Loss Avoidance Study

Eastern Missouri, Building Acquisition
Part One: General Overview

May 2009

FEMA

Federal Emergency Management Agency
U.S. Department of Homeland Security
500 C Street, Southwest
Washington, DC 20472

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Section One:

Introduction

Following the floods in the spring and summer of 2008 in the Midwest, the Department of Homeland Security's Federal Emergency Management Agency (FEMA) initiated a loss avoidance study (LAS or study) to assess the effectiveness of acquisition/demolition projects in the affected areas in eastern Missouri along the Mississippi River and its tributaries. Actual flood events were analyzed to determine the return on investment (ROI)[1] by estimating the losses that were avoided and comparing the estimates to the resources that were invested in the acquisitions. This report contains a description of the general LAS methodology used and the results of the study.

1.1 Background

Mitigation is defined by FEMA as any sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Every year, FEMA provides States and communities with substantial financial assistance for projects that will reduce or eliminate risks from natural hazards through Hazard Mitigation Assistance (HMA) grants, which include post-disaster grants under the Hazard Mitigation Grant Program (HMGP) and pre-disaster grants under the Pre-Disaster Mitigation Program (PDM), the Flood Mitigation Assistance Program (FMA), the Repetitive Flood Claims Program (RFC), and the Severe Repetitive Loss Program (SRL).

With significant investment being made in mitigation, demonstrating cost-effectiveness is crucial for continued support. In order to evaluate the cost-effectiveness of mitigation projects, FEMA has developed a methodology for loss avoidance studies. The methodology is based on the analysis of actual natural hazard events that have occurred in the project study area since the completion of the mitigation activity. The methodology provides a way to assess the benefits of a mitigation activity in terms of its actual performance.

Loss avoidance methodology can be applied to the mitigation of any type of natural hazard (e.g., flood, wildfire, seismic, wind). Flood hazard mitigation is divided into building modification and flood control projects. Building modification projects mitigate damages by modifying a building to reduce its risk of flooding

1 An ROI greater than 1 indicates that project benefits have already exceeded project costs – therefore a good project. Note the FEMA measure of ROI is not the same as a financial ROI. A financial ROI is a measure of net profit, expressed relative to the dollars invested.

through acquisition/demolition, acquisition/relocation, elevation, and floodproofing. Acquisition/demolition projects are referred to as "acquisition projects," and acquisition/relocation projects are referred to as "relocation" projects. Flood control projects mitigate damages by reducing the hazard itself and include stormwater drainage system improvements, channel modifications, flood walls/barriers, and other projects that reduce the severity of flooding.

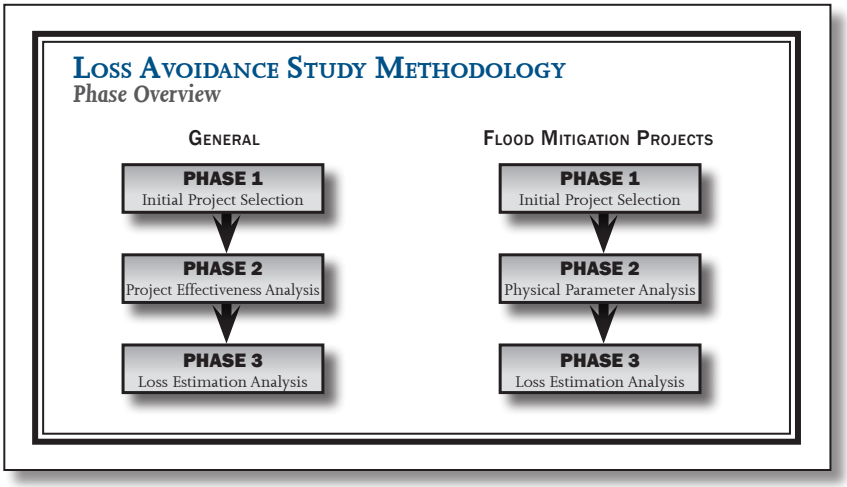
The term "acquisition" refers only to acquisition/demolition projects

This study focuses on the performance of residential acquisition projects. However, the LAS methodology used for this study is consistent with those used in a flood control LAS in southern California (FEMA, 2007a and 2007b) and a flood control and elevation LAS in northern California (FEMA, 2008b and 2008c).

1.2 Purpose

The purpose of the LAS described in this report is to verify the effectiveness of flood mitigation projects in nine communities throughout eight counties in eastern Missouri, specifically residential acquisitions. The study includes a quantification of the losses avoided (also known as damage prevented or benefits) due to the implementation of the projects through analysis of storm events that occurred in 2008.

Figure 1.1



1.3 Methodology Overview

Losses avoided are determined by comparing damage that would likely have been caused by the same storms without the project (Mitigation Project Absent [MP_A]) with damage that actually occurred with the project in place (Mitigation Project Complete [MP_C]). The phases of the general methodology for loss avoidance studies are illustrated in Figure 1.1. Although Phases 1 and 3 are

similar regardless of the type of mitigation project, Phase 2 varies depending on the type of mitigation project. In flood-related studies, Phase 2 is called "Physical Parameter Analysis."

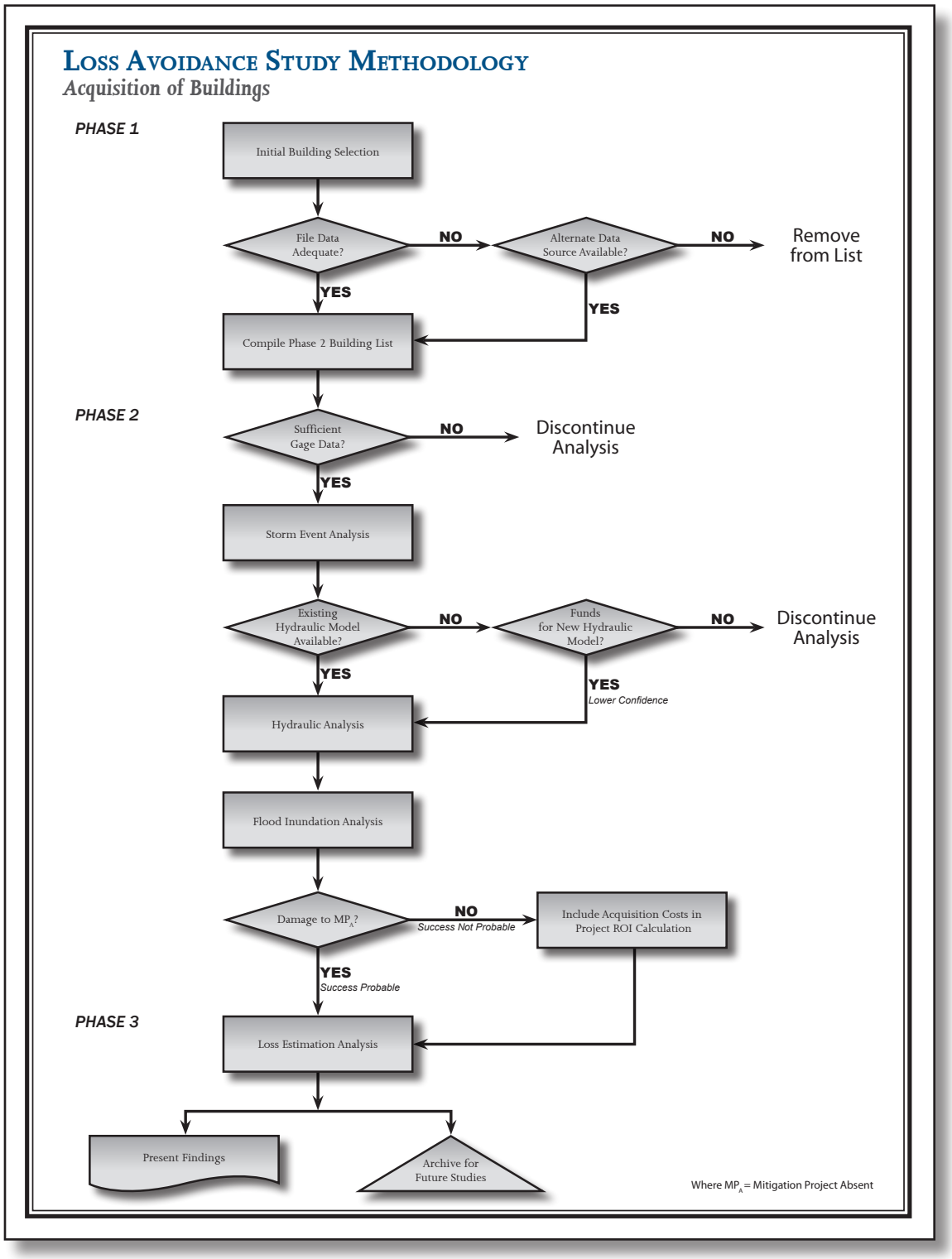
This study focuses on the acquisition and demolition of buildings in eastern Missouri. Figure 1.2 is a detailed illustration of the LAS methodology for acquisition projects.

