</u> of this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Not at all Involved — Extremely Involved

M. On a scale of 1 to 10, where 1 means "not at all involved" and 10 means "extremely involved," how involved were you in the <u>implementation</u> of this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Not at all Involved — Extremely Involved

N. What were your roles and responsibilities in this activity or were you not really involved? Were you involved in:

<u>CIRCLE ALL THAT APPLY</u>

Priority setting 1
Planning 2
Carrying out activities....................................... 3
Providing resources... 4
Educating the community 5
What else?... 6
SPECIFY: ______________________________

____

Not really involved 7

O. Thinking back to the major objective or benefit of this activity, <INSERT FROM F1>, on a scale of 1 to 10 where 1 means "extremely low" and 10 means "extremely high," how would you rate the community's success in meeting this objective with this activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Extremely Low ... Extremely High

P. How would you rate the community's success in meeting this objective without this activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Extremely Low ... Extremely High

Q. Are there any documents like grant announcements, applications, or reports that could help me describe this activity?

YES.............ASK Q1.................... 1
NO...............GO TO R.................. 2

Q1. Where can I get copies of those documents?

____
____
____
____

R. Was this a partnership activity?

YES........... ASK R1-R6.. 1
NO. .... GO TO S.. 2

R1. What resources were provided through this activity?

Time 1
Technology.. 2

Skills.. 3
Money.. 4
Materials... 5
Audience 6
Equipment 7
Other (SPECIFY: ________________________________)...... 8
Other (SPECIFY: ________________________________)...... 9

R2. Why did this partnership form? PROBE: What other reasons were there for this partnership?

Internet 1
Personal Friendship.. 2
Community Betterment.. 3
Company Policy of Good Citizenship.. 4
Properties at Risk 5
Other (SPECIFY: ______________________________).......... 6
Other (SPECIFY: ______________________________).......... 7

R3. What are some indicators of this partnership's success?

____

R4. What are some indicators of this partnership's failure?

____

R5. What do you think contributed to making this partnership successful?

____

R6. What do you think contributed to making this partnership unsuccessful?

____

S. IS THIS PARTICULAR ACTIVITY PROJECT IMPACT?

....................................YES..ASK S1 AND S2 1

....................................NO..SKIP TO T 2

S1. What else did the community do for Project Impact?

S2. How did the Project Impact activities fit into the overall hazard mitigation program?

T. What else can you tell me about this activity that would help me understand it?

____

____

____

____

____

____

U. In your opinion, did this project lead to any <u>new</u> hazard mitigation activities?

Yes, this activity created spin-off activities .... ASK U1 1

No, there was no spin-off from this
activity into others.. RETURN TO Q23.......... 2

U1. What other activity or activities were spin-offs from this activity?

____

____

____

RECORD IN Q24 GRID. COMPLETE Q23 FOR EACH SPIN-OFF.

COMPLETE Q23 FOR NEXT ACTIVITY.

WHEN ALL ACTIVITIES ARE DESCRIBED,
GO TO Q24, STARTING WITH SPIN-OFFS.

DOUBLE-CHECK USING NEMIS TABLE.

24. A. What other natural hazard mitigation activities do you know about in <*community*>? What else? B. Was this activity initiated as a result of a FEMA activity? C. What FEMA activities led to <…>?

Now I'd like to talk some more about <OTHER ACTIVITY>.

COMPLETE Q23 FOR EACH ACTIVITY THAT WAS A SPIN-OFF FROM A FEMA MITIGATION ACTIVITY.

COMPLETE Q23 FOR ADDITIONAL OTHER MITIGATION ACTIVITIES, AS TIME PERMITS.

A. OTHER MITIGATION ACTIVITIES…	B. SPIN-OFF FROM FEMA ACTIVITY? YES NO	C. WHICH FEMA ACTIVITY?	
		RECORD DISASTER # FROM Q23.	RECORD PROJECT # FROM Q23.
1.	1...............2		
2.	1...............2		
3.	1...............2		
4.	1...............2		
5.	1...............2		
6.	1...............2		
7.	1...............2		
8.	1...............2		
9.	1...............2		
10.	1...............2		

IS THE INFORMANT A COMMUNITY PARTNER?

YES (REFERRAL FORM Q6=4)........................ASK Q25.......................1

NO...GO TO Q26...................2

25. Does your agency have any plans for future involvement in hazard mitigation activities?

YES .... ANSWER A & B 1

NO........................ANSWER C 2

A. How does your agency decide what activities to become involved with?

____

____

____

____

B. Why did your agency choose the activities you are planning to participate in?

____

____

____

____

C. Why isn't your agency going to be involved in future hazard mitigation activities?

____

____

____

26. Does the community have plans to expand its natural hazard mitigation activities?

YES	ASK A-D	1
NO	ASK E	2

A. Tell me about this.

____

____

____

____

____

____

B. Are cost-benefit analyses performed on each potential project?

YES	ASK C & D	1
NO	GO TO Q27	2

C. Who performs the cost-benefit analysis?

____

____

____

____

D. How are the cost-benefit analyses conducted?

____

____

____

____

E. Why isn't the community planning to expand its natural hazard mitigation activities?

____

____

____

____

27. ASK FOR ADDITIONAL CONTACTS USING REFERAL FORM, Q4.
COMPLETE REFERRAL FORM FOR EACH NAME GIVEN.

DID THE INFORMANT PROVIDE REFERRALS?

YES, PROVIDED NEW REFERRALS .... 1 (RECORD ID#S BELOW)
NO, PROVIDED ONLY DUPLICATES .... 2 (RECORD ID#S BELOW)
NO, PROVIDED NO REFERRALS 3

#__ __ __ __ #__ __ __ __ #__ __ __ __
#__ __ __ __ #__ __ __ __ #__ __ __ __
#__ __ __ __ #__ __ __ __ #__ __ __ __

28. If we need to ask you anything else, can we contact you again?

Yes 1
No 2

29. INTERVIEW END TIME ___ ___ : ___ ___ AM / PM

That is the end of the interview. Thank you again for your time and the information you provided.
TURN TAPE RECORDER OFF.

COMPLETE AFTER INTERVIEW:

30. HOW MANY "SITTINGS" DID IT TAKE TO COMPLETE THE INTERVIEW? _____

31. HOW LONG DID THE INTERVIEW TAKE TO COMPLETE? ___ ___ ___ MIN.

32. WAS THE INFORMANT GIVEN A COPY OF THE INTERVIEW GUIDE?

YES	1
NO	2

33. DID THE INFORMANT <u>PROVIDE</u> ANY DOCUMENTS <u>DURING THE INTERVIEW</u>?

YES .... ANSWER A & B......................	1
NO	2

A. HOW MANY DOCUMENTS? ____ ____

B. LIST DOCUMENT TITLES:

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

34. DID THE INFORMANT <u>PROMISE</u> ANY DOCUMENTS DURING THE INTERVIEW?

YES ....ANSWER A & B........................ 1
NO 2

A. HOW MANY DOCUMENTS? ____

B. LIST DOCUMENT TITLES:
1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________
5) ______________________________

35. WAS THE INTERVIEWER ALREADY ACQUAINTED WITH THE INFORMANT?

YES ....ANSWER A............................... 1
NO ....GO TO Q36 2

A. LENGTH OF ACQUAINTANCE....................... ___ ___ ___ MONTHS

36. HOW COOPERATIVE WAS THIS INFORMANT?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL COOPERATIVE — EXTREMELY COOPERATIVE

37. HOW KNOWLEDGABLE WAS THIS INFORMANT?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL KNOWLEDGABLE — EXTREMELY KNOWLEDGABLE

38. HOW BIASED DID THIS INFORMANT SEEM?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL BIASED — EXTREMELY BIASED

39. WAS THERE ANYTHING UNUSUAL ABOUT THIS INTERVIEW?

YES..................ASK Q39A................................. 1
NO.. 2

A. EXPLAIN:

40. RECORD ANY OTHER NOTES PERTAINING TO THE INTERVIEW HERE:

Appendix C
DEMOGRAPHIC CHARACTERISTICS OF COMMUNITIES

As reported in the 2000 Census, the demographic characteristics of the eight communities selected for study are diverse (Table C-1). Communities vary in size from 15,527 to 662,047; median age varies from 31.9 to 38.6 years. Two communities have very few non-white inhabitants while two communities are more than 50 percent non-white. The proportion of households with a child under the age of 18 varies from 28.2 to 43.5 percent and the percentage of female-headed households with children varies from 5.5 to 9.3 percent. Households with persons over 64 years of age range from 19.3 to 29.9 percent. With the exception of a resort community with a 33 percent vacancy rate of primarily seasonal housing, vacant units range from 2.3 to 8.6 percent, and the proportion of renter-occupied units ranges from a low of 15.9 percent to a high of 46.8 percent. Labor force participation by persons over the age of 16 is between 61.5 and 69 percent, with a median family income between $42,245 and $64,573, a per capita income between $16,686 and $24,294, and the percent of families below the poverty level ranging from 5.4 to 11.6 percent. Poverty rates are correlated with median family income and percent in the labor force, but do not appear to be correlated with the percent non-white, percent of female-headed households or with the percent of households with persons over 64. Median family income is correlated positively with having children under 18 and negatively with having an adult over 64.

Tables C-2 through C-4 show how the demographic characteristics of communities selected for study compare with those of other communities in the population. In each table, communities selected for study are compared with other communities that were the same size, in the same FEMA region, and received the same combination of awards.

C.1 Communities with Grants for Earthquake

The first set of communities received awards only for earthquakes. The two selected communities differ from each other and from the three unselected communities (Table C-2). Common to all five communities is the fact that they are all in California. Median age is similar for all five communities and at least 26 percent of each community is non-white, but the proportion of female-headed households (4.7-9.9 percent), renter-occupied units (37.4-59.5 percent) and income varies substantially.

C.2 Communities with Grants for Flood and Wind

No communities in the sample received FEMA grants only for mitigation of wind hazards, or for a combination of flood and earthquake hazards. Two communities in the sample (of four in the NEMIS file) received grants only for flood mitigation but the two are different in population and in region (Table C-3). Thus, it is not surprising that they differ substantially in demographic characteristics with one community having essentially no non-white residents as well as having a somewhat older population.

The largest number of communities in both the population and the sample were communities that received FEMA grants for both flood and wind. As seen in Table C-4, most of the small communities meeting this criterion are in Region IV, but none of these 12 small communities in Region IV that received grants for flood and wind were studied. Two small communities in Region II, both located on the coast, received FEMA grants for flood and wind. The unselected community is a resort community with a small permanent population, few non-whites, relatively few households with children and nearly 40 percent of the households containing persons over age 64. The selected community is 53.2 percent non-white with 43.5 percent of households containing children.

The remaining two communities in the sample are one of three medium-sized communities, all located in Michigan, and one of three large communities, all located in Region IV, that received grants for flood and wind. In contrast to other strata, demographic characteristics within these two strata are homogeneous. The selected community in Michigan is the smallest community in the strata with a somewhat older population (median age = 37.0), few non-whites (2.8 percent), 37.2 percent of households having children, and 24.1 percent having persons over 64. Sixteen percent of households are renter occupied (range: 15.9-20.7 percent), and 8.2 percent are vacant (range: 5.4-8.2 percent). Sixty-two percent of persons over 16 are in the labor force (range: 61.7-72.5 percent), median family income is $46,729 (range: $46,729-$59,896), per capita income is $17,985 (range: $17,985-21,676), and 5.4 percent of families are below the poverty level (range: 3.1-6.7 percent).

The large community selected from Region IV has a population of 662,047 (range: 662,047-695,454) with a median age of 36 (range: 33.1-36.7) and 41.3 percent non-white (21.4-41.3 percent). Thirty-five percent of households have children (range: 32.8-35.2 percent) and 9.3 percent are female-headed households with children (range: 7.6-9.3 percent). Twenty-five percent of households have persons over 64 (range: 15.3-24.7 percent). Renters occupy 33.5 percent of households (range: 35.1-37.7 percent) and 8.6 percent of households are vacant (6.2-8.6 percent). Median income is $45,951 (range: $45,951-60,608), per capita income is $20,892 (range: $20,892-27,352), 61.5 percent are in the labor force (range: 61.5-72.4 percent), and a relatively high percentage of families, 11.6 percent, are below the poverty line (range: 6.6-11.6 percent).

The last stratum contains one community, which was selected and studied. This is community 03 in Table C-1, which is one of 56 medium-sized communities, one of 30 communities in Region IV, and the only community that received grants for earthquake, flood and wind.

C.3 Summary

In summary, there is substantial diversity both across the eight selected communities and between each selected community and the other communities in the population it was selected to represent.

Sources: Demographic profile tables for each community were obtained using the *American FactFinder* on the U.S. Census Bureau's website: http://factfinder.census.gov. The variables "Population" through "Renter-Occupied" were taken from: DP-1. Profile of General Demographic Characteristics: 2000, Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data. The variables "In Labor Force >16" through "Families Below Poverty Level, 1999" were taken from: DP-3. Profile of Selected Economic Characteristics: 2000, Data Set: Census 2000 Summary File 3 (SF 3) Sample Data.

Note: The variable “Non-White” was calculated using the percentage of White under the heading, “Race alone or in combination with one or more other races.”

Table C-1 Demographic characteristics of eight communities in the community studies sample

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
01	140,030	31.9	51.8	7.7	42.5	22.2	2.4	46.8	63.8	54,712	19,695	7.2
02	662,047	36.0	41.3	9.3	34.8	24.7	8.6	33.5	61.5	45,951	20,892	11.6
03	196,629	38.3	18.0	6.6	29.5	25.4	33.0	27.0	64.2	42,676	19,949	8.4
04	43,783	34.6	53.2	9.0	43.5	24.5	2.3	34.8	64.8	61,673	21,288	8.0
05	15,527	38.6	2.4	6.1	28.2	29.9	6.7	40.4	64.0	42,245	16,686	6.5
06	58,266	37.0	2.8	5.5	37.2	24.1	8.2	15.9	61.7	46,729	17,985	5.4
07	660,486	34.9	17.4	6.5	29.1	19.3	5.7	43.1	69.0	51,118	22,606	8.2
08	128,821	33.2	26.3	6.0	40.8	20.9	2.3	37.4	66.5	64,573	24,294	6.8

Table C-2 Demographic characteristics of study communities that received FEMA grants for earthquakes only (communities 01 and 08) compared to those with similar sample criteria*

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
A	102,743	32.5	36.3	4.7	19.8	17.7	4.1	57.3	65.8	70,434	30,477	8.3
01	**140,030**	**31.9**	**51.8**	**7.7**	**42.5**	**22.2**	**2.4**	**46.8**	**63.8**	**54,712**	**19,695**	**7.2**
B	399,484	33.3	65.3	9.9	33.5	20.9	4.3	58.6	61.6	44,384	21,936	16.2
08	**128,821**	**33.2**	**26.3**	**6.0**	**40.8**	**20.9**	**2.3**	**37.4**	**66.5**	**64,573**	**24,294**	**6.8**
C	108,724	32.0	26.8	5.5	32.0	17.0	3.0	59.5	69.2	55,456	23,342	8.2

*Communities 01 and 08 are two of the 56 medium-sized (50,000-499,999) communities in the NEMIS population of 113; two of the 10 communities that received FEMA awards only for earthquakes; two of the 30 communities at high risk of earthquakes; and two of the nine communities located in Region IX. Both communities are included in Table 3-1, Received HMGP and/or Project Impact Grants for Earthquake Only, *Track B Scoping Study,* September 22, 2003, page 43.

Table C-3 Demographic characteristics of study communities that received FEMA grants for floods only (communities 05 and 07) compared to those with similar sample criteria

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
Small (10,000-49,999) Communities in Region VI												
D	10,489	37.7	7.0	6.8	37.8	21.4	10.0	39.7	67.7	70,043	26,420	4.9
Small (10,000-49,999) Communities in Region VIII												
05[1]	**15,527**	**38.6**	**2.4**	**6.1**	**28.2**	**29.9**	**6.7**	**40.4**	**64.0**	**42,245**	**16,686**	**6.5**
E	11,893	40.3	3.1	5.6	27.9	32.3	10.4	37.1	64.8	40,234	18,275	8.1
Large (≥500,000) Communities in Region X												
07[2]	**660,486**	**34.9**	**17.4**	**6.5**	**29.1**	**19.3**	**5.7**	**43.1**	**69.0**	**51,118**	**22,606**	**8.2**

[1]Community 05 is one of 46 small (10,000-49,999) communities in the NEMIS population of 113; one of 38 that received FEMA awards only for floods; one of the 64 communities considered at high risk of floods; and one of seven communities in Region VIII. Community 05 and Community E are the only two communities in the population that meet all four criteria: small, awards for flood only, at high risk of flood, and in Region VIII.

[2]Community 07 is one of 11 large (≥ 500,000) communities in the NEMIS population; one of 38 that received FEMA awards only for floods; one of 64 considered at high risk of floods; and one of nine communities in Region X. Community 07 is the only community in the population that meets all four criteria: large, awards for flood only, at high risk of flood, and in Region X.

Table C-4 Demographic characteristics of study communities that received FEMA grants for floods and wind (communities 02, 04 and 06) compared to those with similar sample criteria

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 Years %	House-hold with Child < 18 Years %	House-hold with Member > 64 Years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level, 1999 %
Small (10,000-49,999) Communities in Region II												
04*	**43,783**	**34.6**	**53.2**	**9.0**	**43.5**	**24.5**	**2.3**	**34.8**	**64.8**	**61,673**	**21,288**	**8.0**
F	15,378	47.8	5.7	4.5	18.4	37.7	63.2	38.0	60.7	61,731	33,217	4.3
Small (10,000-49,999) Communities in Region IV												
G	19,973	38.7	18.4	7.5	29.5	27.3	6.1	35.9	66.8	45,791	21,085	7.3
H	42,987	22.6	21.0	4.4	19.9	10.4	8.1	59.1	56.1	55,619	16,431	14.0
I	12,938	36.3	14.7	6.4	34.7	26.0	9.7	31.0	65.2	40,200	19,690	8.3
J	38,978	39.0	36.4	9.9	29.5	34.9	12.5	36.4	50.3	31,740	15,610	18.1
K	24,757	32.6	17.2	9.0	52.1	13.8	6.6	21.7	68.8	53,132	19,897	6.5

*Community 04 is one of 46 small (10,000-49,999) communities in the NEMIS population of 113; one of 49 communities that received FEMA awards for floods and wind; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of four communities in Region II. Community 04 and Community F are the only two communities in the population that meet all four criteria: small, awards for flood and wind, at high risk of flood and wind, and in Region II.

Table C-4 continued

Community	Population	Median Age	Non-White %	Female-Headed Household with Child < 18 Years %	Household with Child < 18 Years %	Household with Member > 64 Years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level, 1999 %
L	10,916	37.1	8.6	5.6	36.1	26.5	9.3	20.0	60.0	39,240	15,722	10.3
M	25,944	33.8	55.9	13.1	34.8	27.0	9.4	45.7	57.9	32,596	16,848	21.0
N	17,320	35.7	11.2	9.1	39.6	21.8	8.9	33.7	65.7	50,014	19,305	7.7
O	14,692	36.2	6.5	5.0	49.6	15.4	2.4	6.1	75.1	77,202	29,082	2.1
P	13,472	21.4	5.5	2.3	10.6	15.0	7.9	70.5	57.7	49,762	12,256	9.2
Q	41,082	38.8	26.5	6.0	33.5	25.2	22.8	17.4	58.5	41,633	17,882	9.5
R	10,974	48.1	4.7	3.3	17.3	31.2	70.1	28.0	59.9	46,052	27,006	5.1
Medium (50,000-499,999) Communities in Region V												
06[3]	**58,266**	**37.0**	**2.8**	**5.5**	**37.2**	**24.1**	**8.2**	**15.9**	**61.7**	**46,729**	**17,985**	**5.4**
S	110,157	38.4	3.6	6.6	33.0	25.7	5.4	20.7	62.8	48,111	19,698	6.7
T	238,314	32.3	7.2	4.9	41.2	19.1	6.0	19.3	72.5	59,896	21,676	3.1
Large (≥ 500,000) Communities in Region IV												
02[4]	**662,047**	**36.0**	**41.3**	**9.3**	**34.8**	**24.7**	**8.6**	**33.5**	**61.5**	**45,951**	**20,892**	**11.6**
U	693,604	36.7	21.4	8.7	32.8	23.5	6.2	35.1	65.0	49,161	22,352	9.5
V	695,454	33.1	34.8	7.6	35.2	15.3	6.6	37.7	72.4	60,608	27,352	6.6

[3]Community 06 is one of 56 medium-sized (50,000-499,999) communities in the NEMIS population, one of 49 that received FEMA awards for wind and flood; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of eight communities in Region V. Communities S and T are the only other communities that meet all four of these criteria.

[4]Community 02 is one of 11 large (≥500,000) communities in the NEMIS population, one of 49 that received FEMA awards for wind and flood; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of thirty communities in Region IV. Communities U and V are the only other communities that meet all four of these criteria.

Appendix D
ASSUMPTIONS AND LIMITATIONS

D.1 Benefit-Cost Analysis of FEMA Mitigation Grants - Assumptions

D.1.1 Overall

Risk neutrality. This is a benefit-cost analysis, which requires the assumption of risk neutrality.

Seventeen categories of costs and benefits. Benefits were calculated as the expected present value of reduction in uncertain future losses. Costs were calculated as the expected present value of the cost to undertake a mitigation measure. Ten categories of benefit and seven categories of cost were considered, as listed in Tables 2 and 3 of the scoping study report for the benefit-cost analysis of FEMA mitigation grants (ATC, 2003a). Other benefits and other costs were ignored.

Constant 50-year or 100-year planning period. Unless otherwise noted, property mitigation efforts were assumed to be effective for 50 years for ordinary structures or 100 years for important structures and infrastructure, regardless of the age of the property mitigated. For convenience, mitigation efforts were treated as if they became effective on January 1, 2002 and remain effective until December 31, 2052.

Constant discount rates. Future economic values were brought to present value at time-constant discount rates of 2%, and results were sensitivity tested to discount rates between 0% and 7%. Value of human health was not discounted.

Present value of past prices per Consumer Price Index (CPI). All past prices were brought to present value (as of January 1, 2002) per the Consumer Price Index (U.S. Dept. of Labor, Bureau of Labor Statistics, 2004).

D.1.2 Repairs, Casualties, and Environmental Impacts

Accuracy of FEMA data. This project used as input three FEMA resources: the NEMIS database provided on July 23, 2003, geocoded information on flood projects provided on February 9, 2004, and data gleaned from FEMA grant applications. These data were assumed to be correct. (Note that limited Quality Control was performed on these data, per Porter [2004a]).

Accuracy of USGS and California Geologic Survey (CGS) site soil data. The US Geological Survey and the California Geological Survey have compiled GIS maps of site soils in California and elsewhere. See, e.g., Wills et al. (2000). These data were assumed to be accurate.

Accuracy of HAZUS-MH. The project team relied on the use of HAZUS-MH for estimates of mean annualized losses for earthquake and hurricane wind losses. While its accuracy remains to be fully proven over the course of time, it nonetheless, represents the only available national standard multi-hazard loss-estimation tool. The project team did not undertake testing or validation of the software.

Estimation of Flood Losses. Because the flood module in HAZUS-MH was in a pre-beta state at the time these analyses were conducted, the project team had to develop a less sophisticated and more empirically-based approach for estimating flood losses for large property portfolios. This new development pertained mainly to the estimation of flood depths. The project team, however, utilized the damage functions that are contained in the HAZUS flood module to estimate expected damage given a particular flood depth.

Adequacy of assumed hazard strata. The project team assumed that hazard levels can be stratified as low, medium, or high, for each of three perils: flood, earthquake, and wind. The stratification scheme for wind and earthquake is defined in the scoping study report for the benefit-cost analysis of FEMA mitigation grants (ATC, 2003a); the flood hazard stratification scheme is defined in an internal written communication (Porter, 2004b).

Value of human health per FHWA assumptions. Values were assumed for unpriced resources, most notably the environment and human health. For human health, values for statistical deaths and injuries per FHWA (1994) were assumed.

Constant hazard levels. Unless otherwise noted, hazard levels were assumed to be time-invariant as codified in HAZUS-MH.

Projects approved before 1 January 1994 were ignored. Per McLane (2004), the project excluded from its scope of work all projects with an approval date of December 31, 1993 or earlier.

No interaction between projects. Unlike the Community Studies, The benefit-cost analysis of FEMA mitigation grants assumed no interaction between mitigation efforts, i.e., mitigation effort X does not increase or reduce costs or benefits for mitigation effort Y, for different X and Y.

D.2 Benefit-Cost Analysis of FEMA Mitigation Grants - Limitations

D.2.1 Repairs, Casualties, and Environmental Impacts

Sociological benefits are probably underestimated. The major limitations in evaluating the sociological benefits of mitigation are: (1) sociological benefits are not easily quantifiable; (2) sociological benefits are very rarely included in cost-benefit analysis and as a result, there are not state-of-the-art models to build from; (3) sociological data are not readily and easily available; and (4) because of the difficulties of data collection, the quantifiable sociological benefits of mitigation are limited to two major variables: casualties and displaced households. As a result, sociological benefits of mitigation are probably underestimated.

Environmental benefits may be underestimated because of lack of data. The major limitation in evaluating the environmental benefits is the lack of information on the environmental effects of any given mitigation project. Without this information, the project team assumed that the environmental benefits are zero or a very small component of the total benefits. As a result, environmental benefits will tend to be underestimated.

D.2.2 Direct Business Interruption

1-3 year old Business Interruption (BI) data. Most input data for direct business interruption calculations are 1-3 years old. There is no known bias, although accuracy is less by some unknown amount than if current BI data were available.

Several HAZUS default values used. The following variables will always require the use of HAZUS default values: relocation costs, repair duration, building recovery time, rental income, and recapture factor. See Table 2 of the *Project Pilot Study: St. Agnes Medical Center* (ATC, 2003b) for the location of HAZUS default values. There is no known bias, although accuracy is less by some unknown amount than if site-specific data were available.

Reliance on some recent IMPLAN I-O variables. The following variables were adapted (data transfer) from value-added composition of the most recent U.S. IMPLAN Input-Output Table: capital-related income, wages and salaries, and rental income. There is no known bias, although accuracy is less by some unknown amount than if site-specific data were available.

Direct BI not applicable for residences. Direct business interruption losses are not applicable to residences directly impacted by the hazard. The project team believes this is a reasonable assumption that does not bias the results.

D.2.3 Indirect Business Interruption

Regional economy delineated by county or county group. The regional economy is delineated as a county or county group (metropolitan area) that incurs physical damage, when, in fact, most economic regions, or trading areas, do not conform precisely to political boundaries. The political boundary is likely to be larger than the trading area. The result is that estimates of the regional economy are biased upward, with accuracy less than if regional economy mapped with more attention to each individual case. At the same time, indirect business interruption impacts are limited by the same boundaries, with the result of a likely downward bias.

Transfer payments set to zero. To exclude transfer payments, outside aid (government aid, private philanthropy, and insurance payments) are set at zero. Note, this still allows for reconstruction spending, but it is offset as individuals and businesses repay loans or replenish savings. This is a controversial point; whether it produces any bias has not yet been determined.

Use of HAZUS Level-1 "synthetic" regional input-output tables. These tables were developed from a sample of actual IMPLAN regional I-O tables in three categories for earthquakes and wind hazards: (1) manufacturing/service, (2) service/manufacturing, and (3) service/trade. Two additional categories relating to agriculturally-based economies are included in the HAZUS flood version. This improves the accuracy of the flood module relative to the wind and earthquake models. The HAZUS input-output (I-O) algorithm is superior to standard I-O formulations. It retains the standard limitations: (1) lack of input substitution, and (2) absence of the explicit role of prices, both of which reduce accuracy. The effect is a bias toward higher indirect business interruption losses. The use of HAZUS Level-1 I-O tables offers greater accuracy than the standard I-O model, in two respects: (1) flexible import and export structures, as well as inventories, to eliminate shortages and surpluses, and (2) explicit constraints on capacity, especially with regard to construction.

1-3 year-old I-O data. Most input data and the I-O tables are 1-3 years old. Accuracy is reduced, with an unknown bias.

Unemployment rate is used as a proxy for excess capacity. Accuracy is reduced, and BI impact estimates experience an upward bias.

HAZUS default values used. The following variables will always require the use of default values (see Table 3 of the *Project Pilot Study: St. Agnes Medical Center* [ATC, 2003b]): (1) import capability - all sectors, though differentiated, (2) export capability - all sectors, though differentiated, (3) restoration of function - all sectors, though differentiated, and (4) rebuilding pattern - all sectors, though differentiated. Accuracy is reduced, but there is no known bias.

Best available data used for other parameters. The following variables are specified with best available data: (1) inventory demand - all sectors, though differentiated, (2) inventory supply - all sectors, though differentiated, and (3) discount rate. Accuracy is reduced, but there is no known bias.

Indirect business interruption losses are not applicable in several cases. These cases are those where the mitigation grant is confined to: (1) residences (reasonable assumption, no known bias) or (2) individual or small in-city groups schools, libraries, hospitals, and fire houses (reduces accuracy, downward bias). In most instances, these cases have no forward linkage to business and backward linkages are maintained by the absorption of their activity by similar units within the region.

D.3 Community Studies — Assumptions

D.3.1 Overall

Scope of Quantification. The main charge of the quantitative side of the community studies is to evaluate benefit-cost ratios for FEMA grants, including market spillover effects when they occur, and spin-offs of these grants. The community studies provide only qualitative accounts of allied or collateral risk-reduction activities. In many cases, as for process grants, qualitative cost-effectiveness accounts were provided.

Interaction between the benefit-cost analysis of FEMA Mitigation Grants and the Community Studies. Local data and circumstances were much richer for the community studies than for the benefit-cost analysis of FEMA mitigation grants. Quantitative studies performed in the community studies provided a feedback loop for the benefit-cost analysis of FEMA mitigation grants in the sense that details found in the field often assisted in clarifying and supplementing more national data. Moreover, the community quantitative studies served as a vanguard for the benefit-cost analysis of FEMA mitigation grants to the extent that quantitative procedures were developed for several unexpected situations. These included consideration of tornado risks, debris flow risks, chlorine releases, underground flood risks to wastewater and storm drain systems, central business district spillover effects, various flood structural mitigations such as diversions, berms, and detention ponds, various flood acquisition and elevation risk reduction activities in cases in which local flood hazards are challenging to model, and localized distress in emergency services when floods cut a community into two isolated areas.

Use of Local Results. In some cases, The community studies found that the risk evaluation tools used by local practitioners are sometimes far more advanced than the more economic methods used in the community studies. Some tools used locally have been exercised over years and sometimes decades by specialists. Small libraries of technical reports sometimes exist that provide support for decisions made. In some cases, owing to resource constraints, all pertinent activities could not be analyzed in the community studies (e.g., acquisitions made for properties in over a dozen riverine basins). In all cases, however, the community studies provided an independent check of general results for a community. In no cases were local results, however credible, used as the sole basis for this independent check.

Treatment of Uncertainties. The community studies have in some instances exposed rather than reduced uncertainties in risk evaluations. Even when risk evaluation tools are mature, but even more clearly when these tools are less mature, the number and variety of possible sensitivity evaluations can become very large (see Porter et al., 2002, Taylor et al., 2004).

Identification of Key Parameters for Benefit-Cost Estimation. Representations of results will stress the primary issue of the credibility of favorable versus unfavorable benefit-cost outcomes. Hence, sensitivity evaluations focused on some of the major parameters affecting this determination.

Acceleration of Pre-Disaster Mitigation Activities. Evaluations of instances in which risk-reduction activities are moved forward in time (i.e., accelerations), are consistent with principles implied by Carol Taylor West (2004).

Discount Rates. Same as assumed for the benefit-cost analysis of FEMA mitigation grants.

Risk Neutrality. Same as assumed for the benefit-cost analysis of FEMA mitigation grants. Exceptions were considered especially on private expenditures for such matters as safe rooms. The assumption that concave elements (risk averse elements) in preference functions play a key role in local and private investments has long been emphasized in the literature (see Markowitz, 1959).