Phase 1 consists of the development of the initial project list. Projects are selected based on criteria determined by the sponsoring agency. For acquisition projects, the initial list of buildings in each project is screened based on the availability of data required for completion of all phases of the study. Buildings with adequate data advance to Phase 2 of the study.

Phase 2 is composed of three distinct analyses—Storm Event Analysis, Hydraulic Analysis, and Flood Inundation Analysis. A Storm Event Analysis is performed to determine whether a post-construction storm event severe enough to have caused damage if the project had not been completed (the MP_A scenario) has occurred. A Hydraulic Analysis is performed to determine the extent and depth of flooding. A Flood Inundation Analysis uses the results of the Hydraulic Analysis and is conducted to determine the depth of flooding inside buildings within the project extents. If the depth or limit of inundation determined for the MP_A scenario indicates damage would have occurred if the project had not been implemented, the building advances to Phase 3 for a Loss Estimation Analysis.

In Phase 3, damages are calculated for the MP_A and MP_C conditions. Once the MP_A and MP_C damages are estimated, the difference between the two scenarios is calculated to determine the losses avoided. The ROI is calculated by comparing the losses avoided to the project investment.

Figure 1.2


Loss Avoidance Study Methodology
Acquisition of Buildings
PHASE 1
Initial Building Selection
File Data Adequate?
NO
Alternate Data Source Available?
NO
Remove from List
YES
YES
Compile Phase 2 Building List
PHASE 2
Sufficient Gage Data?
NO
Discontinue Analysis
YES
Storm Event Analysis
Existing Hydraulic Model Available?
NO
Funds for New Hydraulic Model?
NO
Discontinue Analysis
YES
YES
Lower Confidence
Hydraulic Analysis
Flood Inundation Analysis
Damage to MP_A?
NO
Success Not Probable
Include Acquisition Costs in Project ROI Calculation
YES
Success Probable
PHASE 3
Loss Estimation Analysis
Present Findings
Archive for Future Studies
Where MP_A = Mitigation Project Absent

Section Two:

State of Missouri Acquisition Initiative

Following the record-setting flooding of the Mississippi River in 1993 and 1994, the State of Missouri initiated a campaign to acquire buildings prone to repetitive losses from flooding. Shortly after the initial voluntary acquisitions were completed, the area again experienced substantial flooding (in 1995). The severity of the 1995 floods reinforced the need for mitigation and prompted additional property owners to volunteer for the program.

2.1 History

From 1999 to 2008, Missouri had 14 Presidential Disaster Declarations due to flooding, representing more than one flooding disaster per year (FEMA, 2002). Other floods also occurred in Missouri during this period but were not severe enough to be declared disasters. Table 2.1 shows the Presidential Disaster Declarations experienced by each of the eight counties considered for this study from 1999 to 2008.

Table 2.1

Presidential Disaster Declarations in Missouri Since 1999

County	Declarations
Bollinger	1463, 1748, 1749, 1809
Cape Girardeau	1463, 1748, 1749, 1773, 1809
Jefferson	1328, 1463, 1631, 1749, 1773, 1809
Lewis	1773, 1809
Lincoln	1631, 1676, 1749, 1773, 1809
Marion	1463, 1773, 1809
St. Charles	1328, 1676, 1749, 1773, 1809
Wayne	1748, 1749, 1809

2.2 Funding and Timeline

In response to the flooding, local governments in Missouri acquired 4,045 repetitive-loss properties from 1993 to 2008 at a cost of approximately $75 million (FEMA, 2002). Property owners were given the option of participating in the voluntary acquisition project if their properties had been affected by the 1993/1994 or 1995 floods. Many buildings were acquired before the 1995 flood, and many communities therefore experienced an immediate return on investment. St. Charles County purchased 1,410 properties, by far the highest number for any county.

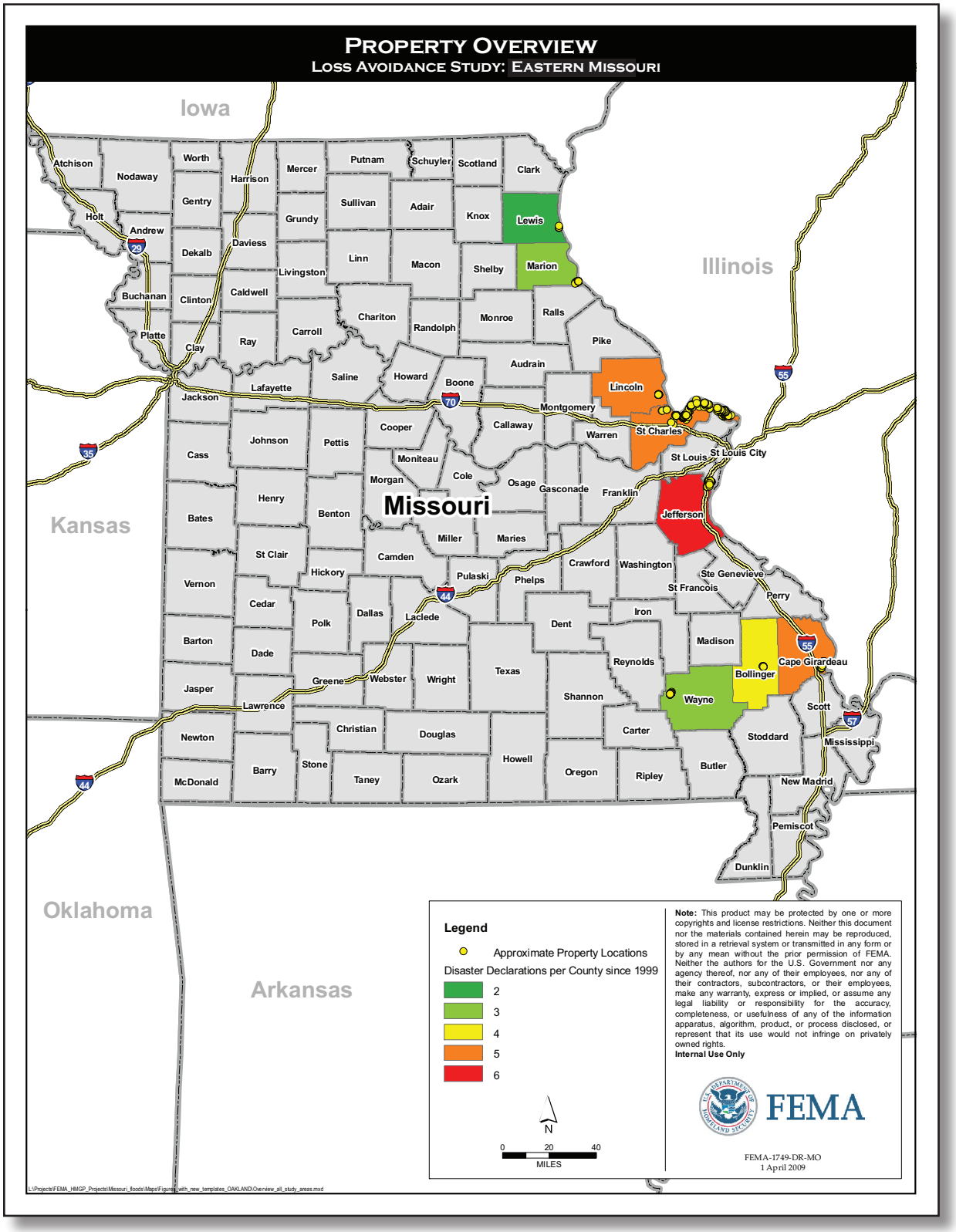
Table 2.2 lists the number of properties that were acquired in the study area by county. Figure 2.1 shows the locations of the acquired properties, and demonstrates the number of disasters experienced by county in the study area. Section 3 contains a detailed discussion of the study area and properties included in this study.