Interaction Between Project Grants. The community studies considered interactions among project grants. This was accomplished through an analysis of spin-off and/or collateral risk reduction activities.

*Augmentation of NEMIS Data. F*ield data were found to clarify or modify as needed NEMIS data on such matters as actual costs.

Useful Life of Projects. Fifty-year time horizons for projects were assumed unless field data suggested otherwise. Some sensitivity evaluations on this matter were made for benefit-cost outcomes for which this assumption may be critical.

Present Value Calculations. Same as assumed for the benefit-cost analysis of FEMA mitigation grants.

D.3.2 Direct Loss Estimation

HAZUS®MH. The community studies relied on HAZUS®MH in all cases in which it is mature with respect to materials and practices for developing risk evaluations. These cases include its use for evaluating earthquake risks, and the response of buildings to severe winds. For estimating flood losses, the project team had to develop a less sophisticated and more empirically-based approach that uses HAZUS damage functions but alternative methods for estimating flood depths.

D.3.3 Indirect Loss Estimation

Indirect Losses. Same as assumed for the benefit-cost analysis of FEMA mitigation grants. Grants pertaining to residential structures were assumed not to be subjected to indirect loss estimation. None of the first seven communities studied yielded grants or spin-offs that would induce the use of indirect loss estimation tools.

D.4 Community Studies - Limitations

Limitations in Loss Estimation Modeling. The maturity of risk assessment tools in cases where HAZUS cannot be used in its entirety ranges from poor to good. Less mature tools are often those in which risk evaluations are often made with either tools dependent on very localized information or in which risk judgments are often made more qualitatively. (See ALA, 2002, especially Section 2, on how models for diverse natural hazards compare in terms of the maturity of risk evaluation practices.) Additional qualifications on results were added to this report to convey the state-of-the-practice in cases in which HAZUS is not used in its entirety.

Appendix E
CASUALTY ESTIMATION METHODOLOGY

E.1 Earthquake – Structural Mitigation Projects

The most developed component of HAZUS is the earthquake module, which was used on this project to determine the benefits of Structural Mitigation projects (e.g., retrofitting a building to improve the earthquake resisting properties of its structural framing system). The benefit of mitigation, expressed in terms of reduced casualties, is the difference between the number of casualties for the structure in its unmitigated state, and the number of casualties for the structure in its mitigated (e.g., retrofitted) state. HAZUS bases its casualty methodology primarily on structural and nonstructural damage. The methodology does not consider casualties due to secondary sources such as power outage or car accidents. The methodology uses casualty rates predominantly based on ATC-13 (Applied Technology Council, 1985), but updated through historical data. (ATC-13 documents an earthquake loss-estimation methodology and provides extensive damage-evaluation data for California). The HAZUS methodology for estimating casualties from structural damage combines a variety of inputs from other HAZUS modules including the probability of being in the damaged state and the relationship between the general occupancy classes and the model building type with specific casualty inputs in combination with occupancy data and time of event. Table E-l highlights the inputs needed for the HAZUS earthquake casualty estimates.

The output from HAZUS reports casualties based upon magnitude of modeled event, day or night scenario, and estimated injury classification. Injury classification focuses on the severity of the estimated injury.

Table E-1 Input variables for HAZUS casualty module in relation to damage state

Variable	Slight	Moderate	Extreme	Complete	Comments
1. Occupancy a. 2 p.m. b. 2 a.m.	 Same Same	 Same Same	 Same Same	 Same Same	 Day Occupancy Night Occupancy
2. Indoor Casualty Rates a. Severity 1 b. Severity 2 c. Severity 3 d. Severity 4	 .05 0 0 0	 .25 .030 0 0	 1 .1 .001 .001	*No Collapse Collapse* 5 40 1 20 .01 5 .01 10	Default based on building type
3. Collapse Rate	n.a.	n.a.	n.a.	10%	Default based on building type
4. Probability of Building being in Damage State	Default	Default	Default	Default	Input from other HAZUS Modules

Severity 1 injuries are the least life threatening, but may require basic medical aid from paraprofessionals such as paramedics. Severity 2 injuries require more medical care and the use of medical technology such as x-ray. These types of injuries are not expected to be life threatening. Severity 3 injuries pose an immediate life threatening condition if not treated quickly and thoroughly. Severity 4 injuries instantly kill or mortally injure (see HAZUS Technical Report, Table 13.1)

Translating injuries and loss of life into quantifiable dollar figures is difficult. Estimates of the value of life vary greatly – from $1 to $10M depending on the agency and use of the figure (Porter, 2002). One of the most applicable figures is from a 1998 study for the Federal Aviation Administration by Hoffer et al. (1998), who estimate the value of a human life at $3M. The methodology uses the $3M figure as its estimate for loss of life.

The development of injury costs for each HAZUS level used Federal Highway Administration data. The least serious injury is valued at $17,000 while the most extreme, loss of life, uses the $3 million FAA estimate discussed above. These values are used for all hazards.

E.2 Earthquake — Nonstructural Mitigation Projects

HAZUS is unable to model the benefit of nonstructural mitigation (projects that result in reduced casualties as a result of reduced damage to nonstructural components, such as ceilings and light fixtures) as it relates to deaths and injuries. For this project, three broad types of nonstructural mitigation were most prevalent: pendant lighting retrofit in schools, ceiling retrofit, and various types of bracing. A literature search revealed that little data exist to help model the reduction of injuries and deaths from these three types of nonstructural mitigation projects. Most available studies examine injuries that occur from other kinds of nonstructural damage. This is because no major earthquake has occurred during school and work hours. Following the 1994 Northridge Earthquake it was reported that "The Northridge Earthquake caused hundreds of lighting units to fall onto desks in classrooms that the students and teachers would normally occupy during a school day. Fortunately, the earthquake occurred early in the morning when the schools were closed in observance of Dr. Martin Luther King, Jr. Day (FEMA, 2004)". Such information highlights the issue, but does not provide enough data to estimate the probability either that lights will fall or that falling lights will injury people.

This project conservatively estimates the benefits of this type of mitigation. Assumptions are based on engineering judgment developed and reviewed by individuals with considerable experience in earthquake engineering and mitigation.

Seligson et al. (1998) suggest that without mitigation, pendant lighting in areas with high shaking likelihood has a moderate probability of falling, and with mitigation, a low probability of falling. The authors do not estimate numeric savings, but the methodology used here focuses on "low probability" of falling as a general guideline.

The project team estimated that without mitigation, between 1% and 10% of pendant lights will fall in earthquakes some time during the life of the building (assumed to be 50 years). A best-estimate value of 5% is used. Next, the method assumes that mitigation reduces the potential for collapse by half. Thus, 2.5% of the lights would have fallen during the next 50 years but will not fall after mitigation. Therefore, if a mitigation project replaces 1,000 pendant lights, 25 lights that would have fallen in an earthquake prior to mitigation now will not fall.

A second assumption relates to how many of those 2.5% (or in the above example, 25) would injure a person. The project team considered a variety of issues that would influence whether someone was injured from a falling pendant light including: (1) likelihood of a light falling where someone was standing or sitting immediately before the earthquake and (2) the likelihood that an individual would either not take protective action or that that action would be inadequate to protect him or her from being hit by the falling debris.

While empirical data are unavailable about these important likelihoods, it is asserted that: (1) the likelihood of a light falling on someone depends on how desks and classrooms are set up (when projects mitigate lights in schools) or where people are located spatially within a room or building; and (2) in areas with high earthquake risk, people are taught to take protective measures when they first become aware of ground shaking. In schools, children receive specific education to go under their desks, and as with fire, they routinely participate in earthquake drills. For purposes of this project, pendant lights are assumed to be approximately 6 inches wide, spaced approximately 6 ft apart, and typically almost the length of the room, meaning they hang over approximately 8% of the floor area. It is also assumed that a falling light could harm someone standing beneath or within 9 inches on either side of the light, thus affecting approximately 33% of the floor area, and therefore impacting 33% of unprotected occupants. Since schools are occupied approximately 25% of the time, it is assumed that approximately 0.33 x 0.25 or 8% of unprotected occupants would be injured if a light fell on them. Further assuming a 50-50 chance that an occupant would effectively protect him- or herself, 4% of the lights that would fall are judged to hit someone and, thus, could cause a major injury in the context of HAZUS.

A similar methodology was used for ceiling retrofit and upgrade. In this case, it was assumed that 2.5% of the retrofitted area would have fallen if the retrofit had not occurred and that, for every 300 square feet of area (area assumed to be occupied by one person) that would not have fallen, an injury would be avoided. Therefore, if a project mitigated 100,000 square feet of ceiling, 2,500 square feet that may have fallen without mitigation will not fall with the mitigation, and of that 2,500 square feet, 8.3 injuries will be avoided (2,500 divided by 300). For mitigation of hard ceilings, the assumption is a reduction of a moderate HAZUS 2 injury, and for hanging ceilings which tend to be a lighter material, the assumption is a reduction of a minor HAZUS 1 injury.

While these estimates appear reasonable, caution must be used when considering them. The estimates are based on assumptions developed using engineering judgment, but are not grounded in empirical evidence. They should not be considered as exact empirically driven estimates, but rather, as best estimates considering available data and sound engineering judgment.

E.3 Flood Mitigation Projects

The majority of flood mitigation projects recorded in NEMIS are buy-outs of repeatedly flooded properties that HAZUS cannot model. To quantify social benefits, a method was developed that considers the number of units bought as part of each project. The method uses data on a variety of flood events that was published by the Center for Disease Control in *Morbidity and Mortality Weekly*. The challenge was to find reports that used households as the unit of analysis and, thus, could be applied to the current project.

Reports were examined on the Midwest Floods in 1993 (CDC MMWR Weekly, October 22, 1993), a 1994 flooding event in Georgia (CDC MMWR Weekly June 29, 1994), and Tropical Storm Allison in Houston (CDC MMWR Weekly May 3, 2002). The first two studies examined the deaths and injuries reported by hospitals and medical examiners while the third study examined injuries within households. The main hazard that resulted from Tropical Storm Allison was flooding. A cluster sample of housing units in selected census tracts was surveyed. Instead of relying on medical examiners or hospital reports, this assessment of injuries relied on self-reports from households.

The Tropical Storm Allison methodology is the most applicable to the current project since it uses housing units as the unit of analysis. While flood intensities do vary, we can already assume that the properties have a high likelihood of being flooded considering their inclusion in the buy-out program.

The Tropical Storm Allison study indicated that 8% of survey respondents reported that at least one person in their household experienced a flood-related injury. Flood related injuries include falls, blunt injuries, animal bites, and cuts or puncture wounds.

One of the major limitations of this method is that it focuses on one flooding event. As a result, the method uses one-half of the injury rate reported in the Allison study (4%) as the rate of injury for the properties purchased. Sensitivity studies used 2% and 8% as the lower and upper bound.

E.4 Wind Mitigation Projects – Hurricane

The majority of hurricane wind projects involved installing or upgrading hurricane shutters on a variety of public buildings such as city halls or hospitals. Because there is a warning period before hurricane landfall, most public buildings have little if any occupancy during a hurricane. The major exceptions are schools that act as hurricane shelters and hospitals that cannot evacuate all patients. Developing a methodology to estimate the social benefits of shutter mitigation was challenging. As a result, the method focuses on only those buildings used as shelters. Two hospital projects in the sample are not included because little empirical evidence supports the development of an appropriate method.

Similar to the flood methodology, the hurricane shutter methodology is based on three Center for Disease Control reports of injuries sustained in hurricane events. Injury estimates are conservative, and focus on injuries reported during hurricanes where evacuation orders were in place

The first report focuses on 1992’s Hurricane Andrew in Louisiana (see CDC MMWR Weekly, April 9, 1993, 42:130). Findings indicate that the three parishes closest to the hurricane’s track had injury rates over 200 per 100,000. Using these numbers, the hurricane injury rate is 0.2% for this storm.

In 1995, Hurricane Opal made landfall in the Florida Panhandle with sustained winds of 115 mph (Category III on the Saffir-Simpson Scale). A review of emergency department records for the six days before Hurricane Opal made landfall and the six days after Hurricane Opal made landfall shows no significant change in the number of visits for lacerations, wounds, sprains and fractures (CDC MMWR Weekly, February 2, 1986, 45:4).

A more recent CDC MMWR report focused on 2003's Hurricane Isabel, which made landfall on the Outer Banks of North Carolina. Using a cluster sample methodology, 210 interviews were completed (62.3% response rate). These 210 interviews represented 93,738 occupied housing units. Of the 210 interviews, only two households reported a hurricane related injury. Using these numbers, the hurricane injury rate is 0.9% for this storm.

Since these injury rates are case specific, the Project Team averaged the two rates to get a point estimate of 0.0055, and used .002 as the lower bound for a sensitivity study and .009 as the upper bound.

For each school shuttering project, the schools that were shuttered were divided into those that are used as shelters and those that are not designated as shelter . Based on the assumption that over the life of the project one hurricane will occur that will fill the shelter, shelter capacity information was retrieved from the State of Florida emergency management shelter status website (http://www.eoconline.org/EM_Live/shelter.nsf), and the proportions designated above were applied to represent quantified reduction in injuries. The majority of the shelter projects are in the State of Florida. Projects not in Florida are harder to model since required data, such as shelter capacity, are not readily available. The injuries avoided are moderate, HAZUS Level 2 injuries.

The assumption of one Andrew or Isabel-sized hurricane per 50 years is probably reasonable or modestly conservative. Hurricane Andrew's peak gusts were roughly 140 mph, approximately equal to 50-year design wind speeds, per NOAA. Hurricane Isabel's peak gust velocities were roughly 100 mph over a fairly wide region (NOAA, 2003). The 50-year design wind speeds there are approximately 130 mph, indicating that Isabel's wind speeds have an approximately 10-year recurrence period using Peterka and Shahid's wind speed-recurrence relationship (1998).

While the numbers appear conservative because they reflect evacuation, data from Hurricane Andrew supports the numbers. Hurricane Andrew had about 14 deaths (out of a population of 1.9M) directly due to the hurricane in an area that had limited evacuation. Using these numbers, the mortality rate would be approximately .000007368. This area had limited evacuation since evacuation is based on water (storm surge) and not wind. The area hardest hit by Hurricane Andrew was the southernmost locations such as Florida City, Homestead, and Kendall. These areas suffered significant damage, but were inland as compared to areas such as Miami Beach that were subject to evacuation orders. In fact, many people evacuated from low-lying areas to the area that was most devastated by the winds.

E.5 Wind Mitigation Projects – Tornado

The majority of tornado wind mitigation projects focus on construction or retrofit of saferooms in public spaces such as schools. HAZUS at present cannot model casualty estimates for tornadoes, so a probabilistic site-specific method of estimating the benefit of tornado saferooms was developed.

Using this methodology, the U.S. is first divided into 1 degree x 1 degree cells, and then, tornado touchdowns are counted. A baseline model is calculated to estimate annualized frequency at a site. This estimate uses models to determine response of structures to wind velocities and to estimate casualties per damage degree. The probabilities of occurrence are aggregated to different Fujita levels to correspond with 100 mile per hour and 200 mile per hour values.
The following table illustrates the injury rates used for the tornado estimation:

Table E-2 Injury rates used for tornado estimation

		Casualties per 1000 people**		
Degree of Damage	Damage State (percent damage)*	minor injuries	major injuries	deaths
minor	2%	0.1	0.01	0
moderate	10%	1.2	0.16	0.04
severe	50%	68.57	9.14	2.29
destruction	100%	400	400	200

* Repair cost divided by replacement cost
** Based on ATC-13 Injury and death rates

This methodology estimates the reduction in annualized casualties after mitigation, and the cost per injury type discussed above in the earthquake section, is applied to estimate dollar benefit of mitigation activities.

Appendix E
CASUALTY ESTIMATION METHODOLOGY

E.1 Earthquake – Structural Mitigation Projects

The most developed component of HAZUS is the earthquake module, which was used on this project to determine the benefits of Structural Mitigation projects (e.g., retrofitting a building to improve the earthquake resisting properties of its structural framing system). The benefit of mitigation, expressed in terms of reduced casualties, is the difference between the number of casualties for the structure in its unmitigated state, and the number of casualties for the structure in its mitigated (e.g., retrofitted) state. HAZUS bases its casualty methodology primarily on structural and nonstructural damage. The methodology does not consider casualties due to secondary sources such as power outage or car accidents. The methodology uses casualty rates predominantly based on ATC-13 (Applied Technology Council, 1985), but updated through historical data. (ATC-13 documents an earthquake loss-estimation methodology and provides extensive damage-evaluation data for California). The HAZUS methodology for estimating casualties from structural damage combines a variety of inputs from other HAZUS modules including the probability of being in the damaged state and the relationship between the general occupancy classes and the model building type with specific casualty inputs in combination with occupancy data and time of event. Table E-l highlights the inputs needed for the HAZUS earthquake casualty estimates.

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* Repair cost divided by replacement cost
** Based on ATC-13 Injury and death rates

This methodology estimates the reduction in annualized casualties after mitigation, and the cost per injury type discussed above in the earthquake section, is applied to estimate dollar benefit of mitigation activities.

Appendix F
HAZUS INJURIES AND THE ABBREVIATED INJURY SCALE

F.1 Overview

To obtain monetary value for avoiding statistical injuries (including fatal injuries), the project team used the monetary values of avoided statistical injuries assigned by the Federal Highway Administration (FHWA 1994). That study attached values to the six-category Abbreviated Injury Scale (AIS). These values are comprehensive, in that they reflect pain and lost quality of life, medical and legal costs, lost earnings, lost household production, etc. Medical costs alone represent a relatively small portion of the comprehensive cost, typically 10% or less.

When actual injuries are coded in research studies, a single person does not necessarily receive a single code; each individual injury is coded. Thus, if the AIS scale is being used to code the injuries obtained, one can code each injury, record the maximum AIS level, or combine the injured person's AIS scores to produce a single number for further data processing and analysis.

Regardless of these issues, the AIS is a commonly used scale with equivalent monetary values assigned by agencies of the US government explicitly for use in cost-benefit analysis. The challenge for this project was to apply the AIS and its monetary values to HAZUS injuries. HAZUS's injury levels are not defined in terms of AIS injuries, and the HAZUS scale has four levels (1 through 4, where 4 is fatal) whereas AIS has six (1 through 6, where 6 is fatal).

This appendix describes the mapping between HAZUS injury severities to the AIS. Four references are examined here. The HAZUS Technical Manual (NIBS and FEMA, 2003a) provides a general description of each of four injury levels and provides 3 to 5 examples of each; see Table F-1, below. The AIS dictionary (AAAM, 2001) lists approximately 1,300 injuries, each provided with a distinct 7-digit numerical injury identifier, of which the last digit after the decimal place is the AIS level. The differences between HAZUS and AIS injury definitions virtually assure an ambiguous mapping between HAZUS and AIS levels.

In an attempt to reduce the ambiguity in mapping, two additional publications were examined. Peek-Asa et al. (1998) and Mahue-Giangreco et al. (2001) both studied large numbers of medical records of people injured in the 1994 Northridge earthquake. However, neither study includes transcriptions of the injuries studied as they were described in the medical records, prior to coding using AIS. In addition, neither the number of injuries nor the type of treatment by assigned AIS score was reported. No other readily available data were found about relative frequencies of AIS injury levels within HAZUS injury levels, based on data from the Northridge Earthquake or other natural disasters.

The method applied for this project was to quote the example injuries as given in the HAZUS Technical Manual Table 13.1 (duplicated in Table F-1 below), list several AIS injuries that appear to correspond to each HAZUS example, and note the range of possible AIS levels for each example. It is not defensible to infer relative frequencies with which injuries at a given AIS level occur simply by counting the number of distinct AIS injuries that correspond to a particular HAZUS level.

Only HAZUS levels 1, 2, and 3 were examined. HAZUS level 4 (fatal) was unequivocally mapped to AIS level 6 (maximum), so no detail was required to support this mapping.

Table F-1 HAZUS Injury Classification Scale

Injury Level	Injury Description
Severity 1	Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self treated are not estimated by HAZUS.
Severity 2	Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.
Severity 3	Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.
Severity 4	Instantaneously killed or mortally injured

F.2 HAZUS Level 1

The project team assigned the monetary value of avoiding a HAZUS level-1 injury the geometric mean of the monetary values of avoiding injuries of AIS levels 1 and 2. (By geometric mean is meant the square root of the product, i.e., cost = $(\text{cost}_1 \times \text{cost}_2)^{1/2}$. It produced a result less than the simple arithmetic average, as if the lower value were somewhat more likely than the upper value.) From the HAZUS technical manual (see Table F-1), HAZUS injury level 1 is described as "Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness." Table F-2 lists examples of AIS injuries that roughly correspond to example HAZUS level 1 injuries (i.e., include the words used in the HAZUS injury descriptions). Note that the last digit in the numeric identifier of each AIS coded injury is the AIS level for that injury. For example, "750620.1 Elbow joint sprain" is AIS level 1. The range of AIS levels in Table F-2 is 1 to 3.

F.3 HAZUS Level 2

The project team equated HAZUS level 2 and AIS level 3. From the HAZUS technical manual (see Table F-1), HAZUS injury level 2 is described as "Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.” Table F-3 lists AIS injuries that roughly correspond to example HAZUS level 2 injuries (i.e., include the words used in the HAZUS injury descriptions). The range of AIS levels is very broad, ranging between 1 and 5.

F.4 HAZUS Level 3

The project team assigned the monetary value of a HAZUS level 3 injury the geometric mean of the monetary values of AIS 4 and 5. From the HAZUS technical manual (see Table F-1), HAZUS injury level 3 is described as “Injuries that pose an immediate life threatening condition if not treated adequately

Table F-2 HAZUS Level-1 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
A sprain	The word “sprain” appears 14 times in the AIS dictionary. Some instances are:	
	750620.1 Elbow joint sprain	1
	751020.1 Shoulder sprain	1
	751420.1 Wrist sprain	1
	850206.1 Ankle sprain	1
	850404.1 Foot joint sprain	1
	850826.2 Knee sprain	2
A severe cut requiring stitches	The AIS dictionary contains 179 instances of “laceration.” Here are 14 that could be called a severe cut, representing 2 kinds of injuries on each of 7 body sections. A third was identical to the first two, except with blood loss >20% by volume; this injury level is considered HAZUS level 3.	
	110602.1 Scalp laceration, minor	1
	110604.2 Scalp laceration, major (> 10 cm long and into subcutaneous tissue)	2
	210602.1 Face skin/subcutaneous/muscle laceration, minor, superficial	1
	210604.2 Face skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	310602.1 Neck skin/subcutaneous/muscle laceration, minor, superficial	1
	310604.2 Neck skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	410602.1 Thorax skin/subcutaneous/muscle laceration, minor, superficial	1
	410604.2 Thorax skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	510602.1 Abdomen skin/subcutaneous/muscle laceration, minor, superficial	1
	510604.2 Abdomen skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	710602.1 Upper extremity skin/subcutaneous/muscle laceration minor, superficial	1
	710604.2 Upper extremity skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	810602.1 Lower extremity skin/subcutaneous/muscle laceration minor, superficial	1
	810604.2 Lower extremity skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
A minor burn (first degree or second degree on a small part of the body)	The AIS dictionary contains 3 injuries that meet these criteria:	
	912002.1 Burn, 1°, > 1 yr old, any fraction of total body surface area	1
	912004.2 Burn, 1°, ≤ 1 yr old, >50% of total body surface area	2
	912006.1 Burn, 2°, <10% of body area	1
A bump on the head without loss of consciousness.	Aside from 110402.1, the AIS dictionary lists 4 injuries that explicitly exclude unconsciousness.	
	110402.1 Scalp contusion (includes subgaleal hematoma)	1
	160402.1 No prior unconsciousness, but may have headache or dizziness known to be a result of	1
	head injury	2
	160404.2 [Same as 160402.1] with neurological deficit	2
	160602.2 Lethargic, stuporous, obtunded post resuscitation or on limited observation at scene	
	(can be aroused by verbal or painful Stimuli; GCS* 914), no prior unconsciousness.	3
	160604.3 [Same as 160602.2] with neurological deficit	

and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome." Table F-4 lists AIS injuries that roughly correspond to HAZUS level 3 injuries (i.e., include the words used in the HAZUS injury descriptions). The associated AIS levels range from 3 to 5.

F.5 Discussion

Peek-Asa et al. (1998) examined medical records of hospitalized injury victims of the 1994 Northridge Earthquake. They coded injuries according to the Abbreviated Injury Severity (AIS) scale. The Injury Severity Score (ISS) is also used, but it is calculated as a function of AIS (ISS is calculated as the sum of the squares of the highest AIS code in the three most severely injured body regions.) The authors report that injuries most commonly affected legs and arms, but at least some injuries were recorded to all other body regions except the neck. The paper does not provide raw injury data, so no inferences can be made as to the relative likelihood of various AIS coded injuries within a HAZUS level.

Table F-3 HAZUS Level-2 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
3rd degree burn, 2nd degree burn over large parts of the body	The AIS dictionary lists 12 nonfatal burn injuries meeting these criteria. They are: 912007.1 Burn, 3° $\leq$ 100 cm^2 (except face $\leq$ 25 cm) 912008.2 Burn, 3° > 100 cm^2 (except face $\geq$ 25 cm) up to 10% of total body surface 912012.2 Burn, 2° or 3° (or full thickness) 10-19% of total body surface 912014.3 Burn, 2° or 3° (or full thickness) 10-19% of total body surface, < 5 years old 912016.3 Burn, 2° or 3° (or full thickness) 10-19% of total body surface, face/hand/genitalia involvement 912018.3 Burn, 2° or 3° (or full thickness) 20-29% of total body surface 912020.4 Burn, 2° or 3° (or full thickness) 20-29% of total body surface, < 5 years old 912022.4 Burn, 2° or 3° (or full thickness) 20-29% of total body surface, face/hand/genitalia involvement 912024.4 Burn, 2° or 3° (or full thickness) 30-39% of total body surface 912026.5 Burn, 2° or 3° (or full thickness) 30-39% of total body surface, < 5 years old 912028.5 Burn, 2° or 3° (or full thickness) 30-39% of total body surface, face/hand/genitalia involvement 912030.5 Burn, 2° or 3° (or full thickness) 40-89% of total body surface	 1 2 2 3 3 3 4 4 4 5 5 5
A bump on the head that causes loss of consciousness	The AIS dictionary lists 27 injuries with explicit reference to unconsciousness. Some are: 160202.2 Head injury, unconscious < 1 hr 160204.3 Head injury, unconscious < 1 hr, with neurological deficit 160206.3 Head injury, 1-6 hr unconsciousness 160208.4 Head injury, 1-6 hr unconsciousness, with neurological deficit 160210.4 Head injury, 6-24 hr unconsciousness 160212.5 Head injury, 6-24 hr unconsciousness, with neurological deficit 160214.5 Head injury, >24 hr unconsciousness	2 3 3 4 4 5 5
Fractured bone	There are approximately 181 instances of the word "fracture" in the AIS dictionary. Here is a sample of 8. 450212.1 One rib fracture 450220.2 Two to three ribs fractured or multiple fractures of a single rib 450230.3 Three ribs on one side and no more than 3 ribs on other side, stable chest 450240.4 More than three ribs on each of two sides, with stable chest 752602.2 Humerus fracture, closed/undisplaced 752604.3 Humerus fracture open, displaced, or comminuted 851606.2 Fibula fracture, head, neck, shaft 851801.3 Femur fracture, open, displaced, or comminuted	 1 2 3 4 2 3 2 3
Dehydration	The word "dehydration" does not appear in the AIS dictionary	
Exposure	The word "exposure" does not appear in the AIS dictionary	

Mahue-Giangreco et al. (2001) similarly examined medical records and other emergency-department records, addressing a larger population of injury victims than Peek-Asa et al. (1998), because they included non-hospitalized injury victims as well as hospitalized injuries. As with Peek-Asa et al. (1998), Mahue-Giangreco et al. (2001) do not provide raw injury data, so no inferences can be made as to the relative likelihood of various AIS coded injuries within a HAZUS level.

F.6 Summary

Table F-5 lists AIS injury levels that are possible under each HAZUS level and shows the mapping used in the present study (Mapping 1), as well as an alternative mapping (Mapping 2).

The table shows that, considering the examples given for each HAZUS injury level, both the original and alternative mapping can be defended solely on the basis of the examples and the definitions of some of the 1,300 AIS-coded injuries in the AIS dictionary (AAAM, 2001).

Table F-4 HAZUS Level-3 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
Uncontrolled bleeding	Neither the phrase “uncontrolled bleeding” nor just the word “uncontrolled” appear in the AIS dictionary. However, many injuries are qualified by amount of blood lost. The expression “blood loss >20%” appears approximately 31 times. Some examples follow. 110606.3 Scalp laceration, blood loss > 20% by volume 216006.3 Face penetrating injury, blood loss > 20% by volume 320212.4 Carotid (common, internal) artery, laceration, major (blood loss > 20% by volume) 320214.5 Carotid (common, internal) artery, laceration, major (blood loss > 20% by volume), with neurological deficit (stroke) not head injury related 416006.3 Thorax penetrating injury with blood loss > 20% by volume 716006.3 Upper extremity penetrating injury with blood loss > 20% by volume 816006.3 Lower extremity penetrating injury with blood loss > 20% by volume	3 3 4 5 3 3 3
Punctured organ	The word “puncture” appears approximately 42 times in the AIS dictionary, but always in relation to blood vessels, never organs. Some examples of internal-organ lacerations include the following. 441012.5 Heart laceration, perforation 441420.4 Lung laceration, with blood loss > 20% by volume 441422.5 Lung laceration, with tension pneumothorax 540624.4 Bladder laceration, perforation; full thickness but not complete transaction 541826.4 Liver laceration, parenchymal disruption of ≤ 75% of hepatic lobe or 1-3 Couinaud's segments within a single lobe; multiple lacerations > 3 cm deep; "burst" injury; major 542824.3 Pancreas laceration, moderate, with major vessel or major duct involvement	5 4 5 4 4 3
Spinal column injuries	The AIS dictionary lists approximately 80 spinal injuries, ranging from AIS 2 to 6. Some nonfatal examples: 630212.2 Cervical spine, brachial plexus injury, incomplete plexus injury, contusion (stretch injury) 630604.3 Lumbar spine, cauda equina contusion, with transient neurological signs, with fracture 630632.4 Lumbar spine, complete cauda equina contusion, with no fracture or dislocation 640224.5 Cervical spine, cord contusion, complete cord syndrome, C4 or lower, with no fracture or dislocation	2 3 4 5
Crush syndrome	The phrase “crush syndrome” does not appear in the AIS dictionary. There are approximately 27 instances of the word “crush” in the AIS dictionary. Some nonfatal examples are: 340212.5 Larynx, laceration, puncture, avulsion, crush, rupture; transection; massive destruction 340610.5 Pharynx or Retropharyngeal area, laceration, puncture, avulsion, crush, rupture; transection; massive destruction 640240.5 Cervical spine cord laceration (includes transection and crush) 640640.5 Lumbar spine cord laceration (includes transection and crush) 713000.3 Upper extremity massive destruction of bone and of muscles/nervous system/vascular system of part or entire extremity (crush)	5 5 5 5 3

Table F-5. Two options for mapping from HAZUS to AIS Injury levels

HAZUS level	AIS in Tables F-2 through F-4	AIS mapping 1		AIS mapping 2	
		AIS levels	Cost	AIS levels	Cost
1	1-3	1-2	$17,000	1	$6,000
2	1-5	3	$180,000	2-3	$114,000
3	3-5	4-5	$1,200,000	4-5	$1,500,000
4	Not addressed	6	$3,000,000	6	$3,000,000

No statistical data from natural disasters were readily available that might improve the mapping by providing actual rates of various AIS-coded injuries by HAZUS level.

The table also shows the equivalent monetary value of avoiding one such statistical injury, using government-endorsed values of avoiding statistical injuries, as listed in Table 4-3. It bears repeating that the costs in Table 4-3 and Table F-5 are comprehensive, reflecting medical costs, lost earnings, lost household production, emergency services, vocational rehabilitation, workplace costs, administrative, legal, pain and lost quality of life, and other factors. Medical costs alone represent a relatively small portion of the comprehensive cost, typically 10% or less.