Table 2.2

Acquisitions Since 1993

County	Properties Purchased
Bollinger	30
Cape Girardeau	145
Jefferson	499
Lewis	14
Lincoln	510
Marion	181
St. Charles	1,427
Wayne	77
Total	**2,885**

Figure 2.1


Property Overview
Loss Avoidance Study: Eastern Missouri
Iowa
Illinois
Kansas
Missouri
Oklahoma
Arkansas
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Andrew
Gentry
Grundy
Sullivan
Adair
Knox
Lewis
Dekalb
Daviess
Linn
Macon
Shelby
Marion
Buchanan
Clinton
Caldwell
Livingston
Chariton
Randolph
Monroe
Ralls
Platte
Clay
Ray
Carroll
Pike
Audrain
Lafayette
Saline
Howard
Boone
Lincoln
Jackson
Montgomery
Cooper
Callaway
Warren
St Charles
Cass
Johnson
Pettis
Moniteau
St Louis
St Louis City
Morgan
Cole
Osage
Gasconade
Franklin
Henry
Bates
Benton
Jefferson
Miller
Maries
St Clair
Camden
Crawford
Washington
Vernon
Hickory
Pulaski
Phelps
Ste Genevieve
St Francois
Perry
Cedar
Polk
Dallas
Laclede
Dent
Iron
Barton
Dade
Madison
Reynolds
Cape Girardeau
Bollinger
Jasper
Greene
Webster
Wright
Texas
Shannon
Wayne
Scott
Lawrence
Christian
Douglas
Carter
Stoddard
Mississippi
Newton
Barry
Stone
Taney
Ozark
Howell
Oregon
Ripley
Butler
New Madrid
McDonald
Pemiscot
Dunklin
Legend
Approximate Property Locations
Disaster Declarations per County since 1999
2
3
4
5
6
N
0 20 40
MILES
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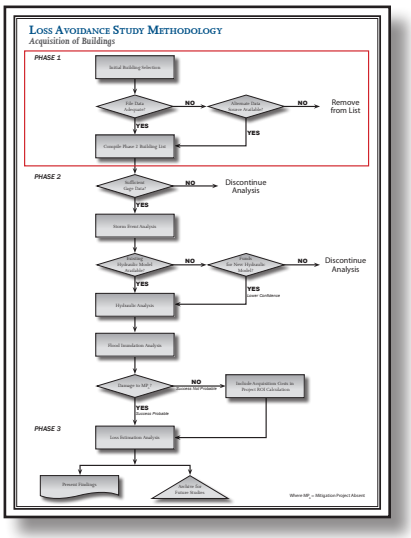
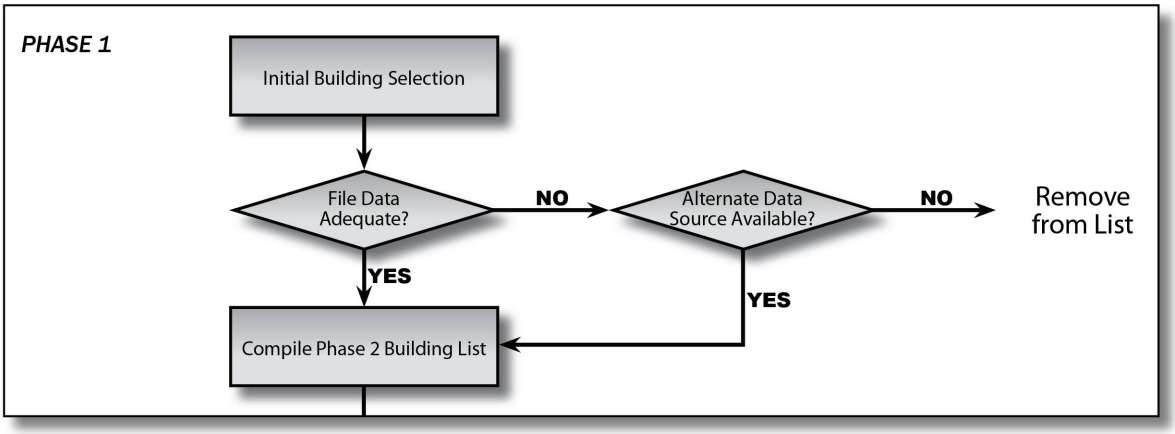
Section Three:

Phase 1 — Initial Project Selection and Screening



This section contains a discussion of Phase 1 (Initial Project Selection) for LAS (see Figure 3.1 for an illustration of the Phase 1 process). In Phase 1, an initial list of candidate projects is selected, and data are collected for analysis of the projects. Buildings are analyzed and screened individually within an acquisition project based on the availability of the data that are required for Phase 1, and a list of buildings advancing to Phase 2 is compiled.

Figure 3.1



3.1 Initial Data Collection and Screening

The selection of the initial projects is based on criteria defined for a particular LAS. The criteria may include but are not limited to:

- **Area of Interest:** The area of interest is the geographic boundary of a study. The boundary can be a reach of a river or channel, a single community or watershed, a region, a jurisdictional boundary (e.g., city, county, state, special district), or any other area. The boundary must be defined by the agency sponsoring the study. An acquisition project can consist of a single building but more often includes multiple buildings. Regardless of the number of buildings in a project, every building is evaluated individually using the information that is available for that building.
- **Hazard Type:** Projects in an LAS are selected based on the type of hazard they are mitigating. Examples of hazard types are riverine flood or coastal flood.
- **Project Type:** Many different project types can be analyzed in an LAS. Flood-related projects include elevation, acquisition,

relocation, floodproofing (called building-modification projects), stormwater drainage system improvements, channel modifications, flood walls/barriers and other projects that would reduce the severity of flooding (called flood-control projects).

- **Study Baseline:** The study baseline for an LAS is the date the mitigation activity was completed. Only the storm events that occurred after the study baseline should be evaluated for a study. For an acquisition/demolition project, the study baseline is the date of demolition for each building. Consequently, it is more likely that losses avoided can be assessed for buildings with older demolition dates. A mitigation project, which may include the acquisition of multiple buildings, is not closed until after the acquisition and demolition of each building included in the project is complete. Therefore, using the demolition date instead of a closeout date is recommended, and each building should be evaluated individually.

For acquisition projects, once an initial list of projects has been selected, buildings in each project must be analyzed individually. Buildings should be removed from the analysis during Phase 1 if specific, necessary building data are not available or cannot be easily estimated. Buildings may also be eliminated based on the quality of the available data.

The data that are required to complete an LAS for acquisition projects are:

- Actual acquisition costs, including the fair market value of the building paid to the homeowner, demolition costs, legal fees, and assessor's costs
- Demolition completion dates for each building
- First floor elevations (FFEs) for the MP_A scenario, preferably in the form of FEMA elevation certificates. FFEs can be estimated in the absence of surveyed FFEs (see Section 6.1.1).
- Building location information in the form of latitude/longitude data, address, and/or assessor parcel number (APN)
- Building information, including building type (i.e., residential, commercial, industrial, or municipal), construction type (e.g., wood frame, manufactured), basement information (finished versus unfinished and square footage), number of floors, living square footage, foundation type, number of stories, garage type and square footage, and building replacement value (BRV)

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- Building location information in the form of latitude/longitude data, address, and/or assessor parcel number (APN)
- Building information, including building type (i.e., residential, commercial, industrial, or municipal), construction type (e.g., wood frame, manufactured), basement information (finished versus unfinished and square footage), number of floors, living square footage, foundation type, number of stories, garage type and square footage, and building replacement value (BRV)

FFEs are important because they provide the basis for the damage calculations. Damages are calculated in Phase 3 based on the depth of flooding inside the building. Due to the sensitivity of the damage calculations, even 0.5 feet of difference in FFE can result in large variations in calculated damages. Therefore, ideally, surveyed FFEs should be used.

3.2 Missouri Study: Phase 1 Summary

After the severe flood events in eastern Missouri during March 2008 and June and July 2008 (referred to as "spring and summer 2008 events" in this report), FEMA Region VII and the Missouri State Emergency Management Agency initiated the eastern Missouri LAS. Both events received Presidential Disaster Declarations for severe storms and flooding: FEMA-1749-DR-MO on March 19, 2008 and FEMA-1773-DR-MO on June 25, 2008. The two agencies worked together to develop a project list for the study based on the following criteria:

- **Area of Interest:** Counties in eastern Missouri that were affected by flooding from the Mississippi River and its tributaries

Building Data Required for Acquisition LAS

- Total acquisition/demolition cost
- Demolition completion date
- First floor elevation
- Building location information
- Building characteristics
- Building replacement value

- **Hazard Type:** Riverine flooding
- **Project Type:** Residential building acquisition
- **Study Baseline:** Acquisitions that were completed before the spring and summer 2008 events.

The initial project list covered eight counties, nine communities, 20 projects, and 2,049 properties. The properties included approximately 1,091 buildings and 958 vacant lots. The communities were located in the eastern Missouri counties of Bollinger, Cape Girardeau, Jefferson, Lewis, Lincoln, Marion, St. Charles, and Wayne. The projects on the initial project list had received funding through HMGP under Presidential Disaster Declarations FEMA-995-DR-MO,

Table 3.1

Mitigation Projects Included in the Study

Community	County	Disaster and Project Number
Arnold	Jefferson	995-0002
		1463-0001
		FMA-PJ-07MO-1997002
		FMA-PJ-07MO-1998002
		FMA-PJ-07MO-1999001
La Grange	Lewis	995-0027
Cape Girardeau	Cape Girardeau	1054-0001
		1403-0004
St. Charles County	St. Charles	995-0001
City of St. Charles	St. Charles	995-0017
Hannibal	Marion	995-0004
Winfield	Lincoln	995-0015
Piedmont	Wayne	995-0045
		1006-0007
		1023-0005
		1054-0008
		1403-0008
		FMA-PJ-07MO-1997003
		FMA-PJ-07MO-1998003
Marble Hill	Bollinger	1403-0011

FEMA-1006-DR-MO, FEMA-1023-DR-MO, FEMA-1054-DR-MO, FEMA-1403-DR-MO, FEAM-1463-DR-MO, or FMA funding in 1997, 1998, and 1999. Table 3.1 is a list of the communities and project numbers included in the study. Data collection efforts for the projects were completed, and some properties were eliminated from the analysis, as described below.

Project Cost Data

Project cost data were gathered from project final closeout reports, and total acquisition costs were obtained for each building. Although the acquisition projects were funded through HMGP funds, demolition costs were often funded under the FEMA Public Assistance (PA) program for the disaster. The demolition costs were often reported as a lump sum for the project, and the costs were prorated for each building. When possible, the date of final inspection for each building was obtained from the project files, indicating that the demolition was complete. The total acquisition cost for each building was then inflated to 2008 dollars based on that date.

Building Location Data

Building location data can be difficult to obtain for acquisition projects because the buildings no longer exist. In this study, the buildings had been demolished for up to 15 years, making the effort especially challenging. Building location data were gathered for Phase 1 using aerial photography, community tax parcel databases, and geocoding technology to determine approximate building locations from the building street address. Geocoding technology uses detailed street mapping and GIS information. In most cases, building locations were determined using the address. In some special cases, such as mobile home parks, building location was based on the locations of private streets and spaced according to typical pad sizes. Some parcels contained multiple buildings or buildings with multiple units.

Detailed street address data were obtained from Google Maps (www.maps.google.com) and available databases such as Environmental SystemsResearch Institute's StreetMap 2008 (www.esri.com/data/streetmap/index.html). Background GIS data and tax parcel mapping were accessed through State and local GIS websites, such as the Missouri Spatial Data Information Service (http://msdis.missouri.edu/). Historical aerial photography was obtained through the U.S. Geological Survey (USGS) Seamless Data website (http://seamless.usgs.gov). When available, mapping included in the project files was also used to locate the acquired buildings.

Building Information

Obtaining information about buildings that were demolished years earlier can be challenging if the information is not available in FEMA project files. Very limited building information was provided in the project closeout files for the projects in this study. Building-specific information such as construction type, number of floors, and square footage was obtained from tax parcel databases when possible, but the data were also found to be limited.

Estimating Building Data

- Building characteristics can be estimated using local Census Bureau data such as the American Housing Survey.
- FFEs can be estimated using high-resolution topographic information in conjunction with factors of height above grade from HAZUS-MH
- Buliding location information can be estimated using geocoding methods in GIS

In the absence of data specific to the buildings included in the study, data from the 1996 and 2004 surveys of the St. Louis metropolitan area (HUD, 2005 and 2007) provided the range of building square footage and the types of foundations for single-family homes. A statistical analysis was conducted, using the data, to estimate building parameters when necessary (see Section 6.1.2 for more information). Because no census data were available for mobile homes, it was assumed that all mobile homes had a crawlspace foundation and no garage when estimating the FFE and the BRV of the building. The Residential Cost Handbook (Marshall & Swift, 2008) was used to approximate 2008 BRVs.

When surveyed FFEs were not available from project files, topographic information was used in conjunction with factors of height above grade from Hazards U.S.–Multihazard (HAZUS-MH) to estimate the FFE based on the foundation type (see Table 3.2). Ground-surface elevations were derived from USGS 1/3-arc-second Digital Elevation Models (DEMs) that were created through interpolation of topographic maps with contour intervals ranging from 10 to 20 feet. For some locations along the Mississippi River, higher resolution 1/9-arc-second USGS DEMs were interpolated from Airborne Light Detection and Ranging Systems (LIDAR) data to derive ground-surface elevations. The ground-surface elevation was found at each building using GIS, and HAZUS-MH values were used to adjust the elevation to estimate the FFE. This method was used only when other FFE data were not available because the results

Table 3.2

FFE by Foundation Type

Foundation Type	FFE (ft above grade)
Basement	4
Crawl	3
Slab	1

may have a low level of accuracy. The accuracy could have been improved if higher resolution topographic information had been available (see Section 6.1.1 for more information).