Note that, where two AIS levels are applied to a single HAZUS injury level in Table F-5, the average of the two amounts is used. In the mapping for this project, where two AIS levels apply, the cost given in the table is the geometric mean, i.e., $cost = (cost_1 \times cost_2)^{1/2}$. This method reflects the notion that the lower level is more likely than the higher one. This approach may be considered overly complicated, and in the alternative mapping, the more common, easily-understood, simple arithmetic mean is applied, i.e., $cost = ½ (cost_1 + cost_2)$

F.7 Conclusion

The definitions of HAZUS injury levels in the HAZUS Technical Manual (NIBS and FEMA, 2003a) are somewhat vague and cannot be mapped uniquely to particular AIS levels using the AIS dictionary (AAAM, 2001). Empirical data are lacking to reduce or eliminate the ambiguity in mapping from HAZUS to AIS. As a result, the mapping is subject to judgment and disagreement. Either the mapping used for this project ("Mapping 1" in Table F-5), or an alternative examined here ("Mapping 2" in Table F-5), can be defended solely on the basis of a strict reading of the HAZUS Technical Manual and of the AIS dictionary.

Appendix G
PROPERTY LOSS ESTIMATION – FLOOD

This appendix describes the approaches followed for estimating property loss due to flood.

G.1 Locating the Structure within the Flood Plain

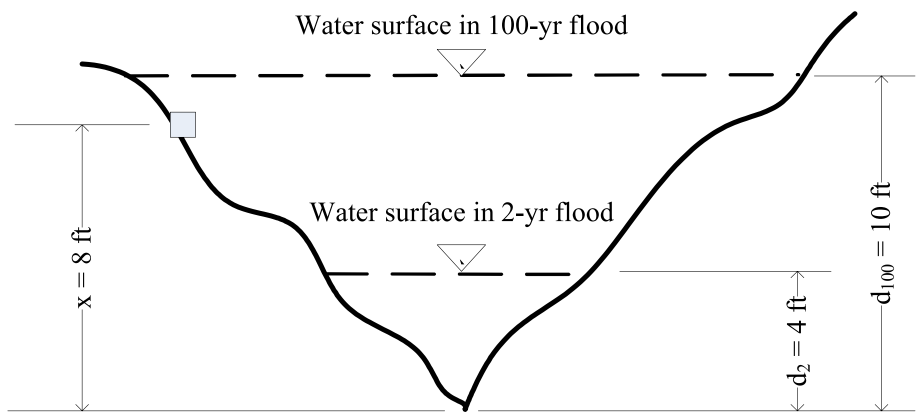

Figure G-1. Illustration of flood-loss calculation

Given: Let d_n denote the n-yr flood depth at the stream channel center. For example, d_{100} denotes the 100-year flood depth at a stream channel center, d_2 denotes the 2-year flood depth at a stream channel, etc. These flood depths are calculated using the methodology that is documented in Section G.5. For this illustration, assume that $d_{100} = 10$ ft and $d_2 = 4$ ft.

Let $\underline{d}$ denote the set of flood depths at the stream channel center, d_5, d_{10}, d_{20}, d_{50}, d_{100}, etc. (It is common notation to use an underline to indicate that a parameter is a vector, potentially containing many scalar values.)

Let x denote the height of the building site above the stream channel center, assuming that $x \geq 0$, i.e., the building is located at a higher elevation than the stream channel center. In the Figure G-1, $x = 8$ ft.

Let h_n denote the depth of flooding at the site in the n-yr flood. For example, h_{100} denotes the depth of flooding at a particular site in the 100-yr flood, h_{50} denotes the depth of flooding at the site in the 50-yr flood, etc. For any return period n,

$$h_n = \text{larger of } (h_n - x) \text{ and } 0 \qquad \text{(G-1)}$$

For example, in Figure G-1 and using the above equation, $h_{100} = 2$ ft, and $h_2 = 0$ ft. If x and $\underline{d}$ were known, it would be possible to calculate all the associated values of h.

Let & (ampersand) denote all of the information needed about a building to calculate loss, other than flood depth, such as the value of the building.

Let y_n denote the loss in the n-yr storm. For example, y_{100} denotes the loss given 100-yr flooding.

Let f denote a function that calculates loss for a known flood depth h and &. (Note: the depth-damage relationships in HAZUS are used but these functions are not detailed here.) Since h_n is a function solely of y and d_n, y_n can be expressed as:

$$y_n = f(x, d_n, \&) \qquad \text{(G-2)}$$

Let y_{ann} denote the average annualized loss to the facility, considering all possible depths h_n, the resulting losses y_n and their associated return periods, n. (Typically y_{ann} is calculated by numerical integration, which is not detailed here.)

Let g denote the function used to perform the numerical integration for y_{ann}. It uses several values of n for y_n. We denote by $\underline{y}_n$ the set of values y_n, and the associated set of return periods by $\underline{n}$, and write

$$y_{ann} = g(\underline{y}_n, \underline{n}) \qquad \text{(G-3)}$$

Problem statement: Assume that $\underline{d}$ can be calculated (this calculation is treated elsewhere), that "&" is known from the grant-application data, that the depth-damage relationships are known (which are taken from HAZUS), and that the numerical integration of the various values of loss and frequency can be calculated. In this case, x is not known precisely, owing to shortcomings in the grant-application data, geocoding difficulties, and the lack of a very accurate nationwide elevation model. The problem is: how can y_{ann} be calculated without a known value of x?

Solution:

Uncertain X. In this case, the elevation difference is recognized as uncertain, and is denoted using a capital letter, X. (Common mathematical notation. That is, x is a particular value, whereas X is uncertain and has a probability distribution.)

Uncertain Y_{ann}. Since X is uncertain, so is y_{ann}, in which case, the uncertain annualized loss is denoted by Y_{ann}. The goal is to obtain the expected value of Y_{ann}, which is denoted by $E[Y_{ann}]$. (That is, y_{ann} is a particular value for a known value x, Y_{ann} is uncertain and has a probability distribution, and $E[Y_{ann}]$ is a best-estimate, average value of Y_{ann}.)

Distribution of X. Next, it is assumed that $0 < X < d_{100}$, i.e., the building site elevation is somewhere between that of the stream channel center ($x = 0$) and the edge of the mapped 100-yr floodplain ($x = d_{100}$). Without any additional knowledge, according to information theory, the proper assumption is that X is uniformly distributed between 0 and d_{100}. That is, the difference in elevation between the building site and the stream channel center is equally likely to be 0, d_{100}, or anywhere in between. If more were known about the difference in elevation, a better assumption could be made, but without more knowledge, the best assumption for X is the uniform distribution.

Alternatives for simulating Y_{ann}. Given the values $\underline{d}$, the information &, the functions *f* and *g*, and the assumed distribution for *X*, samples of *X* can be created, y_{ann} can be calculated for each sample, and the expected value $E[Y_{ann}]$ can be calculated using the samples of y_{ann}. There are at least four reasonable methods (as described below) to select samples of *X*, illustrated in Figure G-2, which shows a cross-section (or transect) of a floodplain, gray boxes for sample sites, and the calculated flood level in the 100-yr flood.

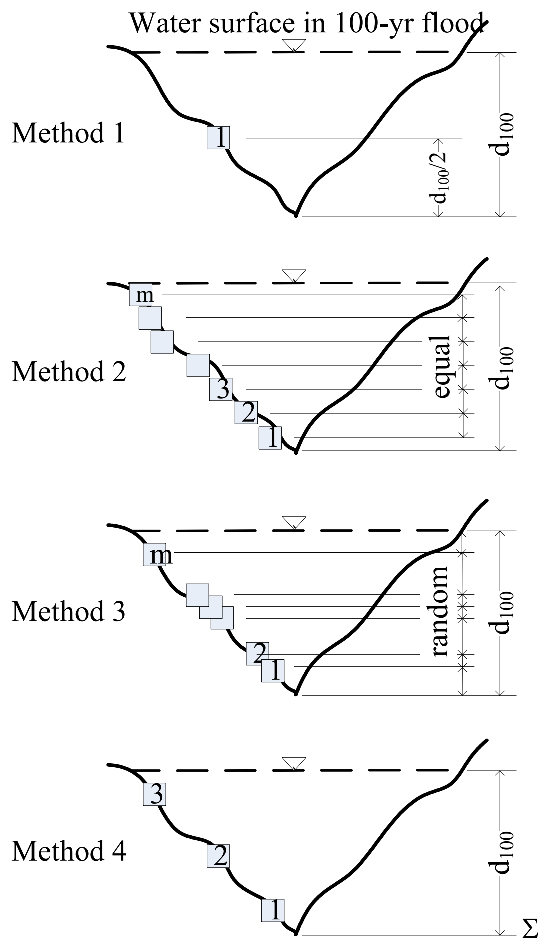

Figure G-2. Four methods of simulating X

Method 1: Select the best-estimate value of *X*, namely $x = d_{100}/2$, which yields *x*, $\underline{d}$, &, *f*, and *g*, and enables the calculation of y_{ann} as before. The problem is that f is a nonlinear function, in which case the estimate of y_{ann} might be significantly biased.

Method 2: Select *m* evenly spaced values of *X*: $x_i = i/m + d_{100}/(2m)$, where $i = 0, 1, \ldots m\text{-}1$. Calculate y_{ann} for each site *i*, and take the simple average, $E[Y_{ann}] = \Sigma_i(y_{ann,i})/m$, where $y_{ann,i}$ corresponds to sample x_i. This avoids the problem of nonlinear *f*, if enough samples are used.

Method 3: Use various Monte Carlo simulation approaches, in which *X* is simulated randomly *m* times. Calculate $E[Y_{ann}]$ as in Method 2.

Method 4: Use Hermite-Gauss quadrature, in which case a few samples of X are carefully selected and assigned weights (or probabilities) w_i, so that they match the first several moments of X (mean, variance, etc.). The losses $y_{ann,i}$ for each value of x_i, and a weighted average of the values $y_{ann,i}$ using the weights w_i are then calculated. This approach is similar to Method 2, except the values of x_i are not evenly spaced, and a weighted, rather than simple, average of the sample losses $y_{ann,i}$ is created. This approach provides a good estimate of $E[Y_{ann}]$ and is exact if f can be represented by up to a 5^{th}-order polynomial.

Preferred Method: Hermite-Gauss quadrature for $E[Y_{ann}]$ (Method 4). Without presenting the pros and cons of each choice, we note that Method 4 is more accurate and efficient.

Following is the approach followed for estimating $E[Y_{ann}]$ using Method 4. Again, X is assumed to be uniformly distributed between 0 and d_{100}, and three Gauss points are used, which means that the uncertain X is replaced by three particular values, denoted here by x_1, x_2, and x_3, each with an associated weight (or probability), denoted by w_1, w_2, and w_3. Under these conditions,

$$\begin{aligned} x_1 &= 0.1127 * d_{100} \qquad w_1 = 0.2778 \\ x_2 &= 0.5000 * d_{100} \qquad w_2 = 0.4444 \\ x_3 &= 0.8873 * d_{100} \qquad w_3 = 0.2778 \end{aligned} \tag{G-4}$$

$E[Y_{ann}]$ is then computed as

$$E[Y_{ann}] = \Sigma_i(w_i * y_{ann,i}) \text{ where } i = 1, 2, 3 \tag{G-5}$$

where Σ_i denotes summation over the three values of i, and where $y_{ann,i}$ denotes the annualized loss given site i. The methodology is illustrated in Figure G-3.

Imagine the 100-yr flood depth at the center of a certain basin (d_{100}) is 10 ft, as shown in Figure G-3, and that d_{20} = 3 ft and d_{50} = 6 ft. (In practice additional flood depths are used, but for illustration, consider just these three.) From Equation G-4, rounding for illustration purposes, x_1 = 1 ft, x_2 = 5 ft, and x_3 = 9 ft. Those elevations would put the building at sites 1, 2, and 3, respectively.

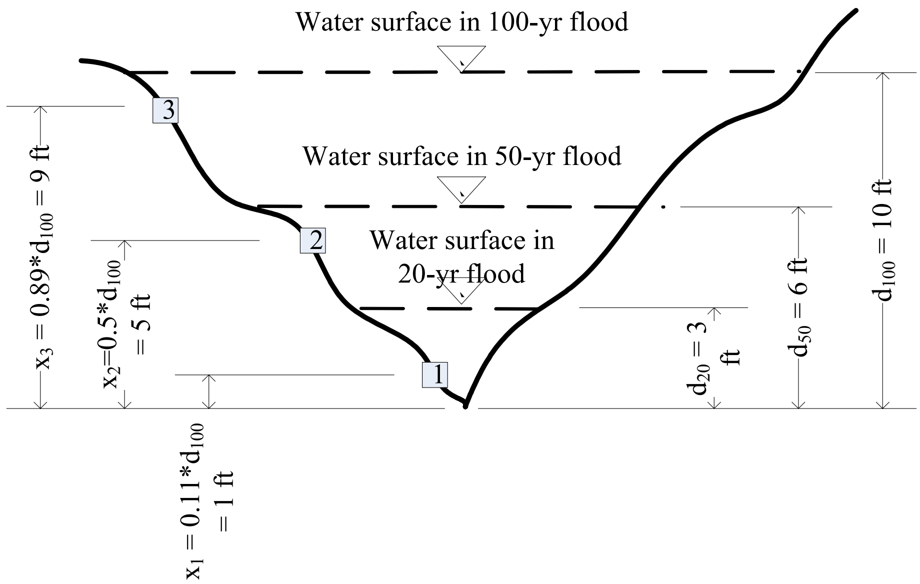

Figure G-3. Illustration of elevation differences X used in Hermite-Gauss quadrature for flood loss.

The next step is to calculate flood depths for each storm (20, 50, and 100-yr) for each sample site, using Equation G-1, as shown in Table G-1

Table G-1 Flood depth h_n given return period and site elevation

Site	20 yr	50 yr	100 yr
1	2 ft	5 ft	9 ft
2	0 ft	1 ft	5 ft
3	0 ft	0 ft	1 ft

Next, the loss for each site and each storm is calculated, using these flood depths, and integrated to get the expected annualized loss for each site, y_{ann}, using Equation G-3. Assumed losses are as shown in Table G-2.

Table G-2 Annualized losses Y_{ann} for each site elevation X

Site	y_{ann}	weight w_i
1	$10,000/yr	0.2778
2	$5,000/yr	0.4444
3	$2,000/yr	0.2778

Finally, a weighted average of the loss for all three sites is created, using the weights in Equation G-4 and the weighted average in Equation G-5:

$$E[Y_{ann}] = 0.2778*10{,}000 + 0.4444*5{,}000 + 0.2778*2{,}000$$
$$= \$5{,}600/\text{yr}$$

G.2 Quality Control/Quality Assurance

The following steps were implemented to assure the reliability of the results:

1. The geographic locations of all properties were checked against the Q3 digital floodplain boundaries and stream data by plotting each site on maps and performing visual inspections. This was done for the 486 properties included in the analysis.
2. Simple models reflecting the loss calculation process were developed to ensure that the damage functions from HAZUS were being implemented correctly.
3. Independent hand calculations were performed for five (5) projects to check the accuracy of the software program developed to estimate BCA ratios. These calculations were performed by an individual who was not involved with the initial development of the methodology.
4. The results of the current analysis were compared to benefit-cost analysis ratios documented in the NEMIS database. In general, there was good agreement between these estimates.
5. Sensitivity studies were performed to quantify the variability of results to changes in key input parameters. The results did not identify any unusual trends or anomalies.

G.3 GIS Data used in Flood Hazard Analysis

<u>USGS NED:</u>

The National Elevation Dataset (NED) conveniently provides USGS Digital Elevation Models (DEM) in a seamless form that corrects many data artifacts such as mismatched edges, data sinks, and rippling effects. The NED has a resolution of 30 meters, and is based on a variety of data collection techniques including stereoscopic interpretation, processing of Digital Line Graph (DLG) data, and Shuttle Radar Topography Mission (SRTM).

<u>USGS NHD level 1 stream data:</u>

The National Hydrography Dataset (NHD) from the USGS contains information about surface water features such as streams. The NHD is based on USGS Digital Line Graph (DLG) hydrography data, which correlates with the USGS NED elevation data. Additionally, these data integrate with the EPA Reach File Version 3 (RF3) stream designation. These data are at a scale of 1:100,000, but may incorporate more detailed data in certain areas.

<u>FEMA Q3 digital flood maps:</u>

The FEMA Q3 digital flood maps are digital versions of FEMA's Flood Insurance Rate Maps (FIRM) that are intended for planning use. The Q3 digital flood maps were developed by scanning the existing FIRM paper maps which had street layers that did not always correspond with real world coordinates. The Q3 data captures only the major features of the paper maps, such as the 1% annual chance of flooding, and does not include the base flood elevation or cross section data.

G.4 Assumptions used in Modeling Flood

ASSUMPTION	JUSTIFICATION
A building included in a FEMA-funded mitigation project is located in a floodplain.	Although FEMA's Flood Insurance Rate Maps are the basis for local regulation of flood hazard areas, it is widely acknowledged that the maps do not show all areas that actually experience flooding. The evidence is found in FEMA's statement that nearly one-third of all flood insurance claims paid are on buildings that are not within the flood hazard areas shown on the maps. Furthermore, about 60% of the nation's waterways have flood maps that were delineated using approximate methods that have insufficient detail to delineate all flood-prone areas. FEMA is authorized to provide grant funds for flood mitigation projects that will avoid or reduce future flood damage. Grants are provided only for projects that are in the floodplain. If a location is not in a FEMA-mapped flood hazard area then applicants must demonstrate that the area is subject to flooding.

ASSUMPTION	JUSTIFICATION
The depth of flooding at the center of the channel of the 1%-annual chance flood is at least 5 feet deep. (This depth, d_{100}, is computed using the routine described in Section G.5 of this appendix).	The height to which water will rise above the stream bottom (flood depth) is a function of many variables. When water rises out of the channel, the adjacent land begins to flood. The horizontal extent of land that is affected, and the depth of flooding above any point of ground, depends on the elevation of the ground relative to the flood depth. If the 1%-annual chance flood depth is 5 feet (measured in the channel), the depth of water in the adjacent floodplain will always be less than 5 feet. For most parts of the country, flood depths this shallow would be found only in small streams. The elevation information used to estimate the flood depth in the channel is taken from the 30-meter Digital Elevation Model (DEM). Although there is no estimate of how elevations from the DEM vary from actual elevations, some smoothing is expected. The assumption that the flood depth in the channel of the 1%-annual chance flood is at least 5 feet underestimates the actual flood depth at locations other than along small streams.
The first (finished) floor of the building is at-grade (i.e., the floor elevation is the same as the ground elevation).	Virtually all flood-prone buildings that are mitigated using FEMA funds are older buildings that were built before communities joined the NFIP or had begun regulating construction (most notably to require new buildings to have their lowest floor raised above the ground to be at or above the depth of flooding associated with the 1%-annual chance flood). Barring specific information about prevalent foundation types, the assumption is that all buildings included in mitigation projects have their first (finished) floor levels "at grade." At specific locations, this disregards the fact that the types of foundations and construction practices vary regionally (basements, crawlspaces, piers/columns, slabs-on-grade). Traditional foundation types (before floodplain regulations) are influenced by local conditions such as high groundwater, frost depth, soil types, termite activity, and simple historic practices.
For non-basement buildings, there is no damage to the building when the water surface elevation is at or below the ground floor elevation at the building site, which is also assumed to the first (finished) floor.	It is assumed that the first (finished) floor is at-grade (the floor and the ground are at the same elevation). Therefore, when the flood level does not rise to the elevation of the floor/ground, the building is not touched by floodwater. Buildings that are not touched by floodwater are not damaged.

ASSUMPTION	JUSTIFICATION
Where descriptions of building types and building/contents values and project costs are available, they are used. Otherwise, average values determined from the entire dataset (486) are used.	1. 2/3 of buildings (out of the 486) do not have basements. 1/3 have basements. 2. 88% of the buildings are 1 story, 12% are 2 story. 3. Where the values of the structure and the property are unknown, a value of $42,576 is used, which is the median of the known values. Where the value of the structure is unknown, the ratio of structure value to the sum of the value of the structure and the property (where both values are known) is used (this ratio is 75%). Where both values are unknown, 75% of $42,576 or $31,932 is used.
Benefits are calculated using a discount rate of 3% for 50 years.	This assumption is being used for all benefit-cost analysis calculations.
Contents are 50% of structure cost.	This assumption comes from HAZUS-MH.

G.5 Flood Depth-Frequency Methodology Options[72]

G.5.1 Background

In order to examine the benefits of a flood mitigation measure located at a specific site, characteristics of the flood hazard at that site are required. The standard default parameter used to characterize flood hazard is depth. Flood characteristics that may contribute significantly to damage include velocity, duration, wave impacts, debris impacts, and scour/erosion. The depth-damage functions developed by FEMA, the Corps of Engineers, and others, generally aggregate damage from all types of flooding so that the influence of each flood characteristic is not separately considered.

Depth-damage functions are developed for different types of buildings. They relate damage (expressed in a percent of value) to the depth of floodwater above the lowest floor. Ideally, one would know the floodwater depths for different frequency floods. The floodwater depths at a specific building are functions not only of the flood frequency, but the ground elevation and the elevation of the lowest floor (Figure G-4).

G.5.2 Problem Statement

In order to examine flood losses it is necessary to know the depth of flooding, for different frequency floods at different project locations along riverine bodies of water (rivers, streams, creeks and the like, that flow downstream under the force of gravity). This project was

[72] Source: R. Quinn project memo.

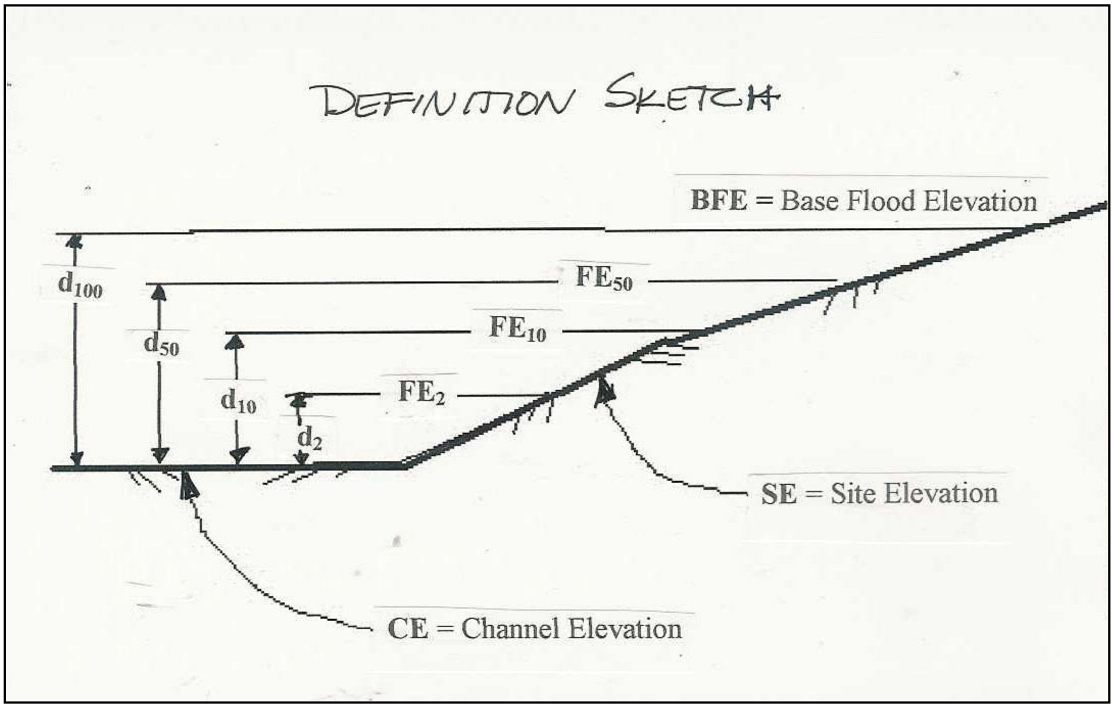

Figure G-4 Sketch showing definitions of various parameters of interest in flood studies.

constrained, however, by the need to apply a method to many different locations with a minimum level of effort.

While depth of flooding is the parameter of interest, it is useful to talk in terms of elevations in order to arrive at depths. For any given location, the flood hazard area associated with the 1%-annual chance flood is usually refered to as the Base Flood Elevation (BFE). The BFE is the height to which floodwaters of the 1%-annual chance flood will rise. Flood discharges of different frequencies produce different water surface elevations (Figure G-4). Many factors influence discharge and elevation, and those factors vary as one moves up and down a stream or river valley (see Figure G-2) and from watershed to watershed. Those factors include:

a. **Hydrology variables** influence the volume and rate of rainfall-runoff (climatic region, drainage area, basin shape, elevation, longitudinal channel slope, land use, vegetation types, soil types, drainage patters, storage (ponds), etc.).
b. **Hydraulic variables** affect the height to which water rises at a given location (valley shape, longitudinal channel slope, frictional effects, constructions such as roads and buildings, etc.)

Within any given floodplain, water depths along the cross-section that is perpendicular to the channel (Figure G-3) as a function of the ground elevation. Thus, in order to apply a depth-damage function at a specific location, it is necessary to know the depth of water above the ground for a range of flood frequencies.

Following are four possible solutions to the problem statement.

G.5.3 Alternative 1 - Solution to the Problem Statement

Alternative 1 would involve accessing flood hazard maps prepared by FEMA. FEMA has prepared Flood Insurance Rate Maps (FIRMs) to show flood hazard areas along most of the waterways in the U.S., except for those in the many rural locations. The maps show Special Flood Hazard Areas that are considered to be the area inundated by the Base Flood (1%-annual-chance flood):

a. **Approximate zones**. More than 60% of the stream miles mapped by FEMA show approximate flood zones, areas that are designated using approximate methods that do not produce BFEs.

b. **Numbered zones.** About 40% of the stream miles mapped by FEMA were done so with detailed hydrologic and hydraulic methods that produced computed water surface elevations. These maps show BFEs referenced to a datum (i.e., a BFE of 285 would mean 285 feet above mean sea level – which in turn is defined based a national datum).

Although FEMA has captured flood hazard areas in digital format for about 1,000 counties (called Q3), the digital files do not contain BFEs. Thus, the paper maps would have to be accessed in order to determine the BFE at specific sites (if the BFE was determined by FEMA; additional manual steps are required to estimate the BFEs for approximate zones). Obtaining the depths for other frequency events involves another manual operation using the flood profiles (only prepared for waterways studied in detail) that are contained in each community's Flood Insurance Study.

Most applications for FEMA grant funding are accompanied by flood depth/elevation data derived from the FIRMs and flood profiles to describe the flood hazard. Other site-specific data are provided, including the ground elevation and lowest floor elevation of specific buildings.

PROS	**CONS**
1. Precision of data	1. Time to obtain paper FIRMs and companion Flood Insurance Studies 2. Manual determination of BFEs and elevations of other frequency floods from paper FIRMS, (including estimating BFE for unnumbered zones) 3. Replicates the methods likely used by applicants

Analysis

Using the paper maps is not only labor intensive, but it is not an independent check because they are the source of data provided by grant applicants. The cons clearly outweigh the pros.

Recommendation for Alternative 1

Do not consider Alternative 1.

G.5.4 Alternative 2 – Solution to the Problem Statement

Alternative 2 would involve using FEMA's loss estimation methodology, Hazards US (HAZUS). FEMA developed a basic automated flood hazard analysis capability as part of HAZUS. The tool can generate discharges and depths for different frequency flood events. The tool will estimate losses "out of the box" for any return period. However, the analysis is very time consuming in terms of both set-up and analysis. The program analyzes single stream segments, rather than a large geographical area. An analysis of properties nationwide would not be reasonable. Additionally, there have been several revisions to the software platform since the release this year, addressing both analytical and software deficiencies.

PROS	CONS
1. FEMA and NIBS approved.	1. Software has not been pilot tested. 2. Analytical and software bugs remain. 3. Time consuming to set-up and run. 4. Interactive process not suitable for nationwide automation.

Analysis

Alternative 2, in addition to offering use of software that is not fully prepared for use, is not appropriate for automated, nationwide analysis.

Recommendation for Alternative 2

Do not consider Alternative 2.

G.5.5 Alternative 3 – Solution to the Problem Statement

In this alternative, we consider the flood depth data for different frequency flood events that is generated during in-depth analysis for specific locations in the community studies. Using just five study regions, a single "flood-depth frequency curve" could be developed as a function of the depth of the 1%-annual chance flood. This curve could be used to estimate flood depths at any location to yield depths for various return periods, provided the depth of the 1%-annual chance flood depth is known.

PROS	CONS
1. Utilizes data from Track B. 2. Simple to implement.	1. Still requires knowing the 1%-annual chance flood depth at specific locations (discussed in Alternative 3) 2. Flood depths at any location have multiple local variables which would not be accounted for 3. Extremely wide error distribution for flood-depth frequency curve. 4. Relies on questionable HAZUS analysis where higher return intervals often result in decreased flooding.

Analysis

The cons out-weigh the pros, in particular the unmet need to determine the depth of the 1%-annual chance flood at project locations. Even if that depth is determined as described in Alternative 4, the use of depth-frequency data from only 5 locations to develop a single relationship is unacceptable. The relationship between depth and frequency varies significantly in different parts of the country.

Recommendation for Alternative 3

Do not consider Alternative 3.

G.5.6 Alternative 4 – Solution to the Problem Statement

Using statistical parameters developed for discharge records at USGS stream gages and GIS-based methods to estimate the Base Flood Elevation and certain ground elevations in the vicinity of project sites, estimation of flood depths for different return intervals can be automated using a standard hydrologic method that applies statistical relationships at nearby gages. The matter of the starting depth, the depth of the 1%-annual chance flood, is addressed.

PROS	CONS
1. Applicable in 1000 counties, where digital flood data are available 2. Using statistical parameters developed for 'nearby' USGS gages to approximate conditions is a common practice 3. Can be automated with GIS programming 4. More likely to produce results that are applicable to each location than reliance on a national average	1. BFE and ground elevations are selected using 30-meter DEMs 2. Elevations from the DEM at a point corresponding to the location of the stream (on stream layer) is assumed to be the elevation of channel bottom 3. Without digital flood maps for several communities, it is not possible to fully test this method

Analysis

The most significant advantage of this approach is that it is based on stream gage data so that regional and hydro-geomorphic variations are captured. The drawback is in the selection of the depth of the 1%-annual chance flood at project location, a drawback that are found in Alternative 3. No methodology can be automated with current tools to account for very local variations, such as presence of a bridge.

Recommendation for Alternative 4

Use Alternative 4

G.5.7 Overall Recommendation

Based on the analysis above, Alternative 4 was recommended and used for this project.

G.6 Approximating Flood Depths for Different Frequency Floods

Following is an approach to approximate depths for different frequency flood events if the depth of the 1%-annual chance flood – as measured in the channel – is known.[73] The key formula is :

$$\log d_T = \log d_{100} - 0.6\,[(K_{100} - K_T)\, S_{logQ}\,]. \qquad \text{(G-6)}$$

where:

> d_T is the depth for a flood with recurrence interval T; specifically, d_{100} is the depth of the 1%-annual chance flood (estimated as the BFE minus the estimated elevation of the bottom of the channel, see following notes).
>
> K_T is a Pearson Type III frequency factor that is a function of recurrence interval T; K_T values can be obtained from Appendix 3 in Bulletin 17B for various values of skewness G.
>
> $S_{\log Q}$ is the standard deviation of logarithms of discharges for each USGS gage (available in HAZUS)
>
> G is skewness computed for each USGS gage (available in HAZUS)

Therefore, if d_{100} is known, as well as the other variables, then depths for other frequencies can be estimated which, in turn, allows estimation of depths d_T at a site.

Before outlining the specific steps necessary, the following notes provided additional explanation, background, justification, and assumptions.

A. Notes on d_{100}

This depth, used in the depth-frequency relationship (above), is the depth of the 1%-annual chance flood as measured in the channel.

The following ways to estimate d_{100} do not meet the need for ease of use and nationwide applicability for this project:

a. For waterways studied with detailed methods, d_{100} and/or the elevation of the channel bed, referenced to a datum, can be obtained manually by accessing the water surface profiles found in the Flood Insurance Study.

b. Thomas' paper (see footnote 7 above) for FEMA's Unnumbered "A Zone" workgroup has a table that lists 20 states (or parts of states) for which USGS has some depth-area relationships that yield d_{100}. Those states are AL, AR, CO, GA, IL, KA, LA, MD, MA, MO, NJ, NY, NC, OK, OR, PA, TN, UT, VA, WY.

[73] Wilbert Thomas, "*An Approximate Method for Estimating Flood Depths for Various Recurrence Intervals"* prepared for Christopher P. Jones, December 2003.

c. For each USGS gage, there is a "gage height". This is an arbitrary datum, selected so that stage (height of water above the datum) is always a positive number. Thomas' paper indicated that the gage height is not the channel bottom, but probably "close" in most cases. In order to relate the gage height to the point of zero flow (bottom of the channel), one would need to reference the gage's rating curve (stage-discharge curve).

Therefore, it is necessary to explore more traditional approaches that rely on standard analyses of long records of discharges at USGS stream gages. Flood discharge is a function of many variables, including volume and rate of rainfall-runoff (climatic region, drainage area, basin shape, elevation, longitudinal channel slope, land use, vegetation types, soil types, drainage patters, storage (ponds), etc.).

B. Notes on G (skew)

A value of G is provided for every USGS gage and is contained in HAZUS. G is shown with three decimal places. The lookup table in Appendix 3 of 17B (used to extract values of K_T) is set up for values of G in decimal increments from +1 to -1. Given the grossness of other assumptions, Thomas' paper (see footnote 7 above) indicates that it would be acceptable to round G. Or, if the Appendix 3 lookup table is automated, interpolation could be done. However, it is notable that the values of K_T do not vary much between whole decimal values of G.

C. Notes on $S_{\log Q}$ (Standard Deviation)

A value of $S_{\log Q}$ is provided for every USGS gage and is contained in HAZUS.

D. Notes on Watersheds with USGS Gages

For locations in the same watershed as a USGS gage, the values of $S_{\log Q}$ and G for the gage can be applied if the location is "near." That is, the values at the gage are "usually applicable if the drainage area [at the location of interest] is within 50 to 200 percent" of the area at the gage (per the FEMA standards & guidelines). This approach is better than using the gross regional values (see paper by Wilbert Thomas for Chris Jones).

E. Notes on Watersheds without USGS Gages (or where drainage area is more than 200% of the gage in the same watershed)

In geomorphologically similar areas, the factors of $S_{\log Q}$ and G do not vary strongly with drainage area. Therefore, it is acceptable to apply values determined for one site to others, within reason. The methodologies for doing so in a very detailed manner are outlined in USGS publications, and generally involve looking for gaged watersheds that are similar in several characteristics.

There are two approaches, with different degrees of reasonableness, for approximating values of $S_{\log Q}$ and G:

1. Use the gross regional values (see paper by Wilbert Thomas for Chris Jones), which advises that using nearby gages is always preferable provided they are in watersheds that are not too dissimilar.
2. Use the average values for the closest gage or gages (ideally selecting gages where the drainage area and other characteristics are similar). Using the average values for the closest gage or gages involves developing a routine to determine the closest gages to each project site. The latitude and longitude of each gage are in HAZUS.

G.6.1 Estimating Depths for Different Frequency Floods

To estimate depth of flooding for different frequency floods (d_T in the channel), for each project site or cluster of building locations, the following steps are required:

1. Determine the *BFE* using Q3;
2. Determine d_{100} (determine the elevation from the DEM that corresponds to the location of the stream from the stream centerline layer and subtract this elevation from the *BFE*);
3. Find the one or two closest gages[74];
4. In HAZUS, extract the values of $S_{\log Q}$ and G for the one or two closest gages (and compute the average values if using two gages);
5. Using the computed G, round to hundredths and look up values of K_T (interpolate) for the frequencies of interest; and
6. Use the formula to compute d_T using K_T and $S_{\log Q}$.

G.6.2 Determining the Depth of Flooding for Different Frequency Floods at a Site

For each site (represented by the 30-meter DEM), the Site Elevation, the Base Flood Elevation, estimated depth of the 1%-annual chance flood (d_{100}) and estimated depths for other frequency floods (d_T) are known. The next step, then, is to determine the depths of those frequency floods at the site – these are the depth values used in the Depth/Damage function.
Figure G-4 is a definition sketch. If:

SE = Site Elevation (known from DEM)
CE = Channel Elevation (determine the elevation from the DEM that corresponds to the location of the stream from the stream centerline layer);
BFE = Base Flood Elevation (known from Q3)
FE_T = Elevation of Flood of frequency T
d_{ST} = Depth at Site for Flood of frequency T

then:

$$FE_T = CE + d_T \qquad \text{(G-7)}$$

and

$$d_{ST} = FE_T - SE \quad \text{and} \quad d_{100} = BFE - SE \qquad \text{(G-8)}$$

Note: When d_{ST} is a negative number it means the ground at the site is dry (higher than the water for that frequency event).

[74] Need to intervene if one or both of the gages are "far away" or is on a watershed that is dramatically different than the site, i.e., the site is a "small" watershed and the gage is on a large river.

G.6.3 Cautions:

1. The differences between water surface elevations for different frequency flood events often are not large (see Figure G-5 for a sample profile from a Flood Insurance Study).
2. The differences between water surface elevations for different frequency flood events varies with several other site-specific factors, such as valley shape and presence of constrictions such as bridges (see Figure G-5).
3. Every step is an approximation.

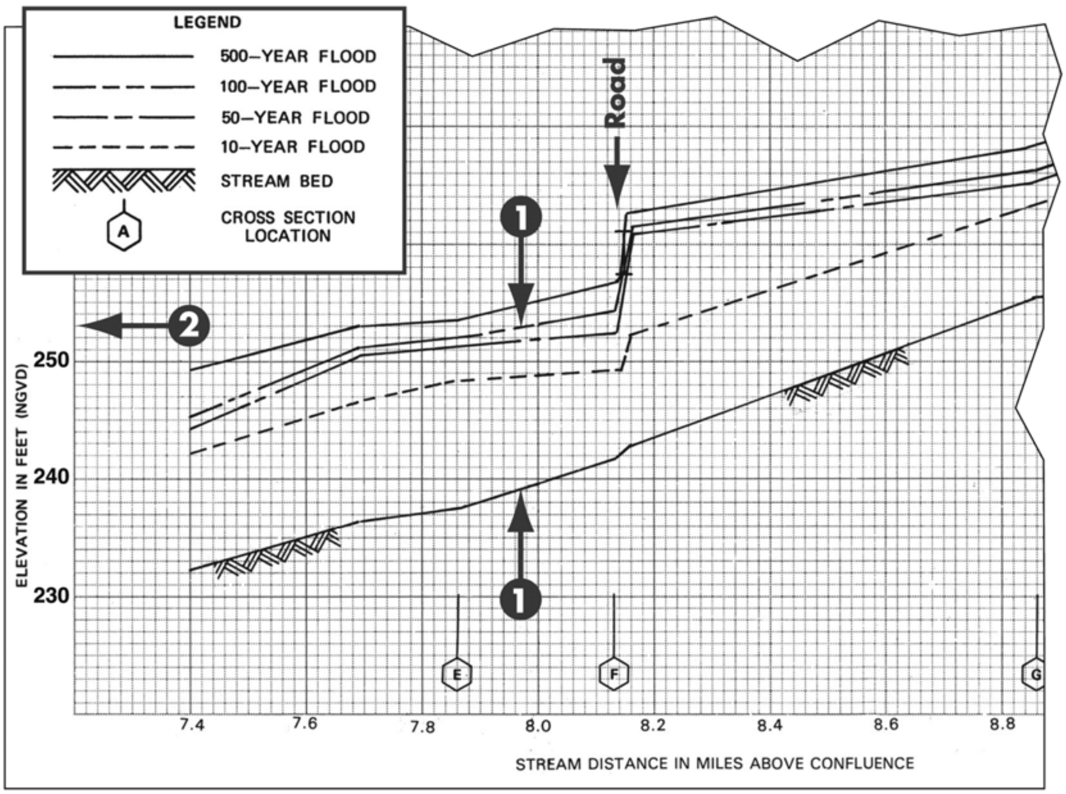

Figure G-5 Plot showing various flood levels for a sample profile from a flood insurance study

Appendix H
PROPERTY AND CASUALTY LOSS ESTIMATION – TORNADO

This appendix describes the steps followed in making probabilistic tornado hazard estimates and related impacts for individual sites considering tornado hazards.

Step 1. Pick a one-degree latitude by one-degree longitude grid that covers the site in question.

Step 2. Estimate the area covered by this macro-grid (e.g., 10,242 km^2).

Step 3. Use NOAA data having tornado vectors and their Fujita ratings to count the number of tornadoes (by their starting-point) in the macro-grid.

Step 4. Divide each count by the number of years surveyed in the NOAA data.

Step 5. Use a linear multiplier for undercount. J. McDonald (oral communication, 2004) suggested a much lower multiplier than Sigal et al. (2000) used; the multiplier of 1.3, or a 30 percent increase, is not adjusted by Fujita rating.

Step 6. Use data by Brooks (2003) from NOAA studies to determine a "mean-based" rectangle that represents each Fujita level tornado. Each rectangle is assumed to occur wholly within the macro-grid, and contains all Fujita level winds associated with each tornado.

Step 7. For each rectangle, determine length degradation (from Sigal et al., 2000) and width degradation (McDonald, oral communication, 2004) matrices, and combine them to determine a total degradation matrix (e.g., how much of the total area of a Fujita 5 tornado has Fujita 5 level winds, Fujita 4 level winds, and so on).

Step 8. Use the foregoing steps to derive the total annualized area in the macro-grid that is exposed to Fujita level 5 winds, Fujita 4 winds, and so on.

Step 9. Divide these total annualized areas by the total macro-grid area in order to estimate the annualized probability of Fujita level 5 winds, Fujita level 4 winds, and so on at each site in the macro-grid.

Step 10. Use HAZUS damage functions to estimate damages and casualties for one- and two-story wood-frame dwellings, with and without safe rooms. Safe rooms are assumed to withstand 250 mph winds as tested by Texas Tech. They are assumed conservatively to be no safer than normal dwellings in higher level winds.

Step 11. Make estimates of casualties as based on HAZUS.

Appendix I
BUSINESS INTERRUPTION BENEFITS – ELECTRICITY AND WATER UTILITIES

Following are the steps undertaken to estimate Business Interruption (BI) losses resulting from damage to water and electric utility systems. The benefit is the reduction in loss resulting from increased resilience of the utility due to execution of a mitigation grant activity.

1. **Calculate the Partial Business Interruption Loss in Dollar Terms**.
   Begin with the HAZUS physical unit downtime loss estimate for the utility in question for one recurrence interval. The dollar loss can be calculated in one of two ways:

   a. Obtain a gross income or net income figure for the utility system component to which the mitigation applies. If provided, this is usually expressed in terms of an annual number. Multiply this annual figure by the ratio of HAZUS-computed downtime and annual operating time (e.g., 4 weeks of downtime yields a ratio of 4/52). Multiply this ratio by the income loss of the utility component to obtain an estimate of the lost income to the utility from failure of this component.

      (1) If an income figure is not available, one can estimate it by using physical component capacity multiplied by unit revenue (e.g., cents/kwh)

      (2) If neither component income nor component physical size are available, the following proxy is used: the ratio of component parts to the total system parts. For example, if the mitigation grant applies to 2 electricity sub-stations of a total of 20 in the system, we assume it applies to 10% of the system. This ratio can be applied to gross or net income estimates or total physical service estimates from Step 1a.

   b. For the calculations below it is necessary to be especially mindful of the distinction between gross income (total revenue or gross output) and net income (total revenue minus total non- primary factor cost, or value added). The desired total BI estimate is expressed in net terms, but some HAZUS calculations require the use of gross income. Translation of one income definition to the other can be accomplished by the use of the following conversion factors: The ratio of net income to gross income for electric utilities is: .646; for water utilities, it is .684.

2. **Calculate Direct Customer BI Losses.**

   Adapt a base vector of gross output changes due to utility outages for each of the 10 sectors of the Indirect Economic Loss Model (IELM) per million dollars of utility income change (actually only 9 sectors, since the Misc Sector is just a placeholder for special computations). The elements of the vector are the reciprocal of the utility input per unit of gross output for each sector weighted according to the sectoral mix of a standard HAZUS model input-output table (i.e., the elements represent the gross output change per unit of utility input change for each sector). One need only multiply each element of the vector by the total gross income loss to the utility from Step 1 (say $40 million) to determine the full *direct* BI loss for each customer sector. Actually, there are 2 separate vectors to choose from because of differences in input intensities and relative use for electricity and for water

	Electricity	**Water**
Agriculture	2.1	192.8
Mining	6.4	1638.8
Construction	72.3	3760.0
Manufacturing	11.1	1084.3
Transportation/Communication/Utility	41.9	2588.3
Trade	17.3	1706.9
Finance/Insurance/Real Estate	55.3	2214.3
Services	70.0	3911.8
Government	38.8	468.1

3. **Set Up the IELM Simulation and Compute Preliminary Estimates of Total BI Losses.** Insert the 9-element vector of sectoral income losses from step 2 into the IELM Module in order to simulate an initial estimate of *total* BI losses to the regional economy. The insertion is to the user option called "Stimulus" as a vector of negative numbers.

   a. Be sure to set some of the user options as follows for the utility sector in question (the "Transportation" sector in HAZUS is actually the Transportation/Communication/Utility or, TCU, sector);

      (1) set inventories for the TCU sector to zero for the case of electricity outages (electricity cannot be stored); set inventories to default value for water outages

      (2) set imports and exports for the TCU sector to zero for both electricity and water

   b. Input other parameter specifications from the "Supplementary Economic Data Sheet" supplied for each stratum:
      - economy-type
      - unemployment rate

   c. set the "outside aid" option to the desired level (for this project equal to zero)

4. **Calculate a "Resilience-Adjusted" Estimate of Total Income Losses.** The IELM will compute a preliminary set of total *net* income losses from the utility disruption. Then:

   a. Multiply each element (sector) of the 9-element "(net) income change" vector by that sector's recapture factor from the list below. (Recapture factors in HAZUS are provided in terms of occupancy categories, so it is necessary to assign them to economic sectors externally according to the following values, see also Rose and Lim, 2002):

Manufacturing, Mining, and Construction	95%
Trade and Finance/Insurance/Real Estate	90%
Government	80%
Agriculture	75%

Services	80%
Transportation	30%

Actually multiply each element of the "net income change" vector by unity minus that sector's recapture factor expressed as a decimal fraction, e.g., for services it would be (1 - 0.8) = .2.

b. Sum the 9-sector computation in 4a to obtain the adjusted total BI (net income) impact on the economy.

5. Compute a "Multiplier" to Apply to Other Recurrence Intervals

(Other Levels of Direct Utility Damage and Downtime). Take the result of Step 4b and the partial BI estimate from Step 1 and compute a ratio, or "multiplier" of total *net* income change/partial *net* income change (say 10.65). The analysis reasonably assumes linearity, so one can apply the same "multiplier" to all the partial net income change results all of HAZUS runs for this mitigation grant (each recurrence interval run for the basic property damage estimate, where each yields a partial BI estimate). Also, this same multiplier should apply to both "with mitigation" and "without mitigation" HAZUS simulations.

Appendix K
PROCESS GRANT BENEFIT ESTIMATION

K.1 Overview

Process mitigation leads to policies, practices, and projects that reduce risks (MMC, 2002). The goal of this section of the report is to estimate net benefits for specific process grants within three general types of mitigation-related activities:

A. information/warning (risk communication)
B. multi-hazard mitigation plans
C. building codes

The analysis below should be considered to be one step beyond a qualitative analysis, for reasons that follow. The benefits of a process grant likely involve two components:

1. spawning and encouraging the development of mitigation plans and activities, such as building codes
2. enhancing the probability that mitigation actions will be taken

As such, it would be difficult to estimate the benefits of a process grant, isolating these from the benefits of actual mitigation activities. Working from the end point of mitigation, assume that individuals' tendency to mitigate (e.g. adopt new building code regulations) increases by some factor, say 50 percent. This in turn leads to benefits in terms of reduced damages from hazards. One would have to isolate the contribution to these benefits from the process grant alone to do an accurate benefit-cost analysis of process grants. However, doing so would be complicated. An individual's propensity to mitigate might increase because his neighbor convinced him to do so, or because his assessment of risk increased. Are these changes due to the process grant and how would we know? Measuring the benefits of hazard risk reduction are most easily done in terms of reduced property damage or a reduction in injuries or mortality. Again, these savings can be directly tied to mitigation activities themselves, but perhaps without the initial process grant, the activities would not have been undertaken (e.g. new building codes would not even exist).

Because of this complexity, and because virtually no known study isolates the benefits of a process grant from benefits of mitigation actions, it is assumed that the net benefits from mitigation activities (total benefits minus the costs of implementation) that are related to a process grant, inclusive of the cost of the process grant, are rough indicators or measures of the net benefits of a process grant.

The limited resources of this study do not allow primary methods to be used to assess the benefits of process grants in these categories. The next best approach is to base benefits estimates on the "Benefits Transfer" approach using existing literature and expert judgment. However, strictly speaking, this approach can not be applied, because no data on process grant benefits are available in any study the project team could find. One generally undisputed outcome in the literature that gauges the effectiveness and accuracy of the Benefit Transfer approach is that the transfer context should be as similar as possible to the original study context. For example, if one wishes to use literature to assess the effectiveness of a process grant for developing new building codes in southern California's urban areas, specifically targeting reduced earthquake damage to multi-dwelling buildings (apartment buildings), then the ideal study is one with the same conditions. Therefore, it is best to consider the analysis below a step beyond a *qualitative analysis*.

K.2 Analysis

With the time available for this project the project team looked across a wide range of studies in all three categories of process grants. No studies were found that explicitly and carefully focused on the benefits of a process grant only, or isolated the two components above. Only two studies were found that could be used to examine a specific process grant and its cost. One study examines impacts from a grant to study the impacts on damages to woodframe homes from earthquakes (Porter et al. 2004). The other examines impacts from an improved multi-hazard planning network, again related to earthquake damages (URS Group, 2001). Both studies were conducted in California. In both cases, the mitigation action costs and benefits are included in the calculations. The project team's assumption is that the benefit-cost ratios provided in these studies roughly pertain to the benefits of a process grant in these categories. In one case, the grant cost is added to the total mitigation costs, and the resulting net benefits and benefit-cost ratio are used to represent the benefit-cost ratio for the process grant.

Benefits from reduced hazard risk are typically calculated as estimates of damages avoided, including lives saved, and materials damage avoided. Costs are the costs of the process grant. Ideally, the estimated ratio of the approximate process grants, by category, based on coded information on benefits, cost, location, and other site specific variables would be calculated. If several process grant studies were available, the analyst could weigh the quality of each study and evaluate which study would be appropriate for a transfer.

K.2.1 Process Grants for Information/Hazard Warnings, and Risk Communication

Process grants might also be used to fund improved communication of risks or better warnings of natural hazards. Current issues in risk communication are summarized in Bostrom and Löfstedt (2003), and a report on the state of the art in effective hazards communication is offered by Mileti (2004).

There were no studies we could find that completely assessed the benefits and costs of a process grant in this category, but the one with the most relevance was a cost-effectiveness study for reducing the risks from radon gas (Marcinowski and Napolitano 1993; Doyle et al. 1990). There are examples of risk-reducing projects, but these differ from process grants because the costs are typically associated with direct hazard reduction.[73] There are also hundreds of studies that assess the likely adoption of various hazard mitigation activities. These should not be ignored, and could perhaps be used in a qualitative assessment. For example, the radon risk studies (see

[73] For example, see the discussion of the use of the FEMA benefit-cost analysis module for estimating the net benefits of flood hazard reductions (http://www.demo.dcc.state.nc.us/mitigation/case_mecklenburg.htm)

Åkerman, Johnson, and Bergman (1991) or Smith et al. 1995) suggest that when faced with mitigation costs, individuals do assess the information provided to them and many do adopt mitigation, or engage in averting behavior.

There are also studies about information campaigns and their effectiveness that demonstrate that such programs can be highly beneficial to society (e.g. the Smokey the Bear advertising campaign, which reduced forest fires), and studies of government-funded programs to label goods and services which pose risks to consumers (e.g., Golan et al., 2000, conclude that nutrition labeling programs have been effective, and cite a case study by the Food and Drug Administration that showed benefits outweighed costs)[74].

The closest study that could be found addresses the cost-effectiveness of the U.S. Environmental Protection Agency's public information program to urge public testing for radon, before and during real estate transactions (Doyle et al., 1990; Marcinowski and Napolitano, 1993). Doyle et al. (1990) surveyed 920 households to gauge responses to the public information and awareness campaign on radon, which they name the "Washington, D.C. Radon campaign." This campaign was a cooperative effort between WJLA-TV, Safeway foodstores, and Air Check, Incorporated (see Chapter 2 details in Doyle et al,. 1990). As part of the campaign, radon test kits were sold at 125 Safeway stores at a 50% discounted price. Doyle et al. (1990) offer no estimate of the cost of this program.

They estimate that only 1.2% of the group of households with radon concentrations exceeding the EPA action level of 4 picocuries per liter of air, or pC_i/L, took remedial actions in response to the campaign. They conclude somewhat negatively:

> "A radon testing and information campaign aimed at the general public was shown to result in very low ultimate mitigation rates. Many of those who claimed to mitigate did not do so in an effective way…many of those who did test could not recall their radon reading or recalled it incorrectly." [Doyle et al., 1990, p. 55]

The Macinowski and Napolitano (1993) analysis also considered the basic standard level set at 4 pC_i/L. The authors apparently did not know the exact response rate to the public information campaign, stating only that it is known to be less than 100 percent. However, they conclude that even if only 10 percent of all homeowners test and mitigate, 220 lives would be saved annually, and that the EPA information program would be cost-effective. This might be high, given the findings by Doyle et al. (1990).

The conclusion is based on the comparison of cost per life saved (in the range of $400,000 to $2.4 million) to the value of a statistical life (in 1991, $2 million to $10.5 million). The authors state that the cost of a radon public information program would be about $2.2 to $3.3 billion per year nationally (they state 0.2 to 0.3 percent of the $115 billion the nation spent on pollution control in 1991). However, it is not clear whether this total program cost includes testing (such

[74] FDA estimates that the benefits of enhanced nutrition information (e.g. reduced fat and cholesterol) greatly exceed the costs of the program to provide such information. This study would not be appropriate for use in this analysis however, because the nature of the risks associated with fat and cholesterol are quite different than those associated with natural hazards.

as mentioned above by Doyle et al., 1990), mitigation, and other activities that are over and above any program cost that might be construed to be a process grant.

It should be noted that for radon, most all of the high risk (when the concentration is over 4 pC_i/L) occurs in only about 6 percent of U.S. homes. The average lifetime risk of getting lung cancer from exposure to radon in these homes is quite high: 1 in 50 (for a non-smoker the average falls to 1 in 500, which would still be considered a high risk). Averaging across all homes in the U.S., average risks would be quite low because most homes have radon levels below the EPA action level.

The validity of the radon risk example for use in assessing other natural hazard risks (flood, hurricanes, earthquakes) would depend on key differences between radon risk and natural hazard risk. One immediate difference is that radon gas releases are ongoing, while most of the natural hazards of interest would be sporadic or episodic. Another is that radon gas is colorless and odorless, giving no cues as to the risks. The validity would also depend on whether the hazard risks are highly concentrated in a few local areas, and the difference between the mortality risks in those areas and the mortality risks in homes with high concentrations of radon.

Another study that has relevance on the value of communicated risk information was a study of land fill or waste disposal siting by Bernknopf et al. (1997). In this study the authors examine the value of improved geographic information system (GIS) maps, weighing the costs of improving the maps and the resulting benefits in terms of avoided expected losses in property values. They find that the net benefits for their example context of Loudoun County, Virginia, are approximately $0.34 million. Using the cost and benefit numbers provided in their analysis, the implied benefit-cost ratio is 1.29. Benefits are expressed as the difference in expected losses when using one of two maps, and are solely couched in terms of average county property values.

We assume that for risk information, the benefit-cost ratio is 1.2, which is lowered from the Bernknopf et al. factor of 1.29 because of the discussion for the radon study.

K.2.2 Process Grants for Multi-Hazard Mitigation Plans

Mecklenburg County, North Carolina (which contains the city of Charlotte) recently revamped the use of, and type of floodplain maps because these were out of date. In the process of doing this, they county realized they had an opportunity to consider regulation of new development, adding future flood protection. Overall, this fits into the category of a multi-hazard mitigation plan.

The Mecklenburg floodplain is an area that has floods that led to 754 claims and $13 million in insured losses, up to the year 2000 (Canaan, 2000). The County hired a consulting firm at a cost of $1.4 million to update its maps. It also hired a consulting firm to assess flood losses, using the NIBS/FEMA HAZUS methodology (EQE, 2000).

The EQE (2000) study is informative, but it is not exactly a process grant, nor is the analysis consistent with the idea study that could be used here. The consultants use methods, including the Federal Insurance Administration’s depth-damage curves, to assess damages in the

Mecklenburg floodplain under several scenarios, including projected future losses. Estimates of the percentage of buildings damaged by floods matching three scenarios are presented in this report, varying from 3.3 percent (for schools and libraries) to a high of 39.4 percent (business/professional and technical service buildings).

They project a total increase in structure damage from $8.5 to $25.2 million, based on a comparison between new estimates of current damage using the new floodplain delineation and future damage, projecting growth and development within the newly delineated floodplain. They suggest that County pursue mitigation measures to avoid this $16.7 million increase in structural damage, with similar analysis for avoiding content damage. Reversing this picture, one could say that the study would lead to savings of $16.7 million in structural damage, and $16.4 million in content damage, if mitigation measures are adopted to avoid the future scenario. The study mentions that removing the structures from the floodplain would cost approximately $12 million. One estimate of net benefits in the structural damage avoidance is then about $3 million ($16.7m less $12m, less $1.4m for the process grant), or a benefit-cost ratio would be about 1.25 ($16.7/13.4).

The TriNet project (see URS Group, 2001) is one of the only other studies found that might be used to assess the effectiveness of a process grant in this area. The project emphasizes improved building codes, but was funded under FEMA's Mitigation Grant Program with other features, including a plan for improved data transmission, improved spatial resolution of the geographic variation in earthquake ground motions, and improved motion sensors. These features were designed as part of an overall plan to reduce damage from earthquakes, so it might be best placed in this multi-hazard plan category. The grant is a process grant, for a total of $16.76 million. The impact of the grant was not only on reduced building damage, but also on reductions in power outages, and reduced casualties. In addition to the grant's cost, there were costs of $23.1 million for replacing/retrofitting old code buildings, and $12.4 million in developing codes for new buildings. The total net benefits of mitigation, excluding the process grant, were estimated to be $37.8 million. Assume that the process grant can be added as a cost, and that the net benefits of the project are then total benefits minus total costs. By adding the $16.76 million to the estimate provided in the report, net benefits are still positive. Put another way, the benefit-cost ratio without the grant cost is 2.06. The benefit-cost ratio, including the grant as part of costs, falls to 1.4, but is still above one. The assumption is that the benefit-cost ratio that is relevant to the process grant is the same 1.4.

Another study that has some relevance was recently completed by the North Carolina Division of Emergency Management (see NCDEM in conjunction with FEMA, 2004). This study assesses the savings (benefits) of a hazard mitigation grant to relocate and elevate homes in the floodplain in Belhaven, North Carolina, as they accrued from avoided losses from Hurricane Isabel. The grant, including state matching funds, was for about $9.3 million. Preliminary estimates indicate that within 2 years of the grant being provided, a return on investment of about 37% has been achieved. It is too early to consider this a complete benefit-cost ratio, but the study is optimistic regarding the return on this mitigation grant.

K.2.3 Process Grants for Changed/Improved Building Codes

This category pertains to the adoption of various building codes to mitigate against hazard damage, most frequently from earthquakes. Earthquakes cause property damage depending on the intensity that buildings are shaken. At the more moderate end of impacts, there will be the need for slight repairs and at the more severe end, entire structures can collapse and be beyond repair. Under many zoning plans various urban or regional zones are designated with codes as to their seismic risk, and building codes are adjusted to factor seismic loads. The benefits of more earthquake-resistant buildings (again, not a process grant per se) are going to be related to reduced property damage, injury, and mortality rates (Schulze et al. 1987).[75]

The risk and economic issues are similar to the ones above in this category of process grants, with two important additional features:

1. Tradeoff of destroying existing structures with loss in buildings of historical value and importance or loss of low-income housing; and
2. Perception of some buildings as public goods, and building code adoption as a public good; differentiation with privately owned buildings.

Porter et al. (2004) provide an extensive and careful analysis of the benefits of retrofitting woodframe homes. This is the one paper that does seem to tie the analysis to a process grant ($5.2 million for the CUREE-California Woodframe Project). Most analyses of the benefits of building codes, such as theirs, focus on property damage. Benefits are measures as losses averted, whether these be in minor repair bills over time, or more major reconstruction. Using a series of equations and Monte Carlo simulation of some of the probability distributions involved, the authors estimate whether retrofitting is cost-effective for areas corresponding to 1,653 California zip-codes. Assuming a 3 percent discount rate and a 30 year planning horizon, the authors estimate that the reduced future earthquake repair cost exceeds the cost to retrofit a certain small house (by adding foundation bolts, structural sheathing to unbraced cripple walls, and the strapping water heater to the frame), if the house were located in any of about half of California ZIP Codes (781 of 1,653). An above-code design for a particular townhouse building is estimated similarly to reduce future earthquake repair costs by more than the additional construction cost of exceeding code requirements, if the building were located in any of 300 California ZIP Codes.

Porter et al. (2004) also examine the benefits of high-quality construction, finding that median savings stemming from reduced seismic risk are from $1,000 to $10,000 over a thirty year period. The paper argues for frequent construction inspection, based on the results.

K.3 Conclusions/Caveats

Information on the benefits and costs of process grants is scant, at best. The analysis above draws heavily on similar analyses, as only two studies allow a direct comparison of some type of

[75] The Schulze et al. (1987) study is dated, but these authors use simulation methods and conclude that expected benefits from adopting uniform building codes that reduce wind, property damage, and reduce mortality from earthquakes along the Southern San Andreas fault outweigh the costs, at an assumed 4.5% real discount rate.

benefits to the cost of the grant (URS Group, 2001; Porter et al., 2004). Therefore, in each category the benefits relative to the costs of mitigation actions (not process grants per se) are mainly considered, but the table reflects consideration of whether the process grant would tip the balance so that net benefits were negative (or the benefit-cost ratio was less than one). When the difference between benefits and costs of mitigation is large relative to the cost of the process grant, it is more likely that a process grant is cost-effective.

Recall that there are no available benefit-cost analyses for category A, the natural hazard risk communication studies. This category is split into two separate subcategories, risk warnings, and risk education. It is more likely that a process grant will have positive net benefits when it relates to direct warnings. The project team used information from the radon risk public information program study (the Washington Study), and differences between the radon context and the natural hazards context have been noted above.

Table K-1 Conclusions on likely benefit-cost ratio for process grant categories

Category of Process Grant	Likely Net Benefits or Benefit-Cost Ratio
A1. Risk Communication (warnings)	Qualitative Adjustment from Radon - Judgment Only- Positive (1.2)
A2. Risk Communication (education)	Inconclusive
B. Multihazard Mitigation	1.25 - Weakly Positive (1 to 1.4)
C. Building Codes	Positive (> 1)

Many of the process grants analyzed are for earthquake-related damages, and are most likely related to building codes. One of the grants (Grant 7201) is for Steel buildings, but no information is available on grants or mitigation activities in that category. Grants related to Tsunami guides and grading are most likely falling into the multi-hazard category. Except for Steel Buildings and for the seismic map project, a conservative estimate of the benefit-cost ratio applicable for process grants in these categories is 1.25 to 1.4. This range is based on the Mecklenberg studies and the URS Group report, which is most applicable to multi-hazard grants. As there is a map involved for the seismic mapping process grant, another estimate to confirm this range for the benefit-cost ratio is 1.29, which based on the Bernknopf et al. (1997) study of the value of map information. Applying this study assumes that property value changes fully capitalize the hazard warning effects via the housing market.