Building Screening

As noted previously, the initial project list contained 20 projects and 2,049 properties. The properties included approximately 1,091 buildings and 958 vacant lots. Communities often acquire vacant lots adjacent to buildings that are being acquired to create a continuous open space that will be protected by deed restrictions in the future and to ensure that the space will not be used for development that would be at risk for flooding. Although vacant lots are not necessarily eliminated from the study, there are no avoided losses associated with the lots, and they are not analyzed in Phase 2 of the study. However, the costs to acquire the lots are included in the final ROI calculation because they are part of the total project investment.

Vacant Lots

The total propery list includes approximately 958 vacant lots. While there are no losses avoided for vacant lots, the costs to acquire the lots are included in the final ROI calculations.

Some of the buildings included in the study were located along the Missouri River, a tributary of the Mississippi River. Records from 2008 showed minimal to no flooding on this tributary, so no losses were avoided from these buildings. This assumption was verified using stream gage data during Phase 2 (see Section 4.1.6). Buildings for Project 995-0001 in St. Charles County did not continue to Phase 2 if they were located along the Missouri River. Project 995-0017 in the City of St. Charles, which included 7 buildings, 1 vacant lot, and 1 mobile home park, was also not evaluated during Phase 2 because the Missouri River was determined to be the major flooding source. However, similar to the vacant lots, although no losses were avoided, the full cost of the projects were included in the final ROI calculation because the costs were part of the total project investment.

In some cases, a building did not have an address that matched available street data and the building location could not be determined using GIS. Therefore, the losses avoided could not be accurately calculated. These buildings did not continue to Phase 2, and the losses avoided were not included in the ROI calculation. However, the ROI calculations include the costs to acquire and demolish the buildings because they are included in the total project investment.

Buildings were eliminated completely from the study if project files showed the buildings had not yet been acquired and demolished. The three buildings in Project 1463-0001 in the City of Arnold were eliminated because the acquisition and demolition of the buildings were not completed prior the spring and summer 2008 events. Therefore, neither the losses avoided nor the costs of the projects were included in any ROI calculations.

Three buildings in 1463-0001 in the City of Arnold were eliminated because the project was not yet closed at the time of the study.

In order for the remaining buildings to proceed to Phase 2, the building data had to be available or could be estimated. The buildings that were selected to proceed to Phase 2 are listed in Table 3.3.

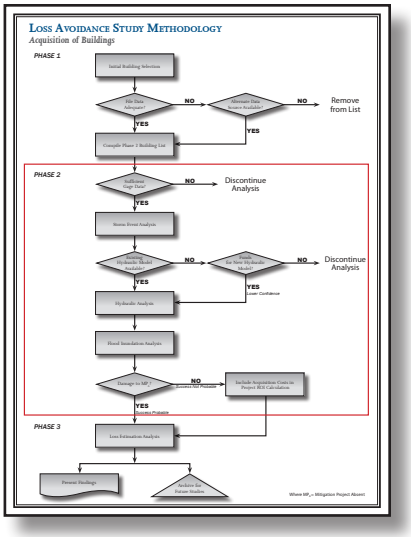
Table 3.3

Buildings Proceeding to Phase Two

Community	County	Disaster and Project Number	Number of Properties Identified	Buildings Proceeding to Phase 2	Reason for Elimination
Arnold	Jefferson	995-0002	211	79	Addresses could not be reconciled, vacant lots
		1463-0001	3	0	Project has not been closed
		FMA-PJ-07MO-1997002	1	1	N/A
		FMA-PJ-07MO-1998002	3	3	N/A
		FMA-PJ-07MO-1999001	6	6	N/A
La Grange	Lewis	995-0027	12	11	Addresses could not be reconciled
Cape Girardeau	Cape Girardeau	1054-0001	109	79	Ungaged flooding sources, vacant lots
		1403-0004	2	2	N/A
St. Charles County	St. Charles	995-0001	1,410	467	Addresses could not be reconciled. Minimal flooding on Missouri River
City of St. Charles	St. Charles	995-0017	9	0	Minimal flooding on Missouri River
Hannibal	Marion	995-0004	144	90	Addresses could not be reconciled, vacant lots
Winfield	Lincoln	995-0015	45	49	Multiple units on some properties
Piedmont	Wayne	995-0045	9	15	Multiple units on some properties
		1006-0007	19	19	N/A
		1023-0005	2	2	N/A
		1054-0008	10	10	N/A
		1403-0008	12	10	Address could not be reconciled, vacant lot
		FMA-PJ-07MO-1997003	10	10	N/A
		FMA-PJ-07MO-1998003	6	6	N/A
Marble Hill	Bollinger	1403-0011	26	26	N/A

Section Four:

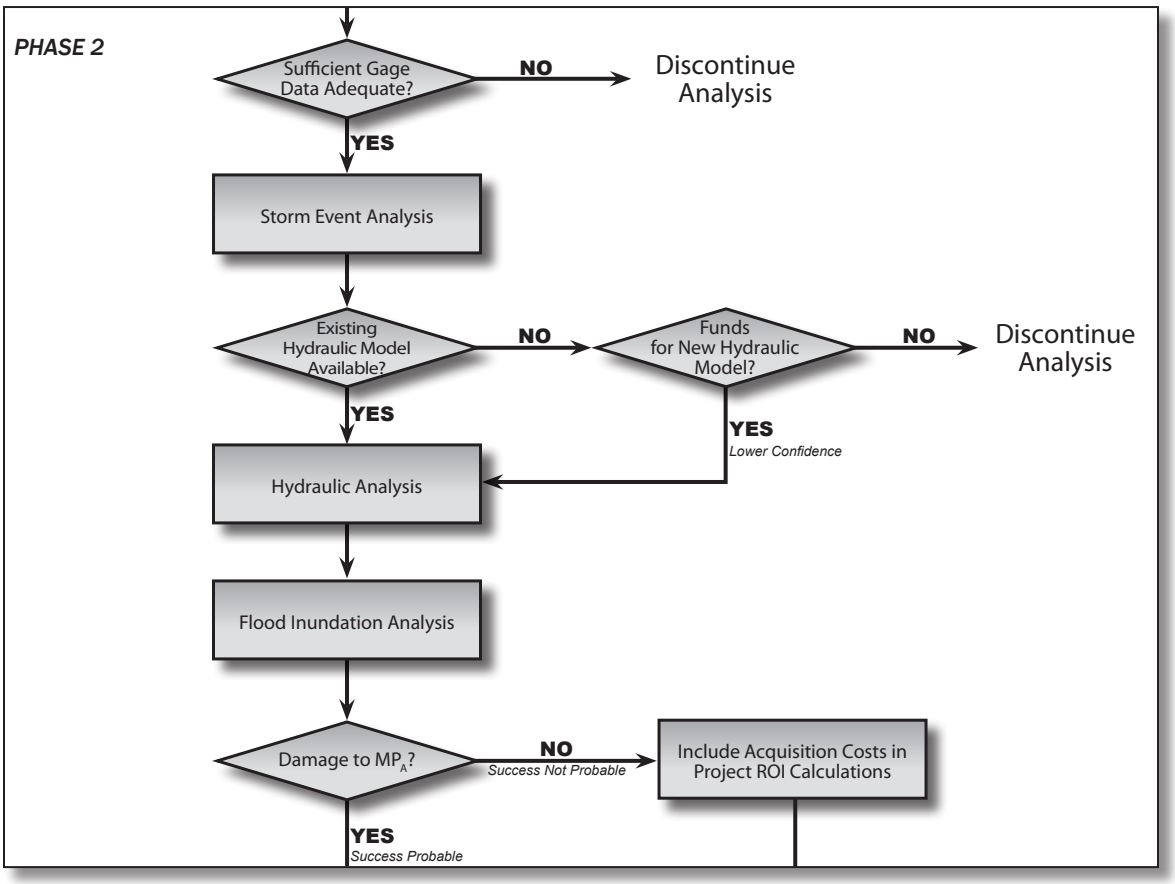
Phase 2 — Physical Parameter Analysis



This section contains a discussion of Phase 2 (Physical Parameter Analysis) for acquisition projects (see Figure 4.1). Phase 2 consists of a Storm Event Analysis, a Hydraulic Analysis, and a Flood Inundation Analysis.