Building code process grants likely have a larger benefit-cost ratio. In addition, if a process grant is small, it is quite likely that its net benefits will be positive, based on the Litan et al. study of earthquake mitigation. The reason is that their average benefit-cost ratio is about 3. Therefore, any process grant that is small, and which does not have negative consequences in obtaining mitigation, will only slightly raise costs, and therefore slightly reduce the benefit-cost ratios in this category.

First, as noted above, most of the literature available does not assess the benefits of a process grant in any of the above categories. Rather, some of the literature assesses the benefits and costs of a particular mitigation action itself.

Based on logic and effectiveness in other contexts (see Golan et al., 2000) there is reason to believe that process grants provide positive net benefits in many situations. The mitigation action in many cases would never have taken place if a process grant had not spawned the initial plan or building code that led to implementation. A simple, common sense conclusion would be that when net benefits from mitigation in a particular category, exclusive of a process grant, are large, then a small process grant certainly cannot much reduce the net benefits, so any grant in that category is likely to be positive. However, when actual mitigation is quite costly to the individual, it is much less likely that a process grant is going to lead to positive net benefits.

Some caveats are warranted. It has to be stated clearly here that in the project team's literature search, no studies were found that specifically estimated the benefits of a process grant, which is the goal of this analysis. Possible key differences between radon risk communication and a natural hazard risk warning were noted: it is not known, however, if the Doyle et al. (1990) finding of about 1.2 percent adoption would pertain to natural hazard migitation adoption. Therefore, one view of this is that none of the estimates are free from concern regarding their accuracy. Only available information is being used, which largely pertains to benefits and costs for mitigation activity grants.

Second, there is still not enough information on the effectiveness in terms of adoption of a mitigation action in the literature to generalize in the above categories. Third, blanket categorical benefit-cost ratios are unwise. Last, there is likely substantial regional variation in adoption rates, and hence, regional variation in the effectiveness of process grants (e.g. see Lindell and Prater, 2002).

Appendix L
BASE-ISOLATED BUILDINGS LOSS ESTIMATION

One effort to base-isolate a building appears in the sample of earthquake mitigation grants. The question arises, how to model the benefits of this grant, and more specifically, how to model the post-mitigation property loss? HAZUS does not contain loss functions for base-isolated buildings, and the paper grant application does not contain pushover parameters (the parameters required for a HAZUS analysis). While a great deal of structural engineering literature exists on base isolation, it was impossible within a reasonable period of time to discover any generic pushover parameters for base-isolated buildings.

It was therefore assumed for present purposes that base isolation virtually eliminates the expected present value of loss, relative to pre-mitigated conditions. The benefit-cost ratio calculation is fairly insensitive to whether the loss is reduced by 90 percent, 95 percent, or 99 percent; the benefit is essentially equal to the pre-mitigation loss. Since the pre-mitigation loss is not that of a base-isolated building, pushover curves for the base-isolated case become immaterial.

Appendix M
DEBRIS FLOW DAMAGE ESTIMATION

Following are the steps taken to estimate damage from debris flow.

Step 1. *Assess the frequency of significantly damaging debris flows*. This is the most challenging step. For the Multnomah County regions affected, two precipitation-induced (low energy source) debris flows occurred in a seventy-year period. In addition, when corrected, a geologic evaluation of debris material accumulations led to estimates of 17-35 years per debris flow for the sites in question. One prominent geologist in charge of natural hazards for geology and knowledgeable about the area estimated a 50-year return interval. She noted that a high-energy source might occur about every 500 years. One other geologist who had made extensive studies thought that a 35-year return interval was reasonable given the paucity of the data. A third geologist, in charge of hazard mapping for the region, claimed that this hazard mapping was designed for land-use and other planning purposes, and not for analysis of risks. All noted that there had been debris flows in the region, even as recently as 2002, that had not caused damage.

Recommendation: Assume a 35-year return interval, with 17-years and 50-years as assumptions for sensitivity evaluations. Assume that a high-energy source might initiate debris flows every 500 years.

Step 2. *Estimate the damages to the six residences based on significantly damaging debris flows.* (see also step 4) In the original benefit-cost evaluation, a very high dollar amount was put on such damages, about 80 percent higher than the market value of properties. This step consists of estimating the replacement value of these six residences and then estimating the degree of damages expected from debris flows. Data should be gathered to estimate replacement values. Since the debris flows selected in Step 1 are “significantly damaging,” it is assumed that losses are 100 percent of replacement value. This at least is consistent with the original benefit-cost evaluation. Costs to clean up the debris, should the damage be less than 100 percent, should be made in consultation with a knowledgeable contractor.

Step 3. *Estimate casualties from significantly damaging debris flows.* There is to date no indication of casualties in the 1996 debris flow. There is much evidence, however, that debris flows worldwide cause many casualties. Debris flows that have low energy sources (precipitation-induced) provided days of prospective warnings. Thus, even though debris flows may only take a few minutes to cause damage once they begin, preparations for precipitation-induced debris flows can occur days in advance. Debris flows caused by high-energy sources may be another matter. They do typically require some degree of prior precipitation, but they may have less warning. In this case, simplified accounts of how many people might be present, and how many might be able to evade, say, 500-year events could be devised. However, because such a simplified technique is highly speculative, it should not govern the benefit-cost ratio. Therefore, assume one death per 500 years as a conservative (lower bound) estimate, and conduct sensitivity evaluations to estimate a possible range of answers.

Step 4. *Determine the degree of damage in the 1996 event*. This step should help not only in refining the prospective degree of damage in debris flows, but more critically should define more clearly the "marginal costs" of buyouts. If the residences are substantially damaged, then buyouts can be a substitute for other payments, such as those through FEMA directly, or from FEMA/FIA (Federal Insurance Agency).

Appendix N
FOUR METHODS TO SELECT SAMPLE AND SCALE-UP BENEFIT

N.1 Summary

This appendix documents four methods to select a sample of size $N = 25$ from a population of mitigation efforts and to calculate total stratum benefit. In all four methods, stratified sampling is used to ensure sampling of the tails of the distribution of approved net eligible project cost (referred to hereafter as cost). In summary, the methods are as follows.

Method 1**:** mitigation efforts are selected for sampling with equal probability, using strata of equal sizes, and population benefit is estimated as the sum of the sample benefits times L/N, where L is the number of mitigation efforts in the population.

Method 1b**:** mitigation efforts are selected for sampling with equal probability, using strata of equal sizes, and population benefit is estimated as $B' = C^*\mu_{bcr}$, where μ_{bcr} is the sample-average benefit-cost ratio.

Method 2**:** mitigation efforts are selected with probability in proportion to their cost, using strata of equal cumulative cost, and population benefit is estimated as the sum of the sample benefits times C/c, where C is the population cost and c is the cost of the sample.

Method 3**:** mitigation efforts are selected with probability in proportion to their cost, using strata of equal cumulative cost, and population benefit is estimated as $B' = C^*\mu_{bcr}$, where μ_{bcr} is the sample-average benefit-cost ratio.

Let:

L = population size (number of mitigation efforts in the population)
N = sample size (number of mitigations in the sample)
c_i = cost of mitigation i.
bcr_i = benefit-cost-ratio of mitigation i
b_i = benefit of mitigation $i = c_i bcr_i$
C = the total cost of all mitigations
B' = estimated benefit of population based on sample

$= (L/N)^*\Sigma_N b_i$	method 1	(N-1)
$= (C/\Sigma_N c_i)^*\Sigma_N b_i$	method 2	(N-2)
$= C^*\Sigma_N bcr_i/N$	methods 1b and 3	(N-3)

B = true population benefit $= \Sigma_L b_i$
ε = relative error of benefit estimate

$$= (B' - B)/B \qquad \text{(N-4)}$$

μ_ε = mean relative error of benefit estimate
σ_ε = standard deviation of relative error of benefit estimate

Two reasonable criteria for accepting a sampling method are: (1) it produces an unbiased estimate of total benefit, i.e., $\mu_\varepsilon \approx 0.0$, and (2) it produces a small uncertainty in the estimate of total benefit, i.e., σ_ε is small. The criterion for acceptable σ_ε is that the uncertainty is small enough that one can answer with 90% confidence whether FEMA grants have been cost effective, i.e., either:

$$B'*(1 - 1.28\sigma_\varepsilon)/C > 1.0 \text{ or equivalently } (1 - C/B')/1.28 > \sigma_\varepsilon$$

or

$$B'*(1 + 1.28\sigma_\varepsilon)/C < 1.0$$

In the former case, one can say with 90% confidence that the population of mitigation efforts within the stratum is cost-effective; in the latter, one can say with 90% confidence, the population of mitigation efforts within the stratum is not cost-effective. Both assume normality of B', an unbiased estimate of B, and ignore error in the estimation of benefit for an individual mitigation effort, b_i. For an unbiased estimator, $E[B'] = B = \$5.57*10^9$ and $C = \$2.36*10^9$. An acceptable sampling approach must therefore have $\sigma_\varepsilon < (1 - C/B)/1.28$, or $\sigma_\varepsilon < 0.45$. Only method 3 passes this criterion.

Explanations of the mechanics of these selection and benefit-calculation procedures follow.

N.2 Method 1

This method applies an equal probability of a grant being sampled, and benefits are scaled up in proportion to number of grants sampled. Method 1 is performed as follows.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. Divide the stratum population in N contiguous bins of increasing cost, with an equal number n of projects in each bin (±1, to account for a stratum population that is not an integer multiple of N).
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.
6. Re-sort projects by increasing bin number and then by increasing u within the bin.
7. Select from each bin the project with the lowest value of u. The result is N randomly selected projects that nonetheless span the range of project costs.
8. Calculate the benefit for each mitigation effort in the sample, b_i: $i = 1, 2, \ldots N$, where i now indexes mitigation efforts in the sample.
9. Calculate B' per Equation N-1.

N.3 Method 1b

This method applies an equal probability of a grant being sampled, and scales up benefits by averaging sample benefit-cost ratio (BCR). Method 1b is performed as shown under Method 1, except that B' is calculated per Equation N-3.

N.4 Method 2

This method applies probability of a grant being selected in proportion to its cost, and scales up benefit in proportion to the cost of sampled grants. It works as follows.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. For each mitigation effort i, calculate the cumulative fraction of total cost, $F_C(c_i) = \Sigma_{j=0..i}c_j$. Divide the population in N contiguous bins of increasing project cost, with equal total bin cost, i.e., bin k includes mitigation efforts p, p+1, … q such that $\Sigma_{j=p..q}c_j = C/N$.
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.
6. Select from each bin the project with the lowest value of u. The result is N randomly selected projects that both span the range of cost and place more emphasis on costlier projects.
7. Calculate the benefit for each mitigation effort in the sample, $b_i = bcr_i{*}c_i$, $i = 1, 2, \ldots N$, where i indexes mitigation efforts in the sample.
8. Calculate B' per Equation N-2.

N.5 Method 3

In this method, the probability of sample selection is proportional to its cost, and the benefit is scaled up by calculating the sample-average BCR and applying this BCR to the stratum.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. For each mitigation effort i, calculate the cumulative fraction of total cost, $F_C(c_i) = \Sigma_{j=0..i}c_j$. Divide the population in N contiguous bins of increasing project cost, with equal total bin cost, i.e., bin k includes mitigation efforts p, p+1, … q such that $\Sigma_{j=p..q}c_j = C/N$.
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.

6. Select from each bin the project with the lowest value of *u*. The result is *N* randomly selected projects that both span the range of cost and place more emphasis on costlier projects.
7. Calculate mean benefit-cost ratio for the sample, $\mu_{bcr}: = \Sigma_N bcr_i/N$, $i = 1, 2, \ldots N$, where *i* indexes mitigation efforts in the sample.
8. Calculate B' per Equation N-3.

N.6 Tests of Method 1

Simulated population. A simulated (hypothetical) population of $L = 1000$ mitigation efforts was created whose cost distribution match that of the FEMA grants, i.e., lognormal with median cost = $732,000 and logarithmic standard deviation = 1.80. It was necessary to assign a value of benefit to each mitigation effort. To do this, the benefit-cost ratios (BCRs) in the NEMIS grant database were examined, and those with project cost (denoted by *C*) > 1 and BCR > 1 extracted. Of the extracted grants, it is found that the average estimated BCR is 10.3, with a logarithmic standard deviation of 0.87. Project cost and BCR appear to be uncorrelated, either for the population (correlation coefficient $\rho = -0.0097$, $N = 3176$), wind mitigation grants ($\rho = -0.025$) or flood mitigation grants ($\rho = -0.024$); a modest negative correlation exists for earthquake mitigation grants ($\rho = -0.10$). A lognormal distribution was assigned to BCR using the statistics quoted above and BCRs were simulated for each mitigation grant in the simulated population.

Testing for bias. The hypothetical population was grouped into $N = 25$ strata of $M = L/N = 40$ samples per stratum, with the substrata grouped by increasing cost, per the sampling approach described above. The Excel add-in "Insight.xla" (see www.duxbury.com) was used to create Q = 1000 simulated sample sets of 25 mitigation efforts, each time calculating the actual population benefit $B = \Sigma_L b$ and the estimated benefit $B' = M\Sigma_N b$, and calculated the error per Equation N-4. There is one value of ε for each sample set, i.e., there are $Q = 1000$ samples of ε. One can calculate a mean bias as $\mu_\varepsilon = 1/Q^*\Sigma_Q\varepsilon$. A value of $\mu_\varepsilon \neq 0.0$ indicates a bias. In these expressions, *b* is the benefit from one mitigation effort, Σ_L indicates the sum over the population of *L* mitigation efforts, $\Sigma_{.}$ indicates the sum over the sample of *N* mitigation efforts, Σ_Q indicates a sum over *Q* sample sets, *B* indicates the "true" total population benefit, and B' indicates the estimated population benefit extrapolated from the sample.

Observations. This simulation approach produces an unbiased estimate of benefit. Using Q = 1000 simulation produces an estimated mean error, $\mu_\varepsilon = -0.022$, and an estimated standard deviation of error $\sigma_\varepsilon = 0.69$, which is too large. One observes an unbiased estimate if BCR is assumed to be a constant value (BCR = 2 produces $\mu_\varepsilon = 0.0014$), if BCR is assumed to increase linearly with cost (BCR = $1 + C/100$ produces $\mu_\varepsilon = 0.013$), to linearly decrease with cost (BCR = $5 - C/100$ produces $\mu_\varepsilon = 0.013$) or to be quadratic with cost (BCR = $1 + (C/100)^2$ produces $\mu_\varepsilon = 0.039$).

Testing using the NEMIS population. The bias test was repeated using a subset of the NEMIS portfolio: all those in-scope mitigation efforts whose $C > 1$ and whose BCR > 1. The subset includes $L = 3176$ mitigation efforts. These were stratified into $N = 25$ strata of $M = 127$ efforts each (the first stratum had $M = 128$). The Microsoft Excel add-in Insight.xla was used to create

1000 sample sets of 25 mitigation efforts, each time calculating the actual population benefit and the estimated benefit $B' = (L/N)\Sigma b$, and calculating the error per Equation N-4. For the "actual" population benefit, the estimated BCRs from the NEMIS database were used: $B = \Sigma_L b = \Sigma_L bcr_i * c_i$. Again using $Q = 1000$, it is found that $\mu_\varepsilon = 0.00058$, which suggests no bias, and a standard deviation of error, $\sigma_\varepsilon = 0.55$, which is approximately equal to that obtained using the simulated portfolio. A test using Method 1b produces a biased and highly uncertain estimate: $\mu_\varepsilon = 0.82$ and $\sigma_\varepsilon = 1.56$.

Method 1 has unacceptably high uncertainty. Method 1b has unacceptable bias and uncertainty.

N.7 Tests of Method 2

This approach was tested once using the simulated population (with random BCR distributed the same as FEMA's estimate shown in the NEMIS population) and once using the NEMIS population. Using the simulated population, this approach produces an unbiased estimate of total benefit, with better accuracy than Method 1: in $Q = 1000$ simulation, one finds $\mu_\varepsilon = -0.010$, and standard deviation of error, $\sigma_\varepsilon = 0.17$. Comparing this $\sigma_\varepsilon = 0.17$ with 0.69 using Method 1 suggests that Method 2 produces a much more-accurate estimate of total population benefit.

However, using the NEMIS population and NEMIS benefits, this method underestimates the population benefit, albeit with very low variability: $\mu_\varepsilon = -0.40$ and $\sigma_\varepsilon = 0.05$. The reason appears to be the slight negative trend of BCR with cost; although $\rho_{c,bcr} = -0.0097$, the trend is strong enough to produce a consistent under-estimate of benefit. That is, benefit accrues disproportionately from smaller projects. Again, this test assumes that the existing FEMA estimates of benefit are unbiased with respect to cost, i.e., that the "true" BCR follows the same trend with cost as does the BCR estimated by FEMA.

Method 2 has unacceptably high bias.

N.8 Tests of Method 3

Method 3 was tested both with the synthetic population and the NEMIS population. The former produced an unbiased estimate of *B*, with $\mu_\varepsilon = 0.0078$ and $\sigma_\varepsilon = 0.13$; the latter a biased estimate: $\mu_\varepsilon = 0.42$ and $\sigma_\varepsilon = 5.18$. The reason is that there are four mitigation efforts in the NEMIS portfolio with $bcr \approx 3300$ and one with $bcr \approx 6200$. They have low cost, so their effect is small under method 2, but method 3 is sensitive to them. When these are eliminated from the population, $\mu_\varepsilon = 0.023$ and $\sigma_\varepsilon = 0.39$, i.e., an unbiased estimate of benefit with a moderate uncertainty. (The previous methods were also checked after censoring these high BCRs; this approach makes too little difference to accept Methods 1, 1b, or 2.)

Method 3 has an acceptable uncertainty, as long as one assumes that samples of BCR > 1000 are erroneous.

Appendix O
COMMUNITY SELECTION PROCESS

Initially fourteen communities were selected for possible study in accordance with the selection procedures described below. Ultimately, for budgetary, scheduling, and operational reasons, eight communities were selected for study.

Communities to be considered for study by the project team were selected using non-probabilistic sampling procedures, specifically quota and purposive sampling procedures. Generally, non-probability sampling is used when the researcher is unable to describe the population from which a sample is to be drawn and, hence, cannot describe the "probability" with which a person, community or some other unit of analysis within the population will be selected for the sample. Non-probabilistic quota samples are sometimes considered roughly analogous to probabilistic stratified samples in that certain variables thought to be important in describing the population are identified and efforts are made to insure that people or communities are selected so that they represent the range or diversity of values or types on those variables.

The following ordered criteria or variables were used in selecting the communities for study: (1) the combination of hazards for which communities had received FEMA awards; (2) validation according to available hazard maps that a community was at high risk of at least one of the three hazards (wind, flood, earthquake) being studied[76]; (3) community size defined as small (10,000-49,999), medium (50,000-499,999) and large (≥ 500,000)[77] [78]; and (4) the geographic distribution of communities. The geographic distribution of communities was largely established once the pattern of awards received and the level of hazard risk were applied, since the distribution of floods, wind and earthquake hazards is not constant across the United States. To further insure geographic distribution the project team examined the distribution of awards across the ten FEMA regions. While noted, demographic characteristics of communities and whether they had or had not received a Project Impact award were not used in selecting communities.

Ultimately, however, the last stage in the selection of any non-probability sample, including a quota sample, is a judgment made by the person or group selecting the sample. Purposive sampling is the application of expert judgment to the selection of who is in the sample. Unusual in the selection of the communities to be studied is the fact that, unlike most non-probability samples, the population of communities from which the sample was drawn can be described. As a result, this sample is somewhat analogous to the multi-stage sampling procedures used in the Gallup Poll where the first stages of selection are probabilistic and the final stages of selection involve, first, *quota sampling* and, second, *purposive sampling* where the interviewer

[76] The community selection procedures are described in the *Community Studies Scoping Study Report* of September 22, 2003, and represent one of multiple procedures explored by the Project team.

[77] Proposed by E. Mittler and C. Taylor in July 2003; approved by the MMC Project Management Committee (PMC) on August 6, 2003.

[78] The PMC recommended the inclusion of at least one county in July 2003.

(in a Gallup Poll) selects the actual persons interviewed. Judgment was used to establish the quotas and in deciding how to structure the actual selection of communities.
The sample that is reflected in this appendix was selected in three stages based on several factors: (1) the project team would sample six communities as a minimum; (2) if additional funds were provided, the project team would include as many as four additional communities, bringing the total number of communities to ten; and (3) a third set of four communities was selected to serve as replacement communities in the event that a community in one of the first set of six communities or second set of four communities was unavailable.

O.1 The Population

The National Emergency Management Information System (NEMIS) data file that ATC received on July 23 2003 was used to identify the population from which the project team selected the additional communities for study. This data set is a transactional database that includes one record for each award. It includes 8,030 awards that had been completed or closed. To be eligible for consideration, communities had to: (1) have received awards whose objective was to mitigate damage from earthquakes, flood, or wind (coastal storm, hurricane, severe storm, tornado, typhoon); (2) be at high or medium risk of earthquakes, flood, or wind hazard(s) as identified on hazard maps as described in the Community Studies Scoping Study of September 22, 2003; (3) be a single jurisdiction identified with a legal title as a city, town, borough, village or county within one of the 50 states; (4) have both project and process (includes Project Impact) activities funded; (5) have received project and process grant awards that total ≥ $500,000; and (6) have received a total of ≤ 15 awards. One hundred thirteen (113) communities met all six criteria.

O.2 Database Considerations

It should be noted that the combination of awards assigned to communities that were used to make the selection of communities for further study may be unavoidably incorrect. There are several reasons for this judgment. First, there are errors in the NEMIS database. One of the findings in the Community Studies Pilot Study was that the NEMIS database for Tulsa, Oklahoma, did not contain any reference to some grants the project team found in Tulsa, and misidentified others. Second, when the description of the grant did not clearly identify what hazard the grant activity referred to, the project team labeled the grant the same as the proximate cause of the Presidential disaster declaration, i.e., flood grant for a flood, earthquake grant for an earthquake. In some cases, these will not be correct because in recent years FEMA has awarded mitigation grants for all hazards following a disaster declaration such that, for example, flood and wind grants can be awarded after an earthquake. Limitations of time and other resources prevented the project team from identifying possible errors, which the team believes were minimal and did not significantly affect choices.

In recognition of problems in the NEMIS data set, once the sample of communities is selected data available in the NEMIS data set for each community was again examined. The objective here was to insure that each community jurisdiction selected had received no more than 15 awards, process and project combined, that totaled at least $500,000, and that the awards had, in fact, been made to the jurisdiction selected. Of particular concern were situations, such as

Atlantic City and Atlantic County, New Jersey, where both a city and a county have the same name. Many grants listed in the NEMIS data set do not clearly indicate which of the two same-name jurisdictions received the award. Information that is not in the data set must be available to determine the awardee.

O.3 Setting and Applying Criteria and Quotas for the Sample

Available funding and other considerations specified that a sample of fourteen communities would be selected iteratively in groups of six, four and four. The last set of four communities selected would be studied *only if* one or more communities within the first ten selected were unavailable for study. One possible reason for a dropout is that the community was severely impacted by a disaster during the conduct of this study, thus limiting possible access to key individuals, organizations, etc. Five criteria were used to determine which communities were selected for inclusion. They were: (1) the combination of awards received; (2) the hazard risk as determined by the maps available in August 2003 (see Community Studies Scoping Study of September 22, 2003; (3) the size of the community; (4) the FEMA region in which communities were located; and (5) a post-selection check of the awards received by each community against the NEMIS data base.

Step 1: Combination of Awards Received. In*n* the *first step,* communities were sorted according to the *combination of awards* they had received from FEMA: earthquakes only (N = 10; 8.8%); wind only (N = 8; 7.1%); flood only (N = 38; 33.6%); earthquake and flood (N = 4; 3.5%); wind and flood (N = 50; 44.2%); and earthquake, wind and flood (N = 3; 2.7%), and quota limits were established for the selection of the sample. In Table O-1[79], Column 4 shows constraints placed on each category in terms of the maximum number of communities that could be selected with that combination of FEMA awards. These were set to be roughly proportionate to how the patterns were represented in the population of 113 communities[80].

Fourteen communities were selected for study in sets of six, four and four. For purposes of this evaluation it was important to allow each combination of awards in the sample to be potentially represented by at least one community. It was also important to insure that all the communities were not selected from only one or two award patterns. If maximum limits were not set in advance of the draw, it was possible, although unlikely, that all of the communities selected for the sample would represent only one or two combinations of awards. For example, the first 14 communities drawn could be the 10 communities with only earthquake awards and the four communities with flood and earthquake awards.

[79] Ninety-five (85%) of the 113 communities in this population received at least one FEMA award for floods; hence, given criteria 2, communities with flood awards are necessarily underrepresented in this sample.

[80] Fourteen communities were to be selected distributed as FEMA awards were distributed in column 1 of Table O-1. The expected number of communities in each category was: 1.23 for earthquake only; 4.7 for flood only; 0.99 for wind only; 0.49 for flood and earthquake only; 6.19 for flood and wind; and 0.378 for flood, quake and wind. Obviously fractions of communities cannot be studied so a lower boundary of one community was set for each award combination. Thus, at least one community had to be selected for the two smallest categories, flood and earthquake, and flood, earthquake, and wind; up to two communities were allowed for the next two smallest categories, earthquake only and wind only. Since no more than 14 communities would be selected in all, this restricted the largest two categories, flood only and flood and wind, to a maximum of four communities.

Table O-1 Distribution of communities and quota limits set for the sample by the pattern of FEMA awards received by a community (N =113)

Awards Received	Population N	Population %	Sample Limits for Category	Communities Selected in the Sample Draw (Set)[1]
Earthquake Only	10	8.8	≤ 2	Hayward (1) Orange (2)
Flood Only	38	33.6	≤ 4	Jamestown, ND (1) Mandeville, LA (2) East Haven, CT (3) Des Moines, IA (3) Multnomah County, OR (3)
Wind Only	8	7.1	≤ 2	Virginia Beach (3)
Flood and Earthquake	4	3.5	≤ 1	Los Angeles (2)
Flood and Wind	50	44.2	≤ 4	Freeport, NY (1) Tuscola County, MI (1) Jefferson County, AL (1) Ft. Walton Beach, FL (2)
Flood, Quake & Wind	3	2.7	≤ 1	Horry County, SC (1)

[1]This column shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for the pattern of FEMA awards received. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

In determining how to set upper limits for the combination of awards received, the proportion of awards received was stratified as follows. Award combinations with less than 5% of the communities in the population were limited to no more than one community in the total sample. Thus, no more than one community could be drawn from the four communities with awards for flood and earthquake and the three communities with awards for flood, quake and wind. Two award combinations included more than 30% of the awards, namely flood only and flood and wind. An upper limit of four communities was set for each of these categories. The remaining two award combinations included, respectively, 8.8% of awards (earthquake only) and 7.1% of awards (wind only). Maximum limits for these two groups were set at no more than two communities.

For the first set of six communities drawn, one community (16.7%) was drawn for earthquake only, one (16.7%) was drawn for flood only, none (0.0%) was drawn for wind only, none (0.0%) was drawn for flood and earthquake, three (50.0%) were drawn for flood and wind, and one (16.7%) was drawn for flood, quake and wind. This demonstrates the difficulties associated with drawing a "representative" sample when both the sample and the population are small.

Step 2: High Risk of Wind, Flood and/or Earthquake. In the *second step*, communities were sorted according to high risk of hazards with 26.5% (N = 30) being at high risk from earthquakes, 56.7% (N = 64) at high risk from floods, and 25.7% (N = 29) at high risk from wind. These are not mutually exclusive categories since communities could be at high risk from more than one hazard. This means that any of the 113 communities can appear in Table O-2 more than once; therefore the total may be greater than 113. Since such a large proportion (67.3%) of communities were at *high risk* of at least one of the three hazards (earthquake, flood, wind) according to the hazard maps available in August 2003, the 37 communities that were not at high risk of at least one hazard were deleted from further consideration. Since it was only important that every community in the sample was judged to be at high risk from at least one hazard and because the experts available to the community studies team were having difficulty establishing hazard levels for floods, in setting the limits for these criteria, rough limits rather than absolute maximums were set. Column five of Table O-2, shows that the approximations were exceeded in each hazard category. This is because many communities in the population are at high risk from multiple hazards.

Table O-2 Distribution of communities and quota limits set for the sample by being at high risk of earthquake, flood or wind hazard (N =113).

Hazard for Which Community is at High Risk	Population		Sample Limits for Criteria	Communities Selected in the Sample Draw (Set)[1]
	N	%		
Earthquake	30	26.5	≈ 4	Hayward (1) Horry County, SC (1) Orange, CA (2) Los Angeles (2)
Flood	64	56.7	≈ 7	Freeport, NY (1) Horry County, SC (1) Jefferson County, AL (1) Jamestown, ND (1) Tuscola County, MI (1) Ft. Walton Beach (2) Los Angeles (2) Des Moines (3) East Haven, CT (3) Multnomah County, OR (3)
Wind	29	25.7	≈ 4	Freeport, NY (1) Horry County, SC (1) Mandeville, LA (2) Virginia Beach (3) East Haven, CT (3)

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for being at high risk of at least one hazard. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

Step 3: Community Size. In the *third step*, criteria were set for *community size* (Table O-3). Within the population, 40.7% (N = 46) were small communities, 49.6% (N = 56) were medium communities, and 9.7% (N = 11) were large communities. In July 2003[2] it was decided that one large community and at least one small community would be included in each set of communities selected for study. This decision reflected a concern that large communities, even if drawn, might be skipped over because it was anticipated that it would be more difficult to study them. Absolute limits were set here for each draw with the *first draw* of 6 communities being two small communities (10,000-49,999), three medium communities (50,000-499,999), and one large community (≥ 500,000). Note that this set of six communities roughly represents the size of communities as represented in the population: 33% small communities; 50% medium communities; and 16.7% large communities. The *second draw* was set at two small communities, one medium community, and one large community, and the *third draw* was set at one small community, two medium communities and one large community. If all 14 communities were studied, the second and third draws result in small communities (35.7%) and medium communities (42.8%) being slightly underrepresented and large communities (21.4%) being substantially overrepresented. If the first two sets of communities were studied, which was the expectation, small communities were correctly represented (40%), medium communities were underrepresented (40%) and large communities were overrepresented (20%).

Table O-3 Distribution of communities and quota limits set for the sample by population Size (N = 113)

Community Size	Population		Sample Limits for Criteria			Communities Selected in the Sample Draw[1]		
	N	%	Set 1	Set 2	Set 3	Set 1	Set 2	Set 3
Small (10,000-49,999)	46	40.7	2	2	1	Jamestown, Freeport	Mandeville, Ft. Walton Beach	East Haven
Medium (50,000-499,999)	56	49.6	3	1	2	Hayward, Tuscola County, Horry County	Orange, CA	Des Moines, Virginia Beach
Large (≥ 500,000)	11	9.7	1	1	1	Jefferson County	Los Angeles	Multnomah County

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for community size. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities

Step 4: FEMA Region. In the *fourth step*, communities were sorted by the *FEMA region* where they were located, and criteria were established. As expected, the largest number of communities are in Region IV and Region IX. The distribution of communities across regions is somewhat similar to the distribution of communities across award patterns in that each of four regions have less than 7% of the awards, four regions have between 7% and 12% of the awards, one region has 10.6% of awards, and one region has 26.5% of awards. These four groupings were identified as strata for purposes of setting limits, while simultaneously attempting to obtain at least one community in each of the ten regions. Regions that contained no more than 6.2% of communities were limited to no more than one community in the sample. These include Regions I, II, VII and VIII. Regions with approximately 10% of communities were limited to no more than two communities in the sample; these were Regions III, V and X. Up to three communities could be selected from Region IX and up to four communities could be selected from Region IV. As can be seen in Table O-4, these limits were exceeded for Region IX.