- **Storm Event Analysis:** A Storm Event Analysis is conducted to identify potentially damaging MP_C storm events and assess data availability. Data include HWMs or stream/precipitation gage readings. If precipitation gages are used, a hydrologic analysis must be completed as part of the analysis to convert rainfall data to flow at the project site.

Figure 4.1



- **Hydraulic Analysis:** A Hydraulic Analysis is used to determine how flows move through the project area and the water surface elevations (WSEs) from known storm events. For building modification projects, if a water surface profile from an existing model is available, or enough HWMs to create a digital water surface were collected during the Storm Event Analysis, this step is unnecessary.

- **Flood Inundation Analysis:** The Flood Inundation Analysis is conducted to determine the depth of flooding that would have occurred during known MP_C storm events at each building location if the building not been acquired.

4.1 Storm Event Analysis

A loss avoidance study for any flood-related project is dependent on the occurrence of an MP_C storm event severe enough to have caused damage in the MP_A scenario. For some projects, more than one storm event may have occurred during the project's lifetime that could have caused damages.

The purpose of the Storm Event Analysis is to determine what storm event data are available. Data for the Storm Event Analysis may be collected in the form of historical flooding data, stream gage discharge data, stream gage stage data, or precipitation gage data (see Figure 4.2). If no historical flooding data were recorded, the availability of sufficient stream gage data should be determined, since this is the best source of data for the analysis. The stream gage should be in or near the study area and have a period of record covering the event(s) of interest. Stream gage data may include measurements of stage (water-surface

Figure 4.2

elevation), discharge (flow rate), or both. When no stream gages are available, precipitation gages must be located. If no storm event data are available, the buildings along that flooding source must be eliminated. A list of peak events since the first building was acquired can be compiled from the gage data during this phase if the scope of the study calls for the analysis of more than one event.

4.1.1 Missouri Study: Storm Event Analysis

The project scope for the eastern Missouri study limited the Storm Event Analysis to the spring and summer 2008 events. Table 4.1 shows the main flooding source affecting each community.

Stream gages maintained by the NWS, USGS, or cooperatively by both, were analyzed to determine whether flooding had occurred in the project area during the spring and summer 2008 events.

Although ungaged Sloan Creek and Cape La Croix Creek are subject to flooding, the major flooding source for the City of Cape Girardeau is the Mississippi River. Buildings affected by the ungaged flooding sources were removed from the analysis. Gage data on the Missouri River in the City of St. Charles, indicated that the 2008 flooding was between a 2- and 5-year event. Therefore, the study scope assumption that flooding along the Missouri River was minimal was verified.

Losses avoided were not calculated for buildings located along the Missouri River due to minimal flooding.

- 995-0001 St. Charles County
- 995-0017 City of St. Charles

Table 4.1

Flooding Source Information

Community	Flooding Source	Flooding Profile Source
Arnold	Meramec River	FEMA FIS
La Grange	Mississippi River	USACE
Cape Girardeau	Mississippi River	USACE
St. Charles County	Mississippi River	USACE
City of St. Charles	Missouri River	FEMA FIS
Hannibal	Mississippi River	USACE
Winfield	Mississippi River	USACE
Piedmont	McKenzie Creek	FEMA FIS
Marble Hill	Crooked Creek	FEMA FIS

4.2 Hydraulic Analysis

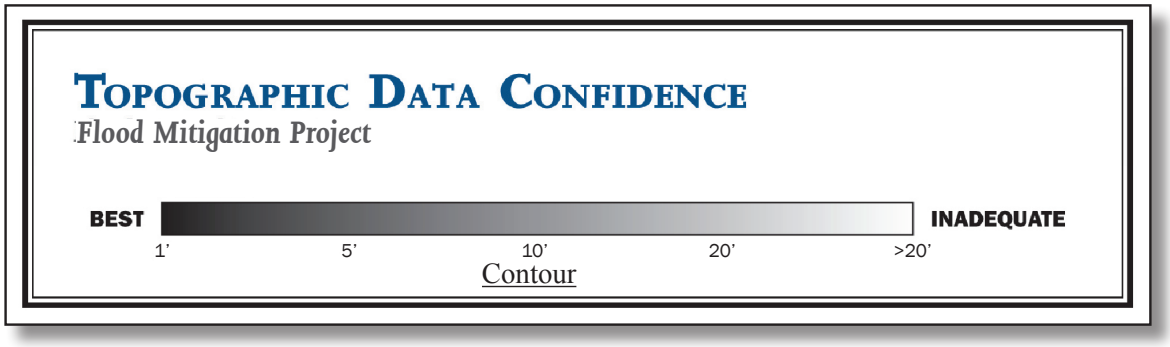
A Hydraulic Analysis is usually required to determine the WSE and depth of flooding at locations of interest. Hydraulic modeling uses discharges determined in the Storm Event Analysis (see Section 4.1) in conjunction with detailed topographic data to estimate WSEs at a series of cross sections for the peak flow event(s) of interest.

If the flood source was studied in detail, for example, for a FEMA Flood Insurance Rate Map, obtaining a copy of the existing hydraulic model may be possible. Results from the existing model in the Flood Insurance Study (FIS) may be used to interpolate actual storm events, or modifying the model may be possible simply by replacing the original flow data with the event of interest. However, only portions of the original model may be applicable for use, especially if the channel has migrated since the model was completed.

When an existing hydraulic model is not available, the parameters required to set up a new model include cross section elevation data, roughness coefficients, boundary conditions, inflow (from Storm Event Analysis), and data for any hydraulic structures in the model area. A list of FEMA acceptable hydraulic models is available at www.fema.gov. If a new hydraulic analysis is necessary, detailed topographic data for all river reaches of interest are necessary for channel cross sections to be created. Outlier buildings or buildings located where adequate topographic data are not available should be removed from the building list. Figure 4.3 demonstrates the appropriate detail of topographic data for use in hydraulic modeling.

Buildings that are located on flooding sources with existing hydraulic modeling available or on flooding sources that can be modeled with appropriate methods will proceed to the Flood Inundation Analysis.

Figure 4.3



4.2.1 Missouri Study: Hydraulic Modeling

Existing models, in the form of FEMA FISs, were available for all communities and were supplemented with the 2004 Upper

Mississippi River System Flow Frequency Study (USACE, 2004) to determine the recurrence intervals corresponding to the flood stages for the spring and summer 2008 events for each community. Therefore, new hydraulic modeling was not necessary and no buildings were eliminated during the Hydraulic Analysis.

4.3 Flood Inundation Analysis

To determine whether buildings would have been affected by the peak storm event or events, the final step of Phase 2, the Flood Inundation Analysis, requires mapping the flood surface and comparing the water surface elevations to the MP_A FFEs.

Most flood analysis and mapping is conducted using GIS software. The cross sections from the hydraulic model can be digitized and attributed with peak water surface elevations for the events of interest. Flood elevations can then be interpolated and converted to a water surface layer to account for flood elevations in all areas between the cross sections. From this surface, a peak WSE at each building can be exported in table format.