Step 5: Post-Selection Against NEMIS In recognition of some of the limitations in the NEMIS data base noted earlier under *Data Base Considerations*, after the 14 communities were selected, information available in the NEMIS data base was again examined in detail for each community.

O.4 Drawing the Communities for the Sample.

Once limits for the four criteria were set, information about each of the 76 communities that were at high risk from at least one hazard was written on pieces of paper. The 76 pieces of paper

Table O-4 Distribution of communities and quota limits set for the sample by FEMA region (N = 113)

FEMA Region	Population		Sample Limits for Criteria	Communities Selected in the Sample Draw (Set)[1]
	N	%		
Region I	7	6.2	≤ 1	East Haven, CT (3)
Region II	4	3.5	≤ 1	Freeport, NY (1)
Region III	11	9.7	≤ 2	Virginia Beach (3)
Region IV	30	26.5	≤ 4	Jefferson County, AL (1) Horry County, SC (1) Ft. Walton Beach, FL (2)
Region V	8	7.1	≤ 2	Tuscola County, MI (1)
Region VI	12	10.6	≤ 2	Mandeville, LA (2)
Region VII	7	6.2	≤ 1	Des Moines (3)
Region VIII	7	6.2	≤ 1	Jamestown, ND (1)
Region IX	18	15.9	≤ 3	Hayward (1) Orange (2) Los Angeles (2)
Region X	9	8.0	≤ 2	Multnomah County (3)

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for the distribution across the ten FEMA regions. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

were placed in an egg basket, shaken up, and the first community was drawn for the first set of six communities. The process was repeated until all fourteen communities were drawn. The papers were shuffled between each draw. Once a community was drawn and either accepted or rejected for inclusion in the sample, it was permanently removed from the pool of eligible communities.

Table O-5 shows the communities that were drawn and rejected, in order, for each of the three sets of selections. As can be seen, the first four communities, Freeport, Jefferson County, Horry County, and Jamestown, were easily drawn and represented the first four communities drawn. At that point, there were two small communities, one medium-sized community, and one large community for the first set of six communities. Given the criteria established for community size, only medium-sized communities could then be selected for the sample. Colusa County was drawn and rejected because it is a small community. Then Tuscola County was drawn, which met the need for a medium-sized community. Then Houma was selected, which again was rejected because it is a small community, and finally Hayward was selected to complete the first set of six communities. Eight communities, the six selected and Colusa County and Houma—the two rejected communities—were now eliminated from the pool of 76 leaving 68 in the pool.

In the second set, the first community drawn was "4 Tampa Bay Counties." After consultation, it was decided that this community did not meet the criteria for a single jurisdiction and it was rejected. The next community in the second set, Mandeville, was the 10th community drawn; it was accepted. The 11th community drawn, Hawaii County, was rejected because it duplicated

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 (N = 76)

Stage of the Draw	Accepted	Rejected	
		Community	**Reason**
First Set of 6 Communities	Freeport, NY Jefferson County, AL Horry County, SC Jamestown, ND Tuscola County, MI Hayward, CA	Colusa County, CA Houma, LA	Needed a Medium Sized Community Needed a Medium Sized Community
Second Set of 4 Communities	Mandeville, LA Orange, CA Ft. Walton Beach, FL Los Angeles, CA	4 Tampa Bay Counties Hawaii County Oakland, CA Pittsburgh, PA Ouachita Parish, LA Ft Payne, AL Gadsden, AL Salem, NH Carteret County, NC Wauwatosa, WI Craven County, NC Westport, CO Ft. Collins, CO Colerain, OH Saco, ME Clermont City, OH Cape Girardeau, MS Seattle	Rejected as not meeting the jurisdictional criteria. Rejected; had all 3 awards Rejected because either a small community or a large community had to be drawn All communities rejected because only a large community could be selected Rejected; have earthquake only

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 (N = 76)(continued)

Stage of the Draw	Accepted	Rejected	
		Community	Reason
Third Set of 4 Communities	Des Moines, IA East Haven, CT Virginia Beach, VA Multnomah County, OR	Terrebonne Parish, LA	Had 4 communities with awards for flood and wind
		Berkeley, CA	Had 3 communities in Region IX
		Darby Borough, DE	Had 4 communities with awards for flood and wind
		Benton County, OR	Needed a small or large community or one with wind awards
		Honolulu	Next large community drawn; poor jurisdiction and overdraws for Region IX
			Overdraws for flood only communities

Horry County in having received wind, flood and quake awards. Orange, California, was the 12th community drawn; it was accepted. At that point, the project team could only accept a large community or a small community for inclusion in the second set of four. Two communities—Oakland, and Pittsburgh—were drawn and rejected because they were medium-sized communities. Next, Fort Walton Beach, Florida, was selected, which was accepted. Then, thirteen communities were drawn and rejected because only a large community could be selected. Seattle was drawn and rejected because it would be the third community with awards only for quakes. Los Angeles was selected next and accepted; the set was completed.

Des Moines was drawn next and accepted for the third set of four communities. Terrebonne Parish was selected next and rejected because the sample already included four communities with FEMA awards for both floods and wind. Then Berkeley was drawn and rejected because the sample already included three communities from Region IX. East Haven was selected next and accepted for the sample. Darby Borough and Benton County were drawn and rejected both because the quota for communities with both flood and wind awards was filled and because it would be helpful to have a community that was simultaneously large or medium and had received FEMA awards only for wind. Virginia Beach, Virginia, was the next community drawn; it was selected.

Unfortunately, the last community selected for the third set of communities had to be large. The next large community drawn was Honolulu. Although included as the 14th community in the sample, it presents problems in that (1) it is not a regular jurisdiction, and (2) it is the fourth community selected in Region IX. The other two large communities still in the pool were Multnomah County, Oregon, in Region X at high risk of quakes, with two flood grants, and San Bernardino County, California, in Region IX, at high risk of quake and flood, with one quake award. Replacing Honolulu with Multnomah County would have resulted in five rather than four communities with flood awards only (over the quota) but would have reduced the overrepresentation of Region IX communities and would have meant the selection of a community in Region X.

After consultation, the project team selected Multnomah County, Oregon as the last community in the third set.

O.5 Post-Selection Check against NEMIS.

Once the 14 communities were selected the NEMIS data set was again examined. When combined with information about the organization of Los Angeles County and City, which was available to the researchers but not available in the NEMIS data set, this revealed that awards attributed to the County of Los Angeles actually were awarded to the city of Los Angeles. Thus, Los Angeles actually had received over 30 FEMA grants, thereby exceeding the eligibility limit of 15 grants or less. Los Angeles in set 2 was replaced with Multnomah County from set 3. If a third large community was needed, San Bernardino, California, would have been selected.

O.6 Final Sample.

The final sample of communities as distributed by community size and pattern of FEMA awards is shown in Table O-6.

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 (N = 13)

Pattern of FEMA Awards	Small Communities (10,000-49,999)	Medium Communities (50,000-499,999)	Large Communities (≥ 500,000)
Earthquake Only ≤ 2		Hayward, CA (1), Orange, CA (2)	
Flood Only ≤ 4	Jamestown, ND (1), Mandeville, LA (2), East Haven, CT (3)	Des Moines (3)	Multnomah County, OR (3)
Wind Only ≤ 2		Virginia Beach (3)	
Flood and Quake ≤ 1			
Flood and Wind ≤ 4	Freeport, NY (1), Fort Walton Beach, FL (2)	Tuscola County, MI (1)	Jefferson County, AL (1)
Flood, Earthquake, and Wind ≤ 1		Horry County, SC (1)	

(1) Selected in the first set of 6 communities for study.
(2) Selected in the second set of 4 communities for study.
(3) Selected in the third set of 3 communities for study.

Appendix P
BIBLIOGRAPHY OF COMMUNITY DOCUMENTS

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Appendix Q
PROJECT IMPACT

Q.1 Introduction

In the community studies, five of the eight communities (Freeport, New York; Horry County, South Carolina; Jamestown, North Dakota; Jefferson County, Alabama; and Multnomah County, Oregon) participated in Project Impact. This appendix contains first a description of Project Impact, how communities were selected, the goals of the community programs, the signing ceremony, and reporting requirements. Second, it contains descriptions of the activities undertaken by the five Project Impact communities including benefit cost analyses of the individual projects that were completed.

Q.2 Background: Why and How Project Impact Started

Between 1989 and 1993, the United States was devastated by a series of major natural disasters: Hurricane Hugo and the Loma Prieta Earthquake in 1989, Hurricane Andrew in 1992, and the Midwest Floods in 1993. The loss of life and property led FEMA to adopt "The National Mitigation Strategy – Partnerships for Building Safer Communities," a proactive, predisaster mission "to strengthen partnerships among all levels of government and the private sector to empower all Americans to fulfill their responsibility for ensuring safer communities."[81] James Lee Witt, then Director of FEMA, explained

> "In response to the unacceptable loss of life and property from recent disasters, and the awesome prospect of even greater, catastrophic loss in the future, the National Mitigation Strategy has been developed to provide a conceptual framework to reduce these losses. Hazard mitigation involves recognizing and adapting to natural forces and is defined as any sustained action taken to reduce or eliminate long-term risk to human life and property. The Strategy is intended to engender a fundamental change in the general public's perception about hazard risk and mitigation of that risk and to demonstrate that mitigation is often the most cost-effective, and environmentally sound, approach to reducing losses. The overall long-term goal of the Strategy is to substantially increase public awareness of natural hazard risk and – within 15 years – to significantly reduce the risk of loss of life, injuries, economic costs, and disruption of families and communities caused by natural hazards".[82]

The content of The National Mitigation Strategy resulted from a series of eleven public Mitigation Forums conducted across the United States from September 1994 to June 1995 and completed questionnaires returned from 15,000 distributed to public and private sector entities.[83]

[81] Witt, James, L., "Forward" to *National Mitigation Strategy – Partnerships for Building Safer Communities*, Washington, DC: FEMA, Mitigation Directorate, December 6, 1995, page *i*.

[82] Ibid.

[83] Ibid. The document does not provide details on the questionnaire, the recipients, how many were returned, or what analysis was performed on the returned questionnaires.

In 1996, Witt's conceptualization of a Natural Hazard Mitigation Strategy was transformed into the operational Disaster Resistant Communities Initiative (later renamed Project Impact), with the goal of providing seed money for selected communities to develop and sustain a comprehensive hazard mitigation program. In describing Project Impact, Tricia Wachtendorf and her colleagues at the University Delaware Disaster Research Center said,

> "…rather than devising a program that would be managed through strict guidelines and tight regulation, FEMA designed Project Impact as a "bottom-up" approach to mitigation that gave local communities fairly wide latitude in deciding what mitigation goals they would pursue and how. The intent of the program was to establish a wide variety of community-based initiatives to address mitigation issues deemed important by the communities and to encourage the development of innovative solutions to hazard-related problems".

Although communities were actively encouraged to develop their own strategies for reducing disaster losses, FEMA did outline general goals and objectives for the program. These overall goals were: (1) to build community partnerships; (2) to identify hazards and community vulnerability; (3) to prioritize risk reduction actions; and (4) to develop communications strategies to educate the public about Project Impact and disaster mitigation more broadly. Communities were then asked to formally establish locally-based organizations and to initiate activities that would address these objectives.[84]

Project Impact was launched in the summer of 1997 with the selection of seven pilot communities, who each received $1 million in seed money to implement their community programs. Project Impact was funded until fiscal year 2001. In total, 250 communities in every state and some U. S. territories received a total of $77 million, ranging from $60,000 to $1,000,000 over three years or less. Most received $150,000 to $300,000 over a two-year period.

Q.3 Community Selection

Nothing in the natural hazards or public policy literature could be found that described exactly how communities were selected to participate in Project Impact. Information from documents obtained in the five Project Impact communities in this study suggests there was no uniform method of community selection. Available evidence suggests that communities were selected with a process that included input from the states, the FEMA regional offices, and FEMA national headquarters. Communities may or may not have participated in the initial decision process. In Oregon, communities like Multnomah County were asked to submit formal requests to be considered as a future Project Impact community. On the other hand, in New York, Freeport was notified by the state of New York after the decision to select had been made. In any event, all selected communities had to make an active agreement to participate at some point during the decision process.

[84] Wachtendorf, Tricia, Rory Connell, Brian Monahan, and Kathleen Tierney, *Disaster Resistant Communities Initiative: Assessment of Ten Non-Pilot Communities,* Report to the Federal Emergency Management Agency, Newark, DE: The University of Delaware, Disaster Research Center, August 30, 2002, pages 1-2.

All information presented herein is based solely on documents available to the project team. The most detailed information concerns the selection of Freeport, New York, as a Project Impact Community, which is presented next.

Community Selection – Freeport, New York.[85] The method by which the Village of Freeport, New York, was selected as a Project Impact community was based on "a combination of factors" listed in what was called the Project Impact Matrix developed by FEMA's National Director of Project Impact. Using the matrix as a guide, Region 2 established priorities with state input and forwarded its recommendations to FEMA national headquarters, where ultimately a final decision was made.

Six New York communities were evaluated to become 1998 Project Impact communities.[86] The Project Impact Matrix used in the evaluation consists of 14 variables plus additional comments. See Table Q-1 for a list of the variables, a general description of the type of information that was used for evaluation, and the information that was provided for Freeport.[87]

In Table Q-1, the first three variables (County, Square Miles, and Population) indicated whether the size of the community was manageable and located geographically close to the regional office in lower Manhattan so it was relatively accessible. A single variable, "Primary Hazard," established the risk from natural hazards. The remaining variables were all related to existing relationships with FEMA or existing community programs that indicated whether the community could establish partnerships and pursue Project Impact goals. The highest priority was given to the communities that were accessible, had a significant natural hazards risk, and had the greatest number of positive characteristics that might indicate success in Project Impact.

Freeport received the highest priority rating. A discussion of Freeport in the FEMA memo stated that it was both relatively small in size and very accessible to regional staff, both good characteristics. Furthermore, "The Village of Freeport has already demonstrated a proactive mitigation effort through its packaging of a major elevation project funded under FEMA's Flood Mitigation Assistance (FMA) program. Additionally, it has an updated and aggressive mitigation plan adopted by the Village Board of Trustees (to apply for CRS Class 8[88]); a very high policy base for a mid sized New York community of 2,268 policies; and, a full time emergency manager that could dedicate time to Project Impact."[89] The FEMA memo also noted

[85] This section is primarily based on an internal FEMA memorandum from Lynn C. Canton, Regional Director of FEMA Region 2 to Jane Bullock, FEMA Chief of Staff, and Michael J. Armstrong, Associate Director, Mitigation Directorate, with a c.c. to Maria Vorel (FEMA National Director for Project Impact) dated January 29, 1998 with the subject "Region 2 Project Impact Recommendations" describing the process used to recommend the first Project Impact communities in New York, New Jersey, Puerto Rico, and the Virgin Islands using a matrix of variables "identified by Maria Vorel and additional information that the Region thought would be helpful in making a determination on recommendations and potential selections."

[86] The Canton memo referred to above includes a completed matrix for three New York communities; the Town of Southhampton, the City of Rye, and the Village of Freeport.

[87] The Freeport comments are copied verbatim from the Canton FEMA memo except for some commas and the full spelling of some abbreviated words added for clarity. Similar comments for the Town of Southhampton and the City of Rye have been omitted.

[88] The Community Rating Service or CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program (NFIP) requirements.

[89] Ibid., p. 3.

that Freeport had a significant flood insurance repetitive loss history, specifying that since 1978, Freeport had 275 properties that suffered 796 losses.

Table Q-1 Project Impact – Matrix

Variable	Description	Village of Freeport
County	County name	Nassau
Square Miles	Area of community	5
Population	Approximate population of community	40,000
Primary Hazard	List of high risk natural hazards	Hurricanes, NorEasters, back bay flooding and high winds
CRS Class	Community Rating System class	Class 9 – close to Class 8 have excellent Hazard Mitigation Plan
HMGP Project (type & $)	Current HMGP grants, if any	NA
NFIP Status – CAV	Number of NFIP policies, % coverage of structures in floodplain, number of losses, past payouts, number of substantially destroyed structures, risk and input from observations made during Community Assistance Visits	As of 3/97 1750 losses paid, 269 are repetitive, total claims close to $10,000,000. This community is historically at significant risk for back bay flooding. Total of 2268 policies, about 70% covered
FMA Grant Status (type, plan, & $)	Current FMA grants, if any	Rec'd 620K in 1997 for elevation of 40 structures, Region 2's largest FMA project
PA/CA Unique Activity	Public Awareness activities, if any	Their local public awareness activities have been very good according to state and they will have a full time Emergency Manager pushing all projects
PA 406 Mitigation Projects (type & $)	Public Assistance grants with mitigation elements, if any	NA
B&I Status – Activity & Status	Current Business and Industry partnerships	NY SEMO will work with their B&I Loss Reduction Task Force with the community if selected
Political Overview	Names of Congresspersons with discussion of their interest in FEMA	Split (D) Carolyn McCarthy (R) Peter King
Potential Project Impact Funding Targets	Likely hazard mitigation projects that would be undertaken	Would continue with further elevation and retrofit projects consistent with FMA grant and their own mitigation plan
Local Leadership Support/Commitment	Evaluation of existing ties between community and business and industry	Recently hired a full time emergency manager to run all mitigation programs – have been very supportive of mitigation and state B&I
Comments	List of positive community characteristics not mentioned above	Very progressive – Community has Mitigation Planning Committee and the Village Board of Trustees have adopted their mitigation plan

The FEMA memorandum suggests that the selection in Region 2 communities in New York, New Jersey, Puerto Rico, and the Virgin Islands was based on (1) staff accessibility, (2) the receipt of FEMA hazard mitigation grants, (3) factors that indicated that the community was likely to develop partnerships with for profit businesses, and (4) political exigencies, whatever they might be. Risk from natural hazards was not a primary consideration in the ultimate selection of communities because all the communities that were evaluated apparently shared similar high risks and discrimination was not possible. High priorities were given for communities that were judged to have a high probability to succeed in developing partnerships that would lead to community-wide mitigation activities.

The decision process for Freeport did not end with the setting of priorities contained in the FEMA memo. On March 5, 1998, the New York State Emergency Management Office (SEMO) selected all six communities that were evaluated earlier by FEMA Region 2 as Project Impact – Disaster Resistant Communities in New York State.[90] The designation was misleading as each community was informed that it could become a Project Impact community by developing an acceptable program that would meet both SEMO and FEMA guidelines. On March 19, 1998, Freeport Village officials held their first steering committee meeting with representatives of local businesses, SEMO, and FEMA Region 2.[91] The business attendees were Home Depot, Lea Ronal Inc., Fleet Bank, Meadowbrook Care Center, and the Chamber of Commerce. In the next few months, Freeport Village officials formed partnerships with these and other local merchants to work with the Village officials "to plan innovative educational and public awareness programs in the village."[92] On June 3, 1998, FEMA Director James Lee Witt invited the Village of Freeport to become a Project Impact community.[93]

Q.4 Community Selection – General Comments

No information as detailed as that for Freeport was located for any of the remaining four Project Impact communities that were part of the community studies. However, the "Grant Guidance for FY99 Communities" provided by FEMA to all prospective Project Impact communities who wished to apply for 1999 funding (including Jefferson County, Alabama and Multnomah County, Oregon in this study) suggests that the Project Impact Matrix used in Region 2 to select Freeport was widely used elsewhere. In the section entitled "Application Review," it is stated:

> When the community's grant proposal is received, the FEMA regional office shall review it to determine if its implementation will reduce disaster costs, and whether there are sufficient measures taken to reduce in a permanent or long-term manner the potential losses from natural hazard events before the hazard occurs. Factors that will be considered will include: the community's current hazards and risks; mitigation projects already funded or completed in the

[90] *About FEMA – New York State Implements Project Impact Ideals in Six Communities*, FEMA News Release, www.fema.gov/about/r2webny.shtm

[91] Ibid.

[92] *Freeport, NY, Asked to Become a Project Impact Community to Reduce the Effects of Disasters*, FEMA News Release, June 3, 1998, www.fema.com/regions/ii/1998/98r2n003.shtm

[93] Ibid.

community; existing mechanisms for public-private partnering; and planned and implemented substantive mitigation measures in the community.[94]

An identical "Application Review" section was included in the FEMA "Program Guidance FY2000" document provided to all prospective Project Impact communities who wished to apply for 2000 funding including Jamestown, North Dakota.[95] Similarly, the FY2001 "Mitigation Grant Guidance" that was sent to Horry County, South Carolina included the same "Application Review" section.[96]

Q.5 Acceptable Project Impact Activities and Application Instructions for Communities

In their assessment of Project Impact, Wachtendorf and her colleagues stated that "Four activities – risk assessment, mitigation, partnership development, and public education and information – constitute core Project Impact goals."[97] Wachtendorf and her colleagues did not mention whether FEMA provided instructions to Project Impact communities that specified the categories within which projects should be undertaken or the kinds of projects that were preferred. Wachtendorf and her colleagues did say that FEMA encouraged the communities to select their own activities to strengthen overall community hazard mitigation.

The three FEMA program guidance documents mentioned above include categories of acceptable activities that are broader than suggested by Wachtendorf and her colleagues. The *Grant Guidance for FY99 Communities* document instructs communities to "categorize mitigation projects as one of the following:

- Mitigation for existing structures
- Mitigation of existing infrastructure, utility facilities, and transportation systems that are publicly owned and operated on a non-profit basis
- Adoption of policies and practices for mitigation in existing structures, development or redevelopment
- Activities that lead to building or sustaining public/private partnerships, or that support public awareness of mitigation
- Hazard identification and risk assessment
- Mitigation of new construction
- Personnel support"[98]

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[94] *Program Description Disaster Resistant Community Mitigation Grant – Grant Guidance for FY99 Communities,* no date, page 3.

[95] *Program Guidance FY2000 – Disaster Resistant Community Mitigation Grant,* no date, page 4.

[96] *Project Impact Building Disaster Resistant Communities Mitigation Grant Guidance FY2001,* no date, page 4.

[97] Wachtendorf et al., op. cit., page *iii*.

[98] *Program Description Disaster Resistant Community Mitigation Grant – Grant Guidance for FY99 Communities,* no date, pages 2-3.

In slightly different language and order, the *Program Guidance FY2000* instructs communities to "identify each mitigation project or activity targeted for grant funding as one of the following:

a. Category A – Hazard identification and risk assessment
b. Category B – Adoption of policies or practices for mitigation in existing buildings or new construction
c. Category C – Mitigation for existing buildings
d. Category D – Mitigation of existing infrastructure: such as, utility facilities and transportation systems that are publicly owned and operated on a non-profit basis
e. Category E – Activities that lead to building or sustaining public/private partnerships, or that support public awareness of mitigation
f. Category F – Personnel support"[99]

The *Mitigation Grant Guidance FY2001* instructions are virtually identical to those of FY2000 except for Category C. In FY2001, Category C was expanded to "Mitigation for existing buildings and properties-at-risk."[100]

The first document varies in several ways from the latter two. The language in some of the categories has changed and two of the categories in the first document have been combined in the second and third documents. Most important are the orders of the categories. Specifically, "hazard identification and risk assessment" has risen from near the bottom of the 1999 list to the top of the 2000 list, and mitigation activities have fallen from the top two places in 1999 to the third and fourth in 2000. If these lists were interpreted by FEMA regions, states, and/or communities as priority lists, then one would expect to find different mixes of approved activities in communities whose funding began in FY 1999 and communities whose funding began in FY 2000 and FY2001.

Q.6 The Signing Ceremony

The signing ceremony was an orchestrated media event that was intended to take place on the official starting date of the Project Impact contract between FEMA and the community. It represented the community formally joining Project Impact. In some public setting, community, state, and federal officials as well as representatives from public, private for profit, and private non-profit organizations met for the formal signing of the memorandum of agreement (MOA). As a sign of commitment, many representatives added their signatures to the MOA.

Because of the public nature of this important event, FEMA recommended that several months be spent in planning and that the event take place at a time chosen by the community. FEMA Region 4's Project Impact Coordinator provided the following advice:

[99] *Program Guidance FY2000 – Disaster Resistant Community Mitigation Grant*, no date, page 3.
[100] *Project Impact Building Disaster Resistant Communities Mitigation Grant Guidance FY2001*, no date, page 3.

> "Based on other communities [sic.] experience, we recommend formation of a special Signing Ceremony committee to organize, prepare for, and operate the event. Several of our Southeastern communities have done a superlative job in this regard. We encourage you to contact your sister communities that have already held Signing Ceremonies and to coordinate closely with your State Project Impact Coordinator. Please give us a two month's "head's up" so we can do our part to assist. Often we will be able to travel to your community to meet with the committee and State staff in advance of the Ceremony".[101]

Q.7 Reporting Requirements

As conceived, Project Impact was designed to encourage local initiative and to grant local control over mitigation strategies and the selection of activities to achieve community goals. FEMA also promised minimal reporting requirements.

Documents in the files of the five Project Impact communities that were part of the community studies do not include sufficient information to state with certainty what the complete reporting requirements for communities were.[102] However, it seems fairly certain that many of the following reports were required in most communities:

- A *Memorandum of Agreement* (MOA) (sometimes referred to as a Memorandum of Understanding (MOU)) that presented the intentions of the community, listing activities to be completed and their costs, including local contributions, and community partners. This was the document that was publicly signed by FEMA, the community, and community partners at the signing ceremony to begin the grant.
- A *Scope of Work* (SOW) (sometimes referred to as a Statement of Work) that provided details concerning the activities listed in the MOA and details concerning the time period in which work was to be completed. It might also contain revisions to the MOA after the community committees overseeing different aspects of Project Impact altered the activity mix. No specific required date of delivery was found; however, there apparently was some urgency in completing a SOW, as FEMA regions apparently required a SOW and a budget before FEMA approved the transfer of any funds.
- A *Budget* that accompanied the *Scope of Work*.
- A *Project Impact Baseline Report* due 60 days after the start of the grant that included a detailed risk assessment and vulnerability analysis. The questions asked mirrored the topics listed in the Project Impact Matrix (Table Q-1) but were more numerous and focused.
- A *Hazard Mitigation Plan* estimated to be completed within the first six months of the grant if the community had not written one prior to Project Impact.

[101] Randolph, Steven, Regional Project Impact Coordinator, to Project Impact Coordinators – FY99 Communities, *Memorandum Re: Disaster Resistant Community Grants (DRCGs),* April 6, 2000, page 3.

[102] For each community, the Project Impact files found at the community and in the FEMA regional office were not identical. Differences between them were often substantial. Also different sets of documents were found for each community. It was therefore unclear if the combined records of the Project Impact grants were complete or if communities were asked to submit different sets of documents. The latter conclusion seems more valid because grant files found for other mitigation projects -- Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance (FMA) -- were consistent and most often complete. It is hard to believe that Project Impact files would be treated differently.

- An *Action Plan* that appears to be an amended Scope of Work that was produced a year or more after the project commenced. It was a combination progress report and scope of work for the remaining time on the grant.
- A *Project Impact Progress Report* due annually after the start of the grant that listed in detail information concerning partnerships, risk, an evaluation of mitigation measures implemented, and a discussion of successes. Most grants ran for two years, so only one progress report was required.
- *Quarterly reports* describing activities completed in the previous three months and changes to the statement of work. These reports included narrative and financial information and were due every quarter. They were also required for communities to get reimbursed for the federal share of expenses incurred.
- *Semi-Annual Performance Reports* providing a narrative status report of the projects approved for federal funding.
- *Close out documents* to end the project that focuses mainly on the budget. Unspent monies were listed and deobligated by FEMA.
- *A final report*, often the last quarterly report, but sometimes a stand-alone document completed at the end of the grant. This report presents a discussion of exactly what was completed during the grant. Because of changes initiated throughout the life of the project, it is the only report that can be trusted as an accurate record of what the community achieved during Project Impact.

There were also indications that things did not always go smoothly, and changes were required. In 2000, FEMA realized that its reporting requirements did not provide communities sufficient time to make decisions that were needed to complete reports and later asked communities to make revisions. One year to the day after its signing ceremony, April 6, 2000, Jefferson County, Alabama, as well as all other Region 4 Project Impact communities was notified by Region 4:

> This is to advise you that we are prepared to accept a major revision to the approved Scope of Work and budget for the Disaster Resistant Community grants (DRCSs) issued for FY98 and FY99.
>
> The grant offer and application process for the ten FY98 and FY99 Project Impact communities was accelerated due to circumstances beyond our control. This did not allow most communities time to hire a Coordinator, form their Project Impact Steering Committees, develop partnerships with the private sector, conduct a complete risk assessment and vulnerability analysis, or develop a hazard mitigation plan. As a result, many of the DRCG grant awards do not reflect the Project Impact strategies and proposed projects now being formulated in these communities.
>
> At the time we promised each community the right to revisit the Scopes of Work and budgets in the DRCG grants awards at a later date. That time has come. Each community now has in place a Project Impact Coordinator and Project Impact committee or task force. Most communities have their Project Impact initiative well

> underway. And, as noted many projects are being proposed that are not within the approved Scope of Work.
>
> Any substantive revision to the Scope of Work as well as revisions to the approved budgets must be submitted for prior approval. To revise the DRCG, please submit revised SF 424 B & C budget forms and a new Scope of Work clearly defining each project and the amount of federal funds involved.[103]

Based on experience with past Project Impact communities, FEMA realized in 2000 that the start of Project Impact programs was often delayed because "most communities do not have the budgetary resources available…until receipt of the federal DRCG 'seed money.'" [104] Therefore, in 2000 FEMA changed the rules on its expectations and funding. For FY2001 communities, Project Impact became a two-phased grant. Phase 1 or "the initial start-up phase" would provide 20% of the grant monies for the "community to hire a project impact coordinator and organize a Project Impact Task Force" that would develop specific projects that would be funded under Phase 2 using the remaining 80% of the grant.[105] This meant that the FY2001 Project Impact communities would have to write two SOW's and two budgets, one for each phase.

The reporting documents collected in each of the five communities studied are shown in Table Q-2. It is clear that there is no consistency across communities.

The inconsistent reporting found in this research study was also found in the assessment of Project Impact completed by Wachtendorf and her colleagues. They found that some communities were pleased with their programs while others were "frustrated with bureaucratic requirements and inconsistencies."[106] Among the many findings reported was "Several communities believed that information and procedures were inconsistent across the country and had received conflicting information from FEMA headquarters and their regional offices."[107]

Q.8 Partnerships

One of the goals of Project Impact was for communities to build partnerships with other government entities, for-profit companies, and nonprofit organizations "to foster a community-wide approach to mitigation."[108] Partners would participate in the establishment of community activities, their management, and often provide services, materials, or funds for their completion. Partner contributions were eligible to be counted as part of the community share of the grant, 25% of the total.

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[103] Randolph, op. cit., page 1.

[104] Randolph, Steven, Senior Project Impact Coordinator, to FY2001 Communities & State Project Impact Coordinators, Memorandum Re: Sample Budget: Initial One-Year Operation of a local Project Impact for FY 2001 *Disaster Resistant Community Grants*, October 27, 2000, page 1.

[105] Ibid.

[106] Wachtendorf et al., op. cit. page 64.

[107] Ibid., page 66.

[108] This goal is the foremost objective listed on the first page of the Grant Guidance documents for FY1999, FY2000, and FY2001.

Table Q-2 Project Impact reporting documents collected during visits to FEMA regional offices and communities[1]

Document	Freeport, NY 1998	Jefferson County, AL 1999	Multnomah County, OR 1999	Jamestown, ND 2000	Horry County, SC 2001
Memorandum of Agreement (MOA)	Yes	No	No	Yes	No
Scope of Work (SOW)	No	Yes	Yes	No	Yes
Budget[2]	No	Yes	No	Yes	Yes
Project Impact Baseline Report	Yes	No	No	Yes	No
Hazard Mitigation Plan	Yes	Yes	No	No	No
Action Plan	Yes	No	No	Yes	Yes
Project Impact Progress Report	Yes	No	No	No	No
Quarterly Reports (Number Present)	3	4	1	0	10
Semi-annual Performance Reports (Number Present)	0	0	2	0	0
Close Out Documents	Yes	Yes	No	No	No
Final Report	Yes	Yes	No	Yes	No

[1]The communities are placed from left to right in the chronological order that they joined Project Impact.

[2]According to an internal FEMA memorandum dated April 6, 1999 discussing project funding found in the Jefferson County, Alabama files, FEMA began requiring separate budgets for *Construction* and *Non-Construction* projects. Neither term was defined.

FEMA did not provide a definition of a partner. Wachtendorf and her colleagues defined partners as those who signed the Memorandum of Agreement at the start of the grant period.[109] They also defined "active" partners as those who "were ranked by any community respondent as a 3, 4, or 5 ('moderately active,' 'quite active,' or 'very active')" in a questionnaire given to the Project Impact Coordinator and between one and four other respondents who were knowledgeable about Project Impact.[110]

While the Wachtendorf et al. definitions have some value, they ignore many complicating factors. First, communities often had partners before joining Project Impact. It is obvious that

[109] Ibid., page 9.

[110] Ibid., page 20. The University of Delaware study was conducted while Project Impact grants were underway. The study ended before the researchers had the opportunity to review completed grants. Therefore, Wachtendorf and her colleagues were unable to update their definition of partners to include anyone who participated in Project Impact activities but who did not sign the MOA.

Project Impact was not responsible for the initiation of these partnerships. Second, during the life of the Project Impact grants, many community organizations and individuals beyond those who signed the MOA contributed services, materials, or funds. Some were involved at a single point in time and others over a period time. In the files of the five communities evaluated in this study, there are sometimes lists of people who contributed to Project Impact activities, but often there are not, making it impossible to know for certain all those who might have partnered with the communities. Third, communities did not keep records of how “active” partners were or even use the term “active” to describe partners. Fourth, because people or representatives of organizations who did not sign the MOA were not asked if they considered themselves partners, there is no method to determine their motivation or whether they would consider themselves partners.[111]

In light of the difficulties of finding and evaluating the status of potential partners, no attempt has been made to impose a definition on who might be considered a partner. When partnership information provided by the community is available, it is reported in the context it was created.

Q.9 Descriptions of the Project Impact Activities Carried out in Five Communities[112]

As mentioned above, this research study included the evaluation of eight communities, five of which were Project Impact communities. Details of their Project Impact experiences and activities are presented next. The order is based on the starting date, the earliest first. Thus, the order of presentation is: Freeport, New York (1998); Jefferson County, Alabama (1999); Multnomah County, Oregon (1999); Jamestown, North Dakota (2000), and Horry County, South Carolina (2001).

Q.10 Freeport, New York

As mentioned above, Freeport was selected as a Project Impact community because it had a significant flood and wind risk, a positive record of hazard mitigation, a full-time emergency manager who could devote time to Project Impact, and had private sector partners who previously completed projects with the village. One example of a pre-Project Impact partnership activity was the construction of a model demonstrating wind resistant construction that was built by the local Home Depot and Simpson Strong-Tie Company, Inc. It was placed and still remains in the foyer of Village Hall outside the offices of the Building Department for everyone, especially contractors and builders, to see.

Freeport was notified that it could become a Project Impact community on March 5, 1998. The community established a Steering Committee chaired by the Mayor that first met on March 19. From initial work completed on the development of a list of activities that would become part of

[111] During some community site visits, a few individuals were encountered who participated in community activities but did not sign the MOA and were asked if they considered themselves “partners.” Some did and some did not.

[112] The community descriptions are based on records obtained from the FEMA regional offices and the communities. The records include the reporting documents listed in Table 2 and others that were produced by the community for other purposes. A review of the records indicates that there is significant missing information for each community. Therefore, the community descriptions include the best estimates provided in the record where omissions exist.

the Memorandum of Agreement (MOA) with FEMA, FEMA invited the village to become a Project Impact community on June 3. A signing ceremony was held on September 17, 1998.

In the MOA signed on September 17, Freeport proposed to:

> Strengthen the community's resistance to disaster by retrofitting and elevating homes and commercial structures. Improve the hazard resistance of the community's infrastructure. Develop and implement public awareness campaigns to insure that the public and private sectors and the residents of the community are educated to the need to support these Hazard Resistant Initiatives.[113]

To meet its goals, the village created five committees with mission statements:

(a) Commercial and Industrial: Identify developed and vacant properties that are subject to flooding.

(b) Bulkhead: Identify existing bulkheads that need to be repaired or replaced and areas without bulkheads that are a source of flooding.

(c) Public Awareness: Develop a program to educate the public about hazards to which our community is exposed, such as hurricanes, nor'easters, flooding, etc.

(d) Infrastructure: Identify essential infrastructure that are at risk and recommend preparedness response & recovery mitigation measures

(e) Retrofitting Residential Structures: Identify residential structures that are prone to flooding and have repetitive losses.[114]

Also in the MOA in Appendix B, Freeport included an Action Plan that listed commitments or partnership agreements with three village departments, Nassau County, the Town of Hempstead, five corporations, one bank, and six nonprofit organizations. In all, including the Mayor representing Freeport and James Lee Witt representing FEMA, there were 21 signatures. The commitments were linked to the goals of the five committees and representatives of the partners made up the membership of the committees.

Although a MOA was signed on September 17, that day did not represent the start of the FEMA grant. The Project Impact Progress Report and other documents indicate that another MOA was signed on December 23, 1998 and that FEMA agreed to grant Freeport $300,000 over a two-year period commencing January 1, 1999 and ending January 1, 2001.[115] Freeport was obligated to provide a local match of $100,000 or 25% of the sum.

As was typical of the five Project Impact communities studied, near the end of the two-year grant, Freeport requested and FEMA approved a no-cost extension to complete its activities. The ending date was extended one year to January 1, 2002.

[113] *Memorandum of Agreement*, September 17, 1998, Appendix A, page i.

[114] Ibid., Appendix A, pages i-v.

[115] The December 23, 1998 MOA was not located.

Q.10.1 A Review of the Project Impact Activities

Freeport proposed 13 activities that it divided into two general categories: those concerned with education and those broadly concerned with retrofitting. See Table Q-3 for a list of the activities, the benefits Freeport sought, and details of the activities with the final status of the project.[116]

The original five committees identified in the original MOA developed the 13 activities shown in Table Q-3. Over the three-year life of Project Impact, the partners identified in the MOA remained with the project as partners. While some Freeport documents mentioned partnership growth, none described or singled out any additional organizations having a partnership role.

According to the information provided in the February 2002 "Project Impact Close Out Summary," the Village of Freeport reported expending all $300,000 granted by FEMA and contributing $217,402.30 in matching funds or in-kind services. However, there was no breakdown according to activity.[117]

Q.10.2 Benefit Cost Analysis

Table Q-4 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Freeport, the dominant activity was the development of a warning system, the installation of a tidal gage in the bay connected to a siren, that permits Freeport residents to use sandbags in order to avoid damages, especially to appliances and other items found in lower stories. Warning systems were assumed to permit 500 residences to use sandbags every two years, with a savings of $1000 per residence per event. HAZUS was used to evaluate the benefits of hurricane windows and doors installed at the Village Emergency Operation Center. Benefits from other activities were not estimated.

[116] The communities in this study each tracked their projects in different ways. The projects are discussed in their community context to avoid misrepresenting them.

[117] Other Freeport documents issued during the life of Project Impact include estimates of federal and local costs for various activities. However, they changed over time and no final detailed accounting could be located that specifically identified federal and local costs for each activity. The Village of Freeport apparently did not issue a stand-alone final report; the last report issued was the narrative statement to the final quarterly report dated December 31, 2001 that contained the final status of each activity.

Table Q-3 Project Impact activities initiated by Freeport, New York

Activity	Benefits	Completion Details and Final Status
(Education)		
Project Impact Coord.	Salary	N/A
Public Awareness Events	Increase the public's awareness of natural hazard mitigation measures, prepared-ness and recovery	Held three Project Impact Awareness Days and one public awareness event for Nassau County elected officials. Village planned to continue to use public forums and mailings for disaster awareness and preparedness.
Mobile Fire Safety House/ Disaster Resistant House	Increase public's awareness of fire safety, natural hazard mitigation measures, and preparedness	Completed project. Purchased through contract, the Fire Safety House, a mobile classroom used mainly by the Freeport School District, a community partner. It is part of an on-going education program.
Seminars and Demonstrations on Retrofitting	Increase public's awareness of natural hazard mitigation measures	The Freeport Building Department conducted site visits to educate home and business owners on mitigation measures. Two community partners, Simpson Strong-tie and Home Depot, conducted workshops. These are on-going activities.
Adult Education Classes on Natural Hazard Preparedness	Increase public's awareness of natural hazard preparedness measures	Freeport Emergency Management Office developed and offered an adult education class on disaster preparedness through the Freeport School District. It is an on-going course.
Communication Network and Video Conferencing	Distance learning and transmission of emergency information	Completed project. Maintenance and expansion of the system will be supported by Village, Freeport Utilities, and the Freeport School District.
Early Warning System – Tidal Gage	Reduce loss of property, thus reducing NFIP claims	Completed project. Record keeping, data production, and maintenance jointly supported by the Village and the USGS.
(Retrofitting)		
Tree Removal	Reduce loss of property	Part of a long-term program to remove trees that pose a threat to power lines and buildings and replace them with smaller "power friendly trees." Approx. $100,000 is allocated to the program each year.
Preliminary Design for Road Elevation Projects	Reduce the effects of flooding	Paid consultant to prepare designs for elevating 13,400 linear feet of roadway of which 1,500 feet were completed and 11,900 scheduled for later construction. Part of an on-going project that dates back to 1983.
Elevation of heating units	Reduction in flood insurance claims	Originally $60,000 was allocated but all homeowners who were contacted to participate in the program withdrew. Nothing was accomplished.
Hurricane Resistant Windows and Doors for Village Emergency Operation Center	Reduction in damages due to wind	Project completed. The windows and doors were installed.
Bulkhead Program	Reduction in flood damage and business losses	Progress was made to develop program to replace existing bulkheads along Woodcleft Avenue and the approval of bonds for homeowners to take out loans to replace their bulkheads. The program began prior to Project Impact and had continued since with portions of the project being completed and the first loan made.
Roadway Grade Raise and Drainage Improvement Project	Reduce the effects of flooding	On-going program dating back to 1983 to raise all streets in the floodplain three feet above the level of the 100-year flood.

Table Q-4 Benefit cost analysis of completed Project Impact activities in Freeport, New York

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Freeport	Community Early Warning System	0.44	0.02	7.86	17.9	1.8-71
	Education	0.13	0.10	Not calculated	Not calculated	Not calculated
	Hurricane windows and doors, bulkheads	0.03	0.02	0.01	0.3 (only windows and doors benefits estimated)	0.2-0.6
	Tree removal	0.02	0.02	Not calculated	Not calculated	Not calculated
	Freeport TOTALS	*0.63*	*0.16*	*7.87*	*12.6*	*1.3-50*

The unmeasured benefits were all seen as positive. The Village of Freeport was able to establish an ongoing education program to teach both school children and adults natural hazard preparedness and mitigation techniques. The contributions of Project Impact also were used to support and possibly accelerate ongoing street elevations and the bulkhead project. Because Freeport apparently did not keep a detailed cost accounting of its activities, there was no way to accurately estimate the value of its education programs or the efforts of the community to develop the bulkhead project.

One very positive benefit, according to the village officials interviewed during the community site visit and the letter of nomination sent by the FEMA Region 2 Project Impact Coordinator to the Project Impact Awards Committee nominating Freeport as a Project Impact Model Community, was that the community had undertaken the role of mentoring other Region 2 Project Impact communities and providing advice to neighboring communities in Nassau and Suffolk counties.[118] In this role, Freeport developed a reputation that Village officials said opened new doors to them to find funding and other assistance in their quest to make the community disaster resistant.

The only negative aspect of the Freeport Project Impact activities was the Village’s inability to convince any homeowner to participate in the project to elevate a heating unit. The time and effort spent was unrewarded.

[118] Mabry, Marshall, Project Impact Coordinator, and Jaye M. Sutton, Project Impact Liaison to the Village of Freeport, to the Project Impact Awards Committee, Letter of Nomination of the Village of Freeport as s Project Impact Model Community, September 28, 2000.

Q.10.3 Conclusions

Not counting the payment of salary to the Project Impact coordinator, Freeport completed or achieved its objectives on 12 of the 13 projects that it undertook in Project Impact.

Q.11 Jefferson County, Alabama

No documentary evidence was located that discussed the process by which Jefferson County was selected as a Project Impact community. What is known is that Region 4 notified the state of Alabama that it had $300,000 that would be granted to a community of the state's choice for FY2000. The state of Alabama decided to split the award, asking FEMA to grant $150,000 to Jefferson County and $150,000 to Mobile County. Several telephone and on-site interviewees mentioned that this was a political decision based on a desire to divide the grant equally between recipients in northern and southern Alabama.

Jefferson County was chosen by FEMA to become a Project Impact Community on December 10, 1998. In the news release announcing the choice, FEMA noted the hazard risks faced by the county:

> The numerous small rivers and streams and hilly terrain of the metro area make flooding a chronic natural hazard. The area is also at risk from tornadoes and ice storms. Hazardous materials are a problem because of the region's heavy industrialization.[119]

The implication of this announcement was that FEMA had expanded Project Impact to include not only natural hazards but also man-made hazards.

FEMA notified Jefferson County on January 17, 1999 that it was "invited to submit an application to participate in [Project Impact]" and that the application must be received by February 17, 1999.[120] Although no copy of the completed application was found, a summary of a Scope of Work attached to the application that specified projects for funding was included in two internal FEMA memos containing technical evaluations of the projects.[121] (See Table Q-5 below for a list of the projects.)

According to the many financial statements in the Jefferson County documents, the official start date of the Project Impact grant was February 17, 1999, not the date of the signing ceremony, April 8, 1999. The project was originally scheduled to end on February 16, 2001.[122]

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[119] *Jefferson County Joins Project Impact*, FEMA Region 4 News Release, December 10, 1998, www.fema.com/regions/iv/1998/98r4_099.shtm

[120] Housand, Helen J., FEMA Region 4 Contracting Officer, to Mary Buckelew, Commissioner, Jefferson County Commission, January 13, 1999, page 1.

[121] Randolph, Steven, FEMA Region 4 Project Impact Coordinator, to Helen Housand, Region 4 Contracting Officer, re: Jefferson County, Alabama Technical Evaluation for Disaster Resistant Community Grant, March 5, 1999 and a second letter from Randolph to Housand with a revised technical evaluation, April, 6, 1999.

[122] Several amendments to the grant eventually changed both the starting and ending dates of the Performance Period of the grant. The starting date was changed from February 17, 1999 to the date of the signing ceremony April 8, 1999, and the ending date was extended from February 16, 2001 to December 31, 2001. By the end of the grant period, Jefferson County had completed its projects but had not spent the full $5,000 given to each Project Impact community for "mentoring" or sharing its experiences

April 8, 1999 was selected as the signing ceremony date because it was the first anniversary of the devastating F-5 tornado that struck Jefferson County killing 32 and injuring hundreds. Included in the signing ceremony was a memorial service. Because no Memorandum of Agreement was found, it is not clear if one was signed at the ceremony or if the previously submitted application served as the MOA. However, among the documents found in the field were a copy of a list of names that was signed by 32 partners on April 8 and a typed list of unknown date that indicates there were 50 signing day partners. Among the partners were representatives of the 32 incorporated cities within the county.

The Statement of Work established that the Jefferson County Emergency Management Agency (EMA), in partnership with officials from Jefferson County and the 32 incorporated cities, would coordinate the Project Impact program. Four Project Impact committees were created to help manage the program and develop ideas for new projects. These committees were:

- Community Preparedness
- Construction
- Environment
- Insurance and Finance

Members of the committees were largely Jefferson County officials. Representatives from only six for-profit companies or nonprofit organizations were members.

Q.11.1 A Review of the Project Impact Activities

In the original statement of work, Jefferson County proposed completing three nonconstruction projects. These are the first three activities listed in Table Q-5. The remaining two projects were added after the project began. All of the $150,000 in federal grant money was allocated to the first three activities. According to the financial records, $20,000 was spent on the part-time Project Impact Coordinator's salary, $30,000 on the update of the Hazard Vulnerability Assessment, and $100,000 on the expanded and updated emergency operations center.

Jefferson County and the partners contributed funds and in-kind services totaling $413,136.17 according to the last Financial Status Report that was submitted on May 6, 2002, as part of the close-out documents. No breakdown according to activity was provided.

In addition to the activities in Table Q-5, the four Project Impact committees discussed other topics including shelters and safe rooms to protect residents from future tornadoes. Beginning with its first meeting on September 13, 1999, the Construction Committee discussed shelters and safe rooms in apartments and mobile home complexes, the possible requirement that safe rooms be included in the construction of new churches, tax credits for safe rooms, and the use of public funds for the construction of private safe rooms or shelters.[123] No specific Project Impact

with other Project Impact communities. An extension of five months was granted. On May 30, 2002, the grant was closed out and Jefferson County de-obligated an unspent $935.12 that was allocated for mentoring.

[123] Project Impact Construction Committee, Meeting One – September 13, 1999 Minutes.

Table Q-5 Project Impact activities initiated by Jefferson County, Alabama

Activity	Benefits	Completion Details and Final Status
Project Impact Coordinator	Salary	N/A
Update of 1996 Hazard Vulnerability Assessment (HVA)	Increase awareness of hazard risks and	Completed project. Information from the updated HVA combined with historical data for the county led to the creation of the *Local Mitigation Strategy*, a document published January 2001.
Community Emergency Information System or WEB EOC	Expand and update the county Emergency Operations Center (EOC)	Completed project. Brought the EOC up to a state-of-the-art information system capability that allows all governing officials, 28 police departments, safety and security personnel from business and industry, 59 fire departments, and the media to have access to up-to-the minute information during emergencies.
Community Education & Outreach	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Created an annual "Community Awareness Day" that was held for three years in 2000, 2001, and 2002. From 3 to 5,000 visitors were estimated to have attended each event.
Early Warning System	Increase the number of people that will be in the range of early warning sirens with and upgraded and expanded outdoor warning system.	During the grant period, the Jefferson County Commission raised money for the system. No Project Impact funds were used and the updating began after Project Impact ended.

activity emerged from these discussions but the committee supported the County's Community Development Agency's initiative to provide safe rooms in the new Edgewater Oaks subdivision that will ultimately contain 80 residences constructed for low-income families.[124]

Q.11.2 Benefit Cost Analysis

Table Q-6 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Jefferson County, the dominant activities were the update of the information systems in the Emergency Operations Center and the update of the Hazard Vulnerability Assessment. In addition, the community with the assistance of the Project Impact committees went forward with the construction of safe rooms in the Edgewater Oaks subdivision. The Jefferson County Emergency Management Agency Coordinator described the project thusly:

[124] The dedication of the Edgewater Oaks Subdivision took place on March 19, 2000.

Table Q-6 Benefit cost analysis of completed project impact activities in Jefferson County, Alabama

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Jefferson County	Community Early Warning and Emergency Information Systems	0.12	0.09	0.40	3.4	0.3-34
	Other activities including Edgewater Oaks safe rooms	0.19	0.14	Not calculated	2.2	1.0-8.7
	Jefferson County TOTALS	*0.31*	*0.24*	*0.40*	*2.6*	*0.7-21*

> "This subdivision will be an excellent example of Project Impact concepts – building partnerships within a community to help save lives and decrease repetitive losses. This subdivision is being developed through a partnership between the Jefferson County Commission, the Alabama Dept. of Economic and Community Affairs (ADECA), Federal Home Mortgage Assn., Habitat for Humanity, YW Homes, Other Non-Profits and Private Lenders. Only $300,000 of county general fund monies will be used to leverage this $8,000,000 project. Habitat for Humanity and others will aid in construction of the homes.
>
> This subdivision will include eighty (80) single-family homes, a centrally located community center and a new fire station. Each home and the community center will include a safe room".[125]

In an internal FEMA e-mail message, a FEMA official stated that Jefferson County was successful in putting the Edgewater Oaks project together was "because they were a PI [Project Impact] Community it made it easier for them to get grants from the State, etc." Furthermore, "They used the partners and teamwork developed through Project Impact to help develop support and leverage to receive the grant."[126]

The unmeasured benefits were all seen as positive. In terms of partners, Jefferson County kept many lists including a Partner List Screen, a Commitment List Report, a Project Impact Partner List, Project Impact Partnership Signees, and a running list of in-kind contributions. In all, many hundred people and organizations are listed as either partners or contributing to partnership activities.[127]

[125] Odom, Woody, Coordinator – Jefferson County Emergency Management Agency, letter to Ms. Mary Lynne Miller, Acting Regional Director, Federal Emergency Management Agency, February 26, 2001.

[126] Denham, Steve e-mail to Christy Brown re: Jefferson Co. AL, May 7, 2001.

[127] No attempt was made to make a final determination of who in these lists should be considered Project Impact partners.

In addition, all of the Project Impact activities listed in Table Q-5 continued after Project Impact ended. The Local Mitigation Strategy became the foundation for the creation of the 2003 Natural Hazards Mitigation Plan. The EOC has been further upgraded with a new server, new software, and 40 laptops. The Community Awareness Day occurred one year after the end of Project Impact, but not thereafter. The U.S. Department of Justice awarded the county two grants in 2001 and 2003 to replace 30 old sirens in the early warning system, upgrade the remaining existing 127 sirens, and install between 80 and 90 new units. Finally, the Jefferson County Emergency Management Agency maintains its original Project Impact web site as www.impactalabama.com.

The only negative aspect associated with the Jefferson County Project Impact activities was the inability to sustain the momentum and keep the partners involved. The educational activities have virtually ended.

Q.11.3 Conclusions

Not counting the payment of salary to the Project Impact coordinator, Jefferson County completed or achieved its objectives on all four of the projects that it undertook in Project Impact.

Q.12 Multnomah County, Oregon[128]

The process by which Mulnomah County got selected as a Project Impact Community was unusual. Every year the State of Oregon asked communities to submit applications to be considered for selection in the next fiscal year. According to an untitled and undated summary of the grant history written prior to the signing ceremony, the document stated:

> In the Fall of 1998, both East Multnomah County and a group representing the Johnson Creek Watershed were pursuing independent applications to become designated as Project Impact Communities. Following a series of meetings and discussions, they combined their Project Impact Applications and requested Multnomah County be designated a Project Impact community.

The region of East Multnomah County extends from the common boundary between the cities of Portland and Gresham, Oregon eastward to the county line, a distance of over 30 miles. The area has a population of approximately 120,000 people in five cities and several unincorporated areas, covering about 130 square miles. The impetus for the grant application came from the Board of the East County User Group that ran the East County Emergency Management Program encompassing the four cities of Fairview, Gresham, Troutdale, and Wood Village, as well as most of the unincorporated area of Multnomah County. In 1997, the five jurisdictions adopted a comprehensive Inter-Governmental Agreement (IGA) that brought together city and county emergency managers to establish a comprehensive all-hazard East County Emergency Management Program. Under Oregon guidelines, IGAs were eligible to become Project Impact Communities.

[128] This community discussion is based on very little information as neither the FEMA region nor Multnomah County was able to find very many Project Impact documents. The discussion, like that for the other communities, will be limited to what was available. No attempt has been made to fill in the large gaps of knowledge.

According to the grant history mentioned above, the East County User Group was made up of a variety of public and private partners who were establishing programs in urban and rural hazard mitigation. These included the U.S. Forest Service, Columbia Gorge National Scenic Area, Chambers of Commerce, private businesses, school districts, and neighborhood associations. East Multnomah County originally applied to become a Project Impact Community to help build program identification, gain citizen confidence, and increase support for its mitigation programs.

The Johnson Creek Watershed is a large area extending from East Multnomah County, across the tip of Clackamas County, and into the City of Portland. Its geography features large floodplains in the lower watershed with a mixture of industrial and residential uses, forested dormant lava domes, and riparian and upland areas with agricultural and rural land uses. The watershed is subject to flooding on the average of every other year. The original Johnson Creek Watershed Project Impact application wanted to use Project Impact funds to inform residents, businesses, and industries about floodplain issues and how to mitigate damages.

The application of Multnomah County that was successful in getting the county named a Project Impact Community merged some of the original projects of both East Multnomah County and the Johnson Creek Watershed. See Table Q-7 below for a list of the projects.

Multnomah County was invited by FEMA to join Project Impact on December 10, 1998.[129] It held its signing ceremony on September 13, 1999.[130] No record was found of how many partners attended the ceremony or who they were. The initial partnership priorities were listed as "Establishing a flood hazard Community Rating System (CRS); developing a business and industry continuation plan; providing flood hazard information to homeowners and businesses; assisting schools in developing disaster educational programs; and establishing neighborhood emergency response teams."[131]

There were no documents found that established the actual dates for Project Impact. The inference from the dates on the quarterly and semi-annual reports located was that this was a two-year program that was scheduled to end in 2001 but extended to 2002.

Q.12.1 A Review of Project Impact Activities

At the start of the program, Multnomah County entered into an Intergovernmental Agreement (IGA) with the City of Portland to transfer $150,000 or 50% of the Project Impact grant to the City of Portland to manage the Johnson Creek Watershed portion. The duration of this IGA was originally specified as from March 31, 1999 until June 30, 2001. An amendment extended the IGA until March 30, 2002. One of the purposes of the Johnson Creek Watershed project was to enhance the City of Portland's CRS application that would be submitted at the start of 2001.[132]

[129] *Multnomah County Invited to Join Project Impact Disaster Resistant Community Partnerships,* FEMA Region 10 News Release, December 10, 1998, www.fema.com/regions/x/1998/98r10_053.shtm

[130] *Multnomah County and City of Portland Join "Project Impact,"* FEMA Region 10 News Release, December 10, 1998, www.fema.com/regions/x/1998/98r10_053.shtm

[131] Ibid.

[132] Except for some brief entries in the two semi-annual reports that were located, there is no information concerning the details of the Johnson Creek Watershed project. Multnomah County considered it a "pass thru" project. Also the procedures used to conduct community studies in this research project limited the investigation to the selected communities only; when counties

Table Q-7 Project Impact activities undertaken by Multnomah County, Oregon*

Activity	Benefits	Completion Details and Final Status
Schools Project	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Completed project. Included the development of the perennial 72-hour emergency preparedness kit program and a mitigation element that will assist students in making their classrooms and homes disaster resistant.
Business and Industrial Communities Project	Increase the capability of businesses, especially small businesses, to develop business continuation plans in light of disasters and mentoring skills	Due to a county budget shortfall and a change in administration, the county pulled its support and the project was unable to be completed before Project Impact ended.
Neighborhood Emergency Response Teams (NERT)	Increase the ability of neighborhoods to become self-reliant in the event of a major emergency or disaster	Due to a county budget shortfall and a change in administration, the county pulled its support and the project was unable to be completed before Project Impact ended.
Flood Hazard Information	Provide businesses and residents with real time data on a particular flood threat, including on a web-site	This was a major element in the Johnson Creek Watershed project. The outcome was not documented by this study.
Retrofitting an Older Flood Prone House	Train homeowners and contractors on alternative all-hazard retrofitting approaches	The retrofit building, nicknamed "the Bates Motel," was believed to have instructed the majority of contractors and engineers in the building community in earthquake retrofit methods.
Community Rating System Program	To create a more comprehensive flood mitigation strategy.	This was part of the Johnson Creek Watershed project. The CRS program was a City of Portland initiative. On September 26, 2001, FEMA announced that Portland had received a Class 6 rating (on a 10-point scale, the higher the flood protection activity, the lower the rating). At the time, this was one the best ratings in nationwide.

*The activities in this table are those listed in the *Project Impact Program – East Multnomah County & Johnson Creek Watershed – Executive Summary*, no date, but internal information suggests it was written while Project Impact was in progress.

Q.12.2 Benefit Cost Analysis

Table Q-8 presents the types of mitigation activities funded that were completed, an estimate of the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

were selected, there was no attempt to investigate actions taken by incorporated cities within them or their hazard mitigation activities. The costs to do otherwise were prohibitive.

Table Q-8 Benefit cost analysis of completed Project Impact activities in Multnomah County, Oregon

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Multnomah County	Emergency kits and model home	0.15	0.11	0.08	0.53	0.2-0.6

As shown in Table Q-8, the benefit cost analysis indicates that the completed projects carried out by Multnomah County had a benefit cost ratio of less than one. Except for the continuation of the school's commitment to continuing to prepare 72-hour emergency preparedness kits, the remaining Project Impact initiatives were discontinued and the web site was shut down.

On the positive side, however, because the final status of many activities, including those associated with the Johnson Creek Watershed, was unknown, a final conclusion cannot be drawn that Project Impact was not worthwhile in Multnomah County. The available quarterly and semi-annual progress reports, as well as telephone and on-site interviewees, indicated that all the activities listed in Table Q-7 were progressing and had shown positive results before the county suffered budgetary problems and the administration was changed. Interviewees suggested that Project Impact had some positive effects on the county. One stated that "it brought people to the table who had never been to the table before." Open communications between members of the business community also led to the development of many business continuity plans. NERT trained many people in emergency response, increasing the capacity of the county to respond to potential disasters. And the retrofit building, nicknamed the "Bates Motel," was believed to have instructed the majority of contractors and engineers in the building community in earthquake retrofit methods.

Q.12.3 Conclusions

Multnomah County completed or achieved its objectives on two of four projects that it undertook in Project Impact.[133]

Q.13 Jamestown, North Dakota

No documentary evidence was located that discussed the process by which Jamestown was selected as a Project Impact community. Both the Action Plan and the Final Report indicate that Jamestown was named a Project Impact City in December 1999. The grant provided $300,000 in federal funds to be matched by $100,000 in local funds or in-kind services for a two-year period starting December 1, 1999 and ending December 31, 2001. Later the grant was extended by a year to December 31, 2002.

[133] No status is included on any projects associated with the city of Portland or the Johnson Creek Watershed project.

Jamestown had been included in seven disaster declarations in North Dakota between 1993 and 1999 all related to flooding. The main reason for the flooding was high water tables that caused basements to flood when the water table rose above the basement floor. Overland flooding from the James River, which runs through the city, had been effectively prevented by two dams north of the city, one established by the U.S. Army Corps of Engineers and the other constructed by the U.S. Bureau of Reclamation and was not considered a major threat. According to the Project Impact Baseline Report, only about 60 of city's 5,000 houses and 600 businesses were located in the regulatory floodplain. Current FEMA statistics showed that in the 26 years between and including 1978 and 2003 there had been just 26 paid National Flood Insurance Program (NFIP) insurance claims totaling $64,000. The Baseline Report also listed high winds and tornadoes as threats to the community.

Between the time Jamestown was named a Project Impact Community and the signing ceremony on June 15, 2000, the city held three open community-wide planning meetings. Seventy-five people attended the first meeting, 15 the second, and 40 the third.
During these meetings, the community vulnerabilities and the upcoming Project Impact grant were discussed and attendees were asked to sign up as themselves or their companies as partners and to be placed on committees that would develop possible Project Impact projects. The committees were:

- Public Awareness and Education
- Storm Water Damage, Flood Control, and River Clean-Up
- Hazardous Materials
- Building and Zoning,
- Early Warning System, and
- Steering.[134]

By the signing ceremony, the first five mentioned committees had created lists of possible projects to be completed as part of Project Impact. The lists were sent to the Steering Committee, which selected 13. These 13 projects were the first and only ones that were attempted. See Table Q-9 for a list of the projects.

The signing ceremony was held on June 15, 2000 at the Civic Center culminating a 3-day Community Awareness Week, "with awareness activities on community safety, dam safety, boating and water safety, emergency management, Red Cross, and storm shelters."[135] Sixty-three partners signed the Memorandum of Agreement.[136] Describing what Project Impact intended to do, the Action Report related that "Jamestown plans to look at flood and tornado early warning systems, improvements to the storm water system, river channel clean-up,

[134] The Project Impact Final Report is a Power Point slide presentation. It is undated but issued in 2004. The community-wide planning meetings are discussed on slides 4, 5, and 6.

[135] *Jamestown, North Dakota Action Plan*, no date, page 3.

[136] This was the only list of partners created by Jamestown found in the documents.

emergency response training, tightening of building and zoning ordinance enforcement, safe school initiative and increased public awareness and education programs."[137]

Q.13.1 A Review of the Project Impact Activities

As mentioned above, Jamestown developed its activity list in time for the signing ceremony. Over the three-year period that Project Impact was operational, the city completed ten of these activities. See Table Q-9.