When MP_A FFE data are available for acquisition projects, extracting the WSE from the flood elevation surface directly can greatly reduce analysis time by eliminating the need to compare the ground elevation and flood elevation surfaces. To determine the depth of flooding in the building for MP_A scenario, the FFE is simply subtracted from the WSE determined at each building.

When the FFE is unknown, detailed topographic information is needed. The flood depth is calculated by determining the flood depth between the ground and the WSE. The flood depth at the building is then calculated by subtracting an assumed height above grade, based on the building's foundation type or building photography, from the overall flood depth.

4.3.1 Missouri Study: Flood Inundation Analysis

During the Flood Inundation Analysis, the flood depth that would have occurred inside each building had the building not been acquired was calculated. FEMA FIS and USACE flood profiles were used for the analysis.

First, for each community, cross sections from the FIS were digitized in GIS. Cross sections between those provided in the FIS were interpolated digitally to facilitate creating a smooth water surface.

Next, stream gage stage data (see Section 4.1.5) was input at the cross section corresponding to the gage location, and it was noted which recurrence intervals the stage fell between using the FIS or USACE flood profiles (see Table 4.1). WSEs at the remaining cross sections along the profile were interpolated through hand calculations using the appropriate recurrence intervals as lower and upper bounds. These WSEs were input into GIS and converted to water surface layers for each event affecting the community to account for flood elevations in all areas between the cross sections.

For the analysis of the City of Marble Hill, discharge data were used instead of stage data. The lower and upper bounding recurrence intervals were determined from FIS discharge tables. The elevation corresponding to the recurrence interval was found on the FIS flood profile for each cross section, and a water surface layer was created.

Once flood surfaces were digitally created for the storm affecting the community, the flood depth at each building location (measured from the WSE to the ground) was extracted and exported in table format. Ground-surface elevations were derived from USGS 1/3-arc-second DEMs that were created through interpolation of topographic maps with contour intervals ranging from 10 to 20 feet. It is important to consider that although a DEM is a continuous representation of the ground surface, its elevation detail is only as good as its source data, which in this case are topographic contours with 10- or 20-foot intervals. Any variations in elevation within these contour intervals will likely not be represented in the DEM and consequently not in the final analysis. Some study locations along the Mississippi River used higher resolution 1/9-arc-second USGS DEMs interpolated from LIDAR data to derive ground-surface elevations. The flood depth inside each building was determined by adjusting the flood depth based on the FFE (actual or estimated with an above-ground offset using HAZUS-MH standard values, as shown in Table 3.2).

Appendices C through J provide detailed tables of the depths of flooding calculated at each building and figures showing the extents of flooding. Table 4.2 provides an overview of the number of damaged buildings in each project. Because the scope of the study included only two events, no threshold analysis was necessary.

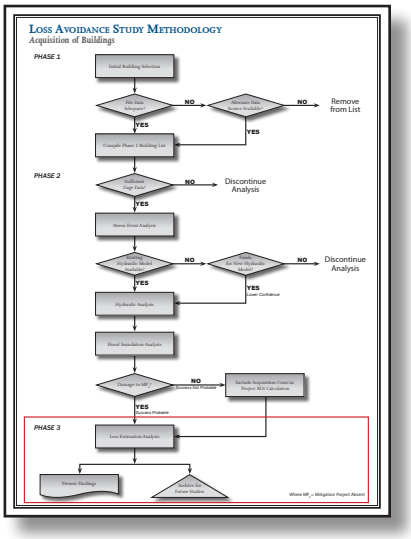
Table 4.2

Buildings Analyzed/Damaged

Community	Disaster and Project Number	Number of Buildings Analyzed	Number of Buildings Damaged
Arnold	995-0002	79	31 (Spring)
	FMA-PJ-07MO-1997002	1	1 (Spring)
	FMA-PJ-07MO-1998002	3	3 (Spring)
	FMA-PJ-07MO-1999001	6	2 (Spring)
La Grange	995-0027	11	11 (Summer)
Cape Girardeau	1054-0001	79	17 (Spring), 37 (Summer)
	1403-0004	2	2 (Spring), 1 (Summer)
St. Charles County	995-0001	467	403 (Summer)
Hannibal	995-0004	90	78 (Summer)
Winfield	995-0015	49	45 (Summer)
Piedmont	995-0045	15	15 (Spring)
	1006-0007	19	16 (Spring)
	1023-0005	2	2 (Spring)
	1054-0008	10	10 (Spring)
	1403-0008	10	10 (Spring)
	FMA-PJ-07MO-1997003	10	10 (Spring)
	FMA-PJ-07MO-1998003	6	6 (Spring)
Marble Hill	1403-0011	26	0 (Spring)

Section Five:

Phase 3 — Loss Estimation Analysis



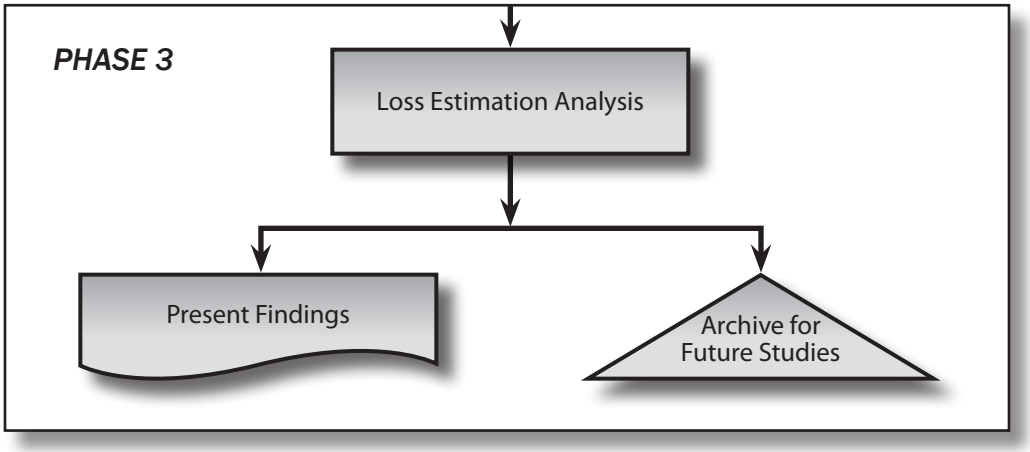
The final phase of a loss avoidance study consists of estimating the losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. This section provides a synopsis of Phase 3, the Loss Estimation Analysis, for an acquisition project. The methodology is illustrated in Figure 5.1.

There are two major tasks in Phase 3:

- Calculating Losses Avoided
- Calculating the ROI

The approach used to estimate flood damages is based on the FEMA Benefit-Cost Analysis (BCA) Version 4 software (FEMA, 2008a) and technical guidance unless stated otherwise. *What Is a Benefit?* (FEMA, 2001) also provides a basis for calculating losses. The values in the 2001 publication have been updated since 2001, but the referenced methodology is still current.

Figure 5.1



5.1 Calculating Losses Avoided

For Phase 3, the dollar value estimate of the damage that would have occurred had the mitigation project not been completed (MP_A) and the damages that did occur after demolition (MP_C) must be determined.

In Phases 1 and 2 of an acquisition study, the following information is determined:

- The MP_C storm/flow events that would have caused damages in the MP_A scenario

- The number and type of buildings affected by the storm events being analyzed in the MP_A scenario
- The flood depth at each building in the MP_A scenario, estimated from the Flood Inundation Analysis

The losses (damages) are calculated for the MP_A scenario using the flood depth at each building for MP_C storm/flow events. Losses avoided (in dollars) are then calculated by subtracting MP_C damages from the MP_A damages, per the formula presented in Figure 5.2. However, for acquisition projects, there are no MP_C damages because the building no longer exists. Therefore, losses avoided are equal to MP_A damages.

When losses are calculated, all of the losses should be presented as present-day values.[1] Therefore, if historical losses from similar events are used as estimates, they should be adjusted to present-day values.