In its final report, Jamestown included the amount of federal funds and local in-kind match for each activity. The city also included either the lead or major partners. It was the only community of the five reviewed in this study that provided this information. See Table Q-10.

Jamestown spent the entire $300,000 allocated to it in the Project Impact grant even though a little less than $8,000 is unaccounted for in Table Q-10; other financial documents show that these funds were approved for start-up activities.

Q.13.2 Benefit Cost Analysis

Table Q-11 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Jamestown, the tornado model developed in this project was used to estimate benefits of the community early warning system. It was assumed that up to 3,000 people could use the civic center as a safe room during tornado events. For the other activities, a benefit-cost ratio of 1.2 (via benefit transfer methods) was used for the city-wide storm study, whose uses were only beginning at the time of this study; benefit-cost ratios of 1.0 were used for the development of a training center and the purchase of a HAZMAT trailer.

There were many unmeasured positive benefits. Jamestown had a much better understanding of its hazard risks and was much better prepared to respond to both floods and tornadoes. Interviewees mentioned that the early warning system eased the minds of the residents. The city officials believed that their experience was a foundation for future developments and many groups had begun to apply what was accomplished during Project Impact. Since Project Impact ended, Jamestown has maintained all the completed projects above and begun either follow-on or additional projects. The local schools have instituted two follow-on projects to make schools safer and a new high school has been designed using the storm water runoff analysis developed in activity 1. In its final report, Jamestown also reported receiving grants from five organizations (Calgill Malting Company, Burlington Northern Santa Fe, North Dakota Farmers Union, RC&D, and Walmart) totaling $11,250 in support of the Fire Training Facility (activity 13).

[137] *Jamestown, North Dakota Action Plan, op. cit.*

Table Q-9 Project Impact activities initiated by Jamestown, North Dakota*

Activity	Benefits	Completion Details and Final Status
1 – City-wide Storm Water Runoff Study	Identify current storm water problem areas within the city and describe alternatives for alleviating problems	Activity #8 "Implement Storm Water Runoff Study" was moved into this project. It was completed by a consultant on June 10, 2002. Detailed maps were produced that can be used in the design of new structures to prevent flooding.
2 – Storm Ready Designation	Community is designated by the National Weather Service as being able to prepare for and respond to hazardous weather events	Activity completed on January 15, 2001. Jamestown was the fourth city in North Dakota to receive this designation.
3 – GIS Implementation	Installation and implementation of flood plain map on GIS system	Activity completed on April 4, 2001.
4 – 24-Hour Skywarn System	Provide emergency communications 24 hours each day	Activity completed on March 7, 2001. A trailer was modified and equipped for emergency communications.
5 – Post Disaster Community Shelter	Provide community with emergency shelter from wind and flooding events	Activity completed on June 10, 2002. An emergency generator was installed at the Civic Center along with storage areas for the Red Cross and National Guard. Contracts were being developed with the Jamestown Hospital and other organizations for using the Civic Center as an emergency evacuation center.
6 – Early Warning System Improvements	Update outdoor sirens in community early warning system for tornadoes and floods	Activity completed on November 14, 2001. Five new sirens were purchased and installed providing a larger reception area.
7 – Haz Mat Training and Equipment	Equip Haz Mat trailer and provide training to 2 firefighters and Red Cross official	Activity completed on November 14, 2001. Haz Mat trailer donated by a partner was equipped and three persons were trained, including 2 of 6 full time fire fighters.
8 – Implement Storm Water Runoff Study	N/A	Merged with Activity #1.
9 – Storm Sewer Flood Gate Controls	N/A	Community was unable to do this project.
10 – Public Awareness and Education	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Activity completed in November 2002. Multiple activities were completed including the purchase of materials for the emergency shelter run by the Red Cross, the purchase and distribution of weather radios, the purchase of computer equipment for disaster presentations and other safety classes, and the development of course for students and adults.
11 – Community Rating System Application	Join the CRS and lower CRS rating from a 10 to 9	Activity not completed.

*Data in this table was taken from the Jamestown Project Impact Final Report.

Table Q-9 Project Impact activities initiated by Jamestown, North Dakota (continued)

Activity	Benefits	Completion Details and Final Status
12 – Model Home Mitigation Project	Train homeowners and contractors on alternative all-hazard retrofitting approaches	Activity completed on September 1, 2002. Worked with students of James Valley Vocational Center to construct a model home demonstrating methods of flood and wind proofing.
13 – Fire and Police Training Facility	Increase fire and police capabilities	Completed project, date unspecified. The project involved building a concrete training pad, a cistern for testing truck pumps, and a building for use as a smoke building, which would provide firefighters with simulated fire situations. The facility will be also be used for Haz Mat drills and will be available for fire departments in smaller cities in the area.

Table Q-10 FEMA and local shares and partners of Project Impact activities*

Activity	FEMA Funds	Local In-Kind Match	Major or Lead Partners
1 – City-wide Storm Water Runoff Study	$60,000.00	$26,646.48	Interstate Engineering, Inc.
2 – Storm Ready Designation	0.00	7,500.00	Stutsman County Emergency Manager
3 – GIS Implementation	5,718.00	5,319.87	Interstate Engineering, Inc. and ESRI
4 – 24-Hour Skywarn System	6,237.25	22,400.00	Jamestown Amateur Radio Club
5 – Post Disaster Community Shelter	59,548.42	30,706.11	Jamestown Hospital
6 – Early Warning System Improvements	104,893.98	30,184.29	(None listed)
7 – Haz Mat Training and Equipment	25,392.28	32,932.10	Jamestown Fire Department and Bob Baumann
8 – Implement Storm Water Runoff Study	N/A	N/A	N/A
9 – Storm Sewer Flood Gate Controls	N/A	N/A	N/A
10 – Public Awareness and Education	28,770.02	24,791.39	Red Cross
11 – Community Rating System Application	0.00	2,000.00	N/A
12 – Model Home Mitigation Project	1,636.48	2,817.50	Jamestown Public Schools and Richard Laqua, Vocational Building Instructor
13 – Fire and Police Training Facility	0.00	190,000.00	(None listed)
Totals	$292,196.43	$375,297.74	

*Data in this table was taken from the Jamestown Project Impact Final Report.

Table Q-11 Benefit cost analysis of completed Project Impact activities in Jamestown, North Dakota

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Jamestown	Civic Center as saferoom, warning for saferooms	0.12	0.10	0.24	1.96	0.93-6.07
	Other activities	0.19	0.14	0.18	0.93	0.3-0.93
	Jamestown TOTALS	*0.31*	*0.24*	*0.42*	*1.33*	*0.56-2.92*

Q.13.3 Conclusions

Jamestown undertook 13 projects at the start of the Project Impact. Two were later merged. Of the 12 remaining projects, 10 were completed or met their objectives.

Q.14 Horry County, South Carolina

Horry County was the only community in this study that entered Project Impact after FEMA revised its application instructions. The following discussion reflects major changes in how the program was managed, obligations of the communities, and the introduction of the two-phased grant in which there was a Phase 1 or start-up phase that permitted the community time to hire a Project Impact Coordinator, form committees, attract partners, and develop activities to be funded in Phase 2 when the activities would be completed. Phase 2 was considered "conditional;" it would begin only at the completion of a FEMA approved Scope of Work and budget.[138]

On July 13, 2000, the Horry County Emergency Preparedness Director notified the South Carolina Emergency Preparedness Division (SCEPD) that Horry County would like to be considered to become a Project Impact Community.[139] No documents were located that confirmed the choice of Horry County as a Project Impact community. However, the FEMA Region 4 *Project Impact Grant Application Instructions [revised 10/27/00]* state that all FY 2001 communities were designated on September 13, 2000. Designated communities were then required to commit to the program and request an application and instructions from the FEMA regional office to qualify for the grant. On October 27, 2000, FEMA Region 4 responded to the request with a lengthy letter outlining what Horry County needed to do to complete the

[138] The Region 4 Grant Application Instructions FY 2001 [revised 10/27/00] contain very detailed requirements and deadlines. However, the only required reports after Phase 2 had begun were Quarterly Financial Reports and Quarterly Programmatic Reports or "Performance Report Narratives."

[139] Whitten, Paul D., Horry County Emergency Preparedness Director, to Stan M. McKinney, SCEPD, July 13, 2000, letter expressing an interest to be selected as a Project Impact Community.

application.[140] In this letter, Horry County was notified that it would receive a $150,000 grant that required a minimum local match of $50,000.

Although the grant application instructions were very detailed and provided a laundry list of required community activities and a timeline, no mention was made of the signing ceremony. In the documents collected, there were also none that discussed the signing ceremony or the date it was held. Interviewees suggested that the signing ceremony set the tone for the entire project. They said it was held in 2001 after the Bush administration announced that Project Impact would not be funded after FY 2001, casting a pall over the proceedings.[141] In the aftermath of the signing ceremony and the Bush administration announcement, interviewees also said that enthusiasm for the project was difficult to maintain and that many potential partners refused to participate. Horry County got off to a rocky start, and some interviewees said it never got better.

On September 21, 2001, an internal FEMA Region 4 memo indicated that the entire grant of $150,000 had been obligated but the community was only eligible to use $19,750 in Phase 1.[142] The Phase 1 grant was awarded effective June 1, 2001. The date for the submission of the Phase 2 Scope of Work and Budget was listed as February 28, 2002. According to dates specified in the *Grant Application Instructions* for FY 2001, Horry County was lagging far behind the original deadlines. The due date in the Grant Application Instructions for the submittal of Phase 2 Scopes of Work and Budgets was May 14, 2001.

Not only was Horry County far behind in meeting the original deadlines established by FEMA, it could not meet the extended ones. The Phase 2 Statement of Work with a list of eleven activities was actually submitted on August 12, 2002 and approved by FEMA on August 19, 2002.[143] Considering that the project duration was established as starting on June 1, 2001 and ending on May 31, 2003, there was little time left to actually complete any proposed activities on time. Horry County attempted to have the grant extended but ran into opposition from FEMA.[144] Although no document was located that specifically stated an extension was granted, apparently one was granted because completed Quarterly Financial Status Reports up to December 31, 2003 were found and there were indications on them that there would be a final Quarterly Report due on March 31, 2004.

During the community site visit conducted between June 28 and July 1, 2004, interviewees in Horry County reported that the project had not ended at that time, that there were still some

140 Housand, Helen J. FEMA Region 4 Regional Assistance Officer to Paul D. Whitten, Emergency Preparedness Director, Horry County, letter re: Request for Application: EMA-2001-RFA-0011.

141 One interviewee said that a FEMA representative refused to be in any photographs of the signing ceremony because he or she did not want to be seen as being associated with Project Impact.

142 Denham, Steven A., FEMA Region 4 Community Liaison, to Brett Bowen, Environmental Specialist, September 24, 2001, memo re: Horry County, SC Project Impact Community Phase I DRCG Grant #EMA-2001-GR-0081 CATEX Review for Grant Projects.

143 Housand, Helen J., FEMA Region 4 Assistance Officer, to Paul Whitten, Public Safety Director, Horry County, August 19, 2002 informing him that Horry County "has been approved to expend funds based on your approved Phased [sic.] 2 Application for Federal Assistance."

144 An e-mail from Jacky Bell, FEMA Region 4 Hazard Mitigation Specialist, to Tabby Shelton, Horry County Emergency Management Department Emergency Planner, February 21, 2003, re: Time Extension Request, stated that "the Regional Director is not receptive to extending the Project Impact grants, so we have a challenge ahead." Later in the e-mail Bell said "We also need to look at a six month time extension vs. a year…we would like to at least get you a 6 month vs. not one at all." It should be noted that application instructions informed the communities that they would be eligible for one-year extensions if justified. All the other communities in this study were granted one-year extensions without difficulty.

activities to be completed. When data collection ended for this community at the end of July 2004, Horry County's Project Impact status had not changed.

Q.14.1 A Review of Project Impact Activities

The activities listed in Table Q-12 were those included in Horry County's Phase 2 Approved Statement of Work dated August 14, 2002. The completion details were provided by the county's Project Impact Coordinator during the community site visit. They reflect the status of the activities as of June 30, 2004.

Table Q-12 Project Impact activities initiated by Horry County, South Carolina

Activity	Benefits	Completion Details and Final Status
Program Administration	Salary	N/A
Enhanced Weather Detection System	Provides real-time weather data to the public and emergency responders	Completed project. Six freestanding weather stations were installed on existing fire stations in the county. A local television station agreed to provide the monthly service charges for each station and has exclusive rights to televise the information in the Horry County TV market.
GIS Critical Facilities and Risk Assessment	Incorporates information regarding critical facilities into existing GIS system, identifying risks that could be alleviated by future mitigation programs and providing information during emergencies	Partly completed. No details provided.
Fire Hydrant Awareness Program	Fire fighters will be able to locate fire hydrants, thereby reducing risk from wildfires	Completed project. Approximately 20,000 reflectors were purchased and installed on all roads in unincorporated areas of the county by fire fighters.
Resident/Tourist Hurricane Awareness Program	Inform residents and tourists regarding hurricane preparedness, evacuation, reentry, and recovery	Not completed. The intent was to create and broadcast public service announcements (PSAs) on local television stations. The person intended to create the PSAs went on maternity leave.
Hazard Analyses and Risk Assessment Exhibition	Inform residents of hazards affecting Horry County and what they can do to mitigate the risks	Not completed. The intent was to create a table top display called "Horry Town" made up of model railroad buildings that could taken to schools, expositions, and community awareness days.
Hazard Awareness Brochures/Posters	Inform residents of hazards, mitigation , and recovery	Partially completed. The community purchased 500 disaster books and passed all of them out. Some posters were created. Needed brochures were identified but not developed.
Hazard Awareness Poster Contest	Involve 4th grade students participating in the *Master of Disaster* program to express what they are learning	Completed project. Twelve posters, one for each month and a different disaster, were created by students and the best were selected for display in various locations in the county.
Fire Rescue & Satellite Police Stations Weather Radios	Enhance the community's warning and response capability	Project completed. Approximately 50 radios were purchased and distributed to all county fire rescue and satellite police stations.
Library Disaster/Preparedness/ Mitigation Books & Displays	Provide the public with disaster preparedness and mitigation information	Project completed. An identical collection of published disaster books was purchased and placed in 9 county libraries, one university, and a reference section within the Public Safety Department for Horry County employees.
Hurricane Strike CD	Provide the FEMA developed *Hurricane Strike* CD to all 6th grade teachers in county	Cancelled. FEMA began to give out the CD at no cost.

Despite its late start, Horry County appears to have successfully implemented many of its proposed activities. However, without a final report, it is not possible to verify whether the uncompleted activities were ever finished. Also, the Project Impact Coordinator said that approximately $40,000 in unspent federal funds as of July 1, 2004 might have to be deobligated.

Q.14.2 Benefit Cost Analysis

Table Q-13 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

Table Q-13 Benefit cost analysis of completed Project Impact activities in Horry County, South Carolina

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Horry County	Warning Systems	0.13	0.04	.16	1.2	1.2
	Fire hydrant reflectors	0.04	0.02	0.05	1.2	1.2
	Education activities	0.04	0.03	N/C	N/C	N/C
	Horry County TOTALS	*0.16(limits of governmental funds)*	*0.12*	*0.21*	*1.28*	*1.03+*

It is difficult to estimate what benefits in addition to those shown in Table Q-13 were in Horry County. Because the overall Project Impact program was cancelled as the grant got underway, it did not have the cache that it had previously. However, Project Impact did bring people together to discuss and solve common problems and did increase the level of hazard and mitigation understanding among the public and emergency responders.

Q.14.4 Conclusions

Not counting the payment of salary to the Project Impact coordinator and the cancellation of the Hurricane Strike CD project, Horry County completed or met its objectives for five of the nine projects that it undertook in Project Impact.

Q.15 Overall Observations

One characteristic was common over all five Project Impact experiences. All five communities were unable to complete their grants in the initially contracted two-year timeframe. Two years was not enough for any community to establish partnerships, determine projects, carry out public events, and complete reporting requirements. Every community applied for and received a time extension.

Overall, the five Project Impact communities completed or met the objectives of 79% of the projects that they undertook (33 of 42).

Appendix R
COMBINED SAMPLING AND MODELING UNCERTAINTY

R.1 Methodology

Sources of uncertainty. As has been noted elsewhere, the total benefit of FEMA grants is uncertain. It was desired to quantify and combine all important sources of uncertainty. This information was then used to calculate two interesting parameters: (a) confidence bounds for the total benefit of FEMA grants for each hazard, and (b) the probability that the "true" benefits exceed the cost. By "confidence bounds" is meant upper and lower bounds between which the "true" total benefit lies with any given level of probability. The uncertainty in total benefit of FEMA grants results from two principle sources:

(1) *Sampling uncertainty*. Total benefits are uncertain because they are estimated from a sample (a subset) of FEMA grants, not the entire population of them.

(2) *Modeling uncertainty*. Total benefits are uncertain because a mathematical model of benefits has been created and applied, and that mathematical model has its own uncertain parameters.

Measures of uncertainty. Let X denote (uncertain) total benefit of FEMA grants. Let $x_{l,p}$ and $x_{u,p}$ denote the lower and upper bounds of X, respectively, that corresponding to probability p that total benefit lies between them. Further, let the confidence bounds be symmetric in that

$$\begin{aligned} p &\equiv P\left[x_{l,p} < X \le x_{u,p}\right] \\ P\left[x_{l,p} < X\right] &= P\left[X \le x_{u,p}\right] = \left(\frac{1+p}{2}\right) \end{aligned} \qquad \text{(R-1)}$$

One can calculate the effect of each type of uncertainty and combine them into an overall estimate of the uncertainty of total benefit. To begin this process, it is reasonable to assume that the total must be greater than or equal to zero, i.e., that no mitigation actually has negative benefit. Without any additional knowledge, by information theory (Shannon and Weaver, 1963), the best assumption for the distribution of total benefit is the lognormal distribution, i.e.,

$$F_X\left(x\right) \equiv P\left[X \le x\right] = \Phi\left(\frac{\ln\left(x\right) - \lambda}{\beta}\right) \qquad \text{(R-2)}$$

where x represents a particular value of X, $F_X(x)$ denotes the cumulative distribution function of X, P denotes probability, Φ denotes the cumulative standard normal distribution, and λ and β are parameters of the distribution, referred to as the logarithmic mean and logarithmic standard deviation. If C denotes the total cost of FEMA grants, then the probability that benefit exceeds cost is given by

$$\begin{aligned} P\left[X > C\right] &= 1 - F_X\left(C\right) \\ &= 1 - \Phi\left(\frac{\ln\left(C\right) - \lambda}{\beta}\right) \end{aligned} \qquad \text{(R-3)}$$

and the confidence bounds $x_{l,p}$ and $x_{u,p}$ are given by

$$x_{l,p} = \exp\left(\Phi^{-1}\left(\frac{1-p}{2}\right)\beta + \lambda\right)$$
$$x_{l,p} = \exp\left(\Phi^{-1}\left(\frac{1+p}{2}\right)\beta + \lambda\right) \quad \text{(R-4)}$$

where Φ^{-1} denotes the inverse cumulative standard normal distribution. Denoting the sample mean value of X by m_X, parameter λ is given by

$$\lambda = \ln\left(m_X\right) - 0.5\beta^2 \quad \text{(R-5)}$$

Combining uncertainty. It is common to assume that sampling uncertainty is independent of modeling uncertainty, and that one can estimate β as

$$\beta = \sqrt{\beta_1^2 + \beta_2^2} \quad \text{(R-6)}$$

where β_1 denotes the logarithmic standard deviation of X resulting from sampling uncertainty, and β_2 denotes the logarithmic standard deviation of X resulting from modeling uncertainty.

Sampling uncertainty. One can calculate β_1 as

$$\beta_1 = \sqrt{\ln\left(1 + \left(\frac{s_X}{m_X\sqrt{n}}\right)^2\right)} \quad \text{(R-7)}$$

where ln denotes the natural logarithm, s_X denotes the sample standard deviation of X and n denotes the sample size. If one knows m_X and the sample standard deviation and sample mean of benefit-cost ratio (s_{BCR} and m_{BCR}, respectively), it is straightforward to calculate s_X as

$$s_X = m_X \cdot \left(\frac{s_{BCR}}{m_{BCR}}\right) \quad \text{(R-8)}$$

Modeling uncertainty. One can calculate β_2 as

$$\beta_2 = \sqrt{\ln\left(1 + \left(\frac{\sigma_X}{\mu_X}\right)^2\right)} \quad \text{(R-9)}$$

where σ_X denotes the standard deviation of X associated with modeling uncertainty, and μ_X denotes the mean value of X, considering modeling uncertainty.

R.2 Results

All the required parameters were available for these calculations. The values of C, m_X, s_{BCR}, and m_{BCR} are shown in Tables 6-1, 6-3, and 6-4. The values of n are not shown elsewhere, but were available from the sample data. The parameters σ_X and μ_X are presented in Section 6.5, the tornado-diagram analyses. Table R-1 presents the results for the symmetric 90% bounds of the total benefit of FEMA grants. Two interesting observations are apparent:

1. Modeling uncertainty dominates total uncertainty ($\beta_1 << \beta_2$, so $\beta \approx \beta_2$), so larger sample would not improve the accuracy of the estimated benefits.
2. The results reaffirm the observation that project mitigation grants produce benefits in excess of costs with high probability for all three hazards.
3.

Table R-1 Combined sample uncertainty and modeling uncertainty

Parameter of Interest	Projects			Source
	Earthquake	Wind	Flood	
Sample properties (n)	128	204	483	Sample data
Total cost of grants ($M) ($C$)	$ 867	$ 280	$ 2,204	Table 6-1
Total benefit of grants ($M) ($m_X$)	$ 1,194	$ 1,307	$ 11,172	Table 6-3
Total sample mean BCR (m_{BCR})	1.4	4.7	5.1	Table 6-4
Sampling uncertainty				
Sample standard deviation of BCR (s_{BCR})	1.3	7.0	1.1	Table 6-4
Standard deviation of benefit ($M) ($s_X$)	$ 1,157	$ 1,969	$ 2,424	Equation (R-8)
$_1$	0.09	0.11	0.01	Equation (R-7)
Modeling uncertainty				
Mean benefit of grants ($M) ($_X$)	$ 1,288	$ 1,308	$ 10,494	Section 6.5
Standard deviation of benefit ($M) ($_X$)	$ 468	$ 555	$ 3,778	Section 6.5
$_2$	0.35	0.41	0.35	Equation (R-9)
Total uncertainty				
	0.36	0.42	0.35	Equation (R-6)
	7.02	7.09	9.26	Equation (R-5)
Probability that benefit exceeds cost	76%	99.97%	99.9996%	Equation (R-3)
90-percent bounds of benefit of FEMA grants				
Lower-bound benefit ($M) ($x_{l,0.90}$)	$ 617	$ 600	$ 5,918	Equation (R-4)
Upper-bound benefit ($M) ($x_{u,0.90}$)	$ 2,029	$ 2,389	$ 18,670	Equation (R-4)

Appendix S
VALIDATION AND QUALITY CONTROL

S.1 External Quality Control

In a highly visible public project, multiple modes of quality assurance are desirable. One mode that is especially desirable is the formation of a review committee that is independent of the actual investigations undertaken. The Project Management Committee (PMC) of the Multihazard Mitigation Council (MMC) provided this external oversight management function. In this multi-disciplinary setting, the PMC included representatives of such disciplines and topics as natural hazards risk assessment, land-use planning, community studies, economics, and sociology.

In practice, the ongoing reviews by the PMC provided critical perspectives on the project in progress. These began with the development of the "Parameters" document that provided important guidelines, definitions, goals, and bounds during the undertaking of this project. During the course of this project, additional instances of the PMC critical assistance included:

- Posing challenging questions that required clarification of definitions and methods,
- Referring the project team to important advances in the literature,
- Assisting in resolving points of controversy among project participants,
- Acting through the PMC Project Manager to facilitate access of the project team to FEMA field offices, grantee staff, and data, and
- Providing feedback on such notions as spin-offs that are accelerations, and the procedures to be used in their quantitative evaluation.

S.2 Internal Quality Control Procedures

Two main types of internal quality control procedures were used in this project: the formal and the informal.

Formal procedures consisting of a variety of internal checks and a report form that was used by the Track A[145] team to check the work of Track B[146] and vice versa.

This Quality Control (QC) review form (Table S-1) was included as part of each internal report. A report passed the QC check if the reviewer was satisfied with each of the 13 points listed in the form. Final reports were not delivered to MMC until the report passed the QC check. Interim reports have been provided with the caveat that the QC procedure had not yet been applied.

[145] Benefit-cost analysis of FEMA hazard mitigation grants

[146] Community studies

The Track A co-leader acted as reviewer of Track-B reports at the draft and final stages. The Track B co-leader performed similar QC checks of Track-A reports.

Table S-1 QC Form (Track B reports)

Reviewer:____
Report: (Title)____
Date of review: ______________________________________

Tests: (explain any "no" responses in comments section, below)	**Satisfactory**
1. All important assumptions clearly stated & justified?	
2. All data sources clearly referenced, all bibliographic references complete & verified?	
3. All important study parameters clearly defined?	
4. Clear statement of study objectives?	
5. Clearly document data-collection procedures?	
6. All relevant data presented & summarized?	
7. All math clearly documented with numbered equations, no skipped steps?	
8. All conclusions supported by well documented data and analysis?	
9. Assess sensitivity of results to important alternative assumptions?	
10. Clear & complete statement of study limitations?	
11. Spot checks: calculations, selection of track-B communities, selection of track-A samples, and result tables. (List calcs & results tables checked in "comments" section.)	
12. Acceptable grammar, style, and organization?	
13. Response to prior QC commentary?	
Summary: does the report pass QC? (Yes if the answer to all of the above is yes)	

The QC form referred to "important" assumptions, limitations, study parameters, and relevant data. Track A provided to Track B, and vice versa, a draft document listing these important assumptions, limitations, etc.; the QC person also reviewed this document. Thus, QC attention was not paid to parameters, assumptions, and the like, that were unlikely materially to affect the study results.

These formal procedures were originally designed chiefly to fit situations in which mature risk evaluation tools, namely, HAZUS for specific types of wind, earthquake, and flood risks, were used. In these cases, parameters dominating outcomes were considered to be fairly well understood, and modification of inputs for sensitivity evaluations were likewise fairly mechanical. Greater ambiguities in the application of these formal procedures were believed to arise when the grants under consideration could not be evaluated through the use of these mature tools. In these cases, parameters and assumptions potentially dominating benefit estimates may be poorly understood. Absent extensive new research, assessment of the uncertainties in these benefit estimates may remain subjective.

Informal procedures included:

- The use of subject-matter specialists to review approaches and draft documents on matters pertaining to their specialties,
- Project team members reviewing general drafts of data, reports, analyses, and proposed approaches written by other project team members, and
- The technical project manager and project Track leaders reviewing all documents pertinent to their general charges.

These more informal procedures were continuously exercised no less than weekly and often more frequently in the course of this project.

S.3 Internal Project Review Team (IPRT) Input

Independent review of the project was provided by the periodic review and input of ATC's Internal Project Review Team (IPRT). The IPRT consisted of six experts, all of whom are nationally recognized experts in their respective fields. They all have long-term experience in working with FEMA and in hazard mitigation. They were selected to provide independent, broad, consensus-based input to the ATC Project Team. This broad input was extremely important to the success of this project, in order to keep the Project Team focused on the big picture, while they performed very detailed data collection and analysis tasks. This balance of long-term experience, coupled with the breadth and depth of expertise resident on the IPRT and project team, allowed the Project Team to make technical recommendations and draw conclusions based upon the best available science and expert judgment. The IPRT was composed of the following individuals:

- William Petak (Chair) – policy analysis
- David Brookshire – economics/non-market impacts
- Dennis Mileti – social science
- Doug Plasencia – flood hazard mitigation
- Zan Turner – building code implementation
- Stephanie King – loss estimation modeling.

These six experts provided input in the areas of benefit-cost analysis, social science research, economics, policy analysis, implementation of hazard mitigation programs at the local level, and on earthquake, flood, and wind hazard issues. All major deliverables were reviewed by the IPRT before delivery to the PMC. Their input was solicited via conference calls, documented in minutes, and disseminated to the Project Team.

S.4 Validation of Costs

For Track A, validation of costs was relatively straightforward, consisting chiefly of using RS Means (Means, R.S., 2002) to spot-check construction costs given facility type and geographic location. Track A also gathered secondary field data in order to substantiate costs.

Track B gathered cost data at the federal, state, and local levels, and so was not restricted to secondary data. Data gathered in the field provided corrections to secondary data. As a result, cost data for Track B had potentially greater certainty than cost data in Track A.

For both Track A and Track B, FEMA grants with multiple objectives were believed to have the potential for posing special cost estimation problems. For one thing, it was believed that costs of pertinent activities may need to be broken down for these grants. For another thing, some costs may not be pertinent to this project (e.g., grants for activities not pertaining to natural hazards mitigation).

S.5 Validation of Benefits

For situations in which HAZUS tools are mature, Track A had the following procedures to check primarily inputs to HAZUS.

Spot-check samples. Some parameters were spot-checked and some were checked for the entire population. Samples for performing spot checks were selected from the Track A study samples as follows. Track A examined three project-type mitigation efforts from each of three hazards and three hazard levels, and three process-type activities from each of three hazards (3 project samples × 3 hazards × 3 hazard levels + 3 process samples × 3 hazards = 36 mitigations, less empty strata). In particular, the samples from each stratum were those selected from the 1st, 12th, and 25th fractile of cost.

- *Hazard assignment*. Track A checked hazard assignment for the wind and earthquake population by mapping each project location and its associated hazard level. Track A produced one map for each hazard. Track A visually compared project hazard-level assignments for earthquake and wind with the FEMA 154 (2002) earthquake-hazard-level map and ASCE-7 windspeed map. Track A performed spot checks for flood projects, taking stream order and stream distance as given, and checked one property from each sample project to ensure that, given stream order and stream distance, the highest-hazard property in the project actually met the project definition of flood hazard.
- *Project location*. Track A spot-checked the address stated in NEMIS with the address stated in the grant application. Track A used online geo-location tools (e.g., MapQuest) to check general agreement with FEMA's geo-location. Mitigation efforts with a precise address had to agree within ±0.01° of latitude and of longitude. Mitigation efforts with imprecise location (e.g., processes applicable to a county) had to agree within ±0.1° of latitude and of longitude.
- *Mitigation type*. Track A spot-checked to ensure that the grant-application description agreed with HAZUS input data, which agreed with the FEMA project-type coding.
- *HAZUS coding*. Track A spot-checked pre- and post-mitigation HAZUS structure type, value, location, and all other parameters listed in the data-collection form, compared the data-collection person's assessments with that of either another data-collection person or of the Track A co-leader, based on a hardcopy of the hazard mitigation grant application or considered internal consistency. Approximately 1,500 changes were made to coded project data. Most were minor but there were obvious transcription or typographic errors such as data from one field entered in an adjacent one or incorrect state abbreviations. Many were

critical data missing from one field that could be readily inferred from another, such as HAZUS's code for occupancy type being inferred from the project description. Some critical additions were made to address, geolocation, occupancy, number of stories, etc., using data available on the Internet and via mapping software. Some systematic checks were also performed, such as checking that the ratio of building value to square footage or the ratio of content value to structure value was within reason.

In similar situations in which HAZUS was considered a suitable mature risk evaluation tool, Track B used field data at various levels of completeness but generally more complete than those used in Track A. These were geo-coded with sometimes very precise longitudes and latitudes, with clear designations of the mitigation type and the hazard type, respectively.

Greater challenges in QC arose when the available risk tools for quantitatively evaluating benefits were less mature. In these cases, non-linearities in benefit estimates were believed to arise as a result of parameters not well-understood. For instance, a risk evaluation tool that did not have a category for commercial-industrial-institutional buildings with and without shutters would likely require the substitution of another building category to develop any benefit estimates for a mitigation consisting of installing shutters. In these cases, it was expected that Track A and Track B would clearly document the relative credibility of risk evaluation tools, assumptions used, and their limitations.