Figure 5.2

Loss Estimation Analysis

$$MP_A - MP_C = LA$$

Where MP_A = Mitigation Project Absent
Where MP_C = Mitigation Project Completed
Where **LA** = Losses Avoided

5.1.1 Loss Categories

Once the Flood Inundation Analysis is complete and potentially affected buildings have been identified, flood damages must be evaluated. As shown in Table 5.1, potential damages are divided into loss categories. Loss categories generally include physical damage, loss of function, and emergency management costs, all of which

1 Present-day value is the current value of past, present, or future payments that are adjusted to a base period by a discount or inflation rate.

Table 5.1

Loss Estimation Categories and Types

Loss Types	Loss Category
Physical Damage	Buildings*
	Contents*
	Roads and Bridges
	Infrastructure
	Landscaping
	Environmental Impacts
	Vehicles/Equipment
Loss of Function	Displacement Expense*
	Loss of Rental Income*
	Loss of Business Income*
	Lost Wages*
	Disruption Time for Residents*
	Loss of Public Services*
	Economic Impact of Utility Loss
	Economic Impact of Road/Bridge Closure
Emergency Management	Debris Cleanup
	Governmental Expense

Source: FEMA, 2007
* Loss Types that apply to building acquisition projects.

contain multiple loss types. The calculation of the losses avoided for building modification projects, such as acquisition projects, differs from flood-control projects in that only the loss types that apply to buildings can be used in calculating losses.

Physical Damages

For an acquisition study, physical damage is limited to the direct damage to the building and its contents. Physical damages can be estimated using either:

- FEMA BCA Version 4 depth-damage functions
- Historical damages from events of similar size

When available, actual repair costs (or replacement costs if the building was substantially damaged) should be used to estimate losses, if similar flood events have occurred in the past. Historical damage data may be obtained from various sources such as homeowner insurance claims, flood insurance claims, the NFIP BureauNet database, Small Business Administration load application databases, local contractors, and homeowner interviews. The BCA that was performed for the funding application of the mitigation project may also contain historical damage data. Additionally, for

Physical Damage Data Sources

- Depth-damage curves obtained from HAZUS-MH or USACE
- Insurance information
- HMGP or FMA project files and BCAs
- Public Assistance program Project Worksheets
- Historical flood damage information

events in which there was a disaster declaration, FEMA may have provided grant funds under the PA Program for repairs to buildings owned by public entities and certain private non-profit organizations. Damage and repair information may be obtained from Damage Survey Reports or Project Worksheets (PWs) that FEMA prepared to document eligible costs under the PA Program. If this information is not available, the losses must be estimated.

Standardized damage curves relating depth of flooding to building and contents damage (calculated as a percentage of the BRV) are available from FEMA and the USACE.

Loss of Function

For an acquisition study, loss-of-function damages are the economic impacts to an individual or the community that occur because of the physical damage to the building. Loss-of-function damages can vary extensively depending on the type of building. For example, loss-of-function costs associated with damage to a residence could be costs associated with moving to and renting another residence while flooding subsides and repairs occur. Loss-of-function costs associated with damages to a business could be lost business, temporary relocation to another building, and lost wages for employees. Loss-of-function costs resulting from damages to public buildings could be the loss of critical public services, such as police and fire departments.

Loss of Function Required Data

- Factors used in HAZUS-MH for loss of function calculations
- FEMA BCA loss of function calculations
- Individual Assistance program documentation
- Public Assistance program Project Worksheets
- Net income from business owners
- Annual operation budget from local agencies
- Population served by critical facilities and distance to next available facility
- Historical flood damage information

For acquisition studies, loss of function includes displacement expense, loss of rental income, loss of business income, lost wages, disruption time for residents, and loss of public service.

Loss-of-function costs are based on the amount of time a building is not functional after a flood because of the amount of destruction to the building and the value of the particular function. The amount of time a building cannot be used in its normal capacity increases with the severity of damage to the building.

As with physical depth-damage relationships, published relationships between flood depth and loss-of-function time can be used to calculate these costs. For example, the FEMA BCA Version 4 software contains methodologies and values that can be used to calculate loss of function. The *HAZUS-MH Technical Manual* (FEMA, 2006) contains methods similar to the FEMA BCA Version 4 software, with regional adjustments to various loss-of-function methods. Additionally, USACE publications on post-disaster impacts from flooding contain information about loss of function from specific locations.

Communities may also provide costs from past events that demonstrate the impact of the events. In these cases, local values provide a more accurate representation of a project area than the national or regional values from tools such as the FEMA BCA Version 4 software or HAZUS-MH.

Emergency Management Costs

Emergency management costs are costs related to response and recovery activities conducted by Federal, State, and local, government agencies as a result of a hazard event. For example, the community experiences costs for ensuring public safety. It is important to note that emergency management costs should be considered only for a loss avoidance study when a large group of adjacent buildings is acquired. The costs are obtained primarily from historical damage records, such as PWs prepared by FEMA during declared disaster events under the PA Program. If actual costs from previous events are known, they should be used. If FEMA previously provided PA Program funds for emergency work, PWs prepared to document emergency work costs may provide relevant information. The following steps can be used to calculate the impacts of other emergency response measures:

- Local representatives can be interviewed to identify the types of services required and the level of effort required in delivering those services.
- The duration of the flood and the appropriate salary categories can be used to estimate the costs for first responders.
- The estimated flood recovery time and the appropriate salary categories can be used to estimate the impact to other municipal employees. The impact may include cleanup and costs associated with implementing repairs.

If acquiring a large number of buildings in one area significantly reduces the emergency management costs, the benefits of reduced emergency management costs should be counted.

Emergency Management Data Sources

- Public Assistance program Project Worksheets for emergency work
- Interviews with local public safety officials
- Historical flood damage information

5.1.2 Missouri Study: Calculating Losses Avoided

The methodology described above was used to calculate MP_A damages for all communities in this study. As explained previously, no MP_C damages exist because all buildings were demolished. Physical damages were limited to building and contents damage and were estimated based on the flood depths above FFE, calculated during the Flood Inundation Analysis (see Section 4.3.4). Physical damage to buildings and their contents resulted in displacement

and disruption time for the residents. Because all buildings acquired were residential, loss of business income, lost wages, and loss of public service damages were not calculated.

FEMA BCA Version 4 software guidance for displacement time was used to estimate the repair time in days for each building. Displacement cost was estimated based on the repair time and the default values of a $500 one-time displacement costs and $1.44/square foot/month rental costs.

For disruption, FEMA BCA Version 4 software guidance provides a national average wage of $28.11 per hour per person. The time of disruption was calculated using the estimate that each adult occupant is disrupted 40 hours plus 8 hours for every 1% in building damage (FEMA, 2006). Assuming a conservative estimate of two adults per building, these standards were used to calculate the disruption time for residents.

Emergency management costs are not expected to change and therefore are generally not included in loss avoidance studies for acquisition projects. Acquisition of a single residential building, small groups of buildings, or groups in scattered locations is unlikely to reduce a community's emergency management costs because the area affected by a disaster is not decreased and the total population affected by disaster is not substantially decreased (FEMA, 2001). Therefore, emergency management costs should be considered only when a large group of adjacent buildings is acquired.

The acquired buildings in all of the studied eastern Missouri communities were scattered over a large area. Emergency management costs were therefore not estimated for this study.

5.1.2.1 Missouri Study: Physical Damages

The methodology described above was used to calculate MP_A damages for all communities in this study. As explained previously, no MP_C damages exist because all buildings were demolished. Physical damages were limited to building and contents damage and were estimated based on the flood depths above FFE, calculated during the Flood Inundation Analysis (see Section 4.3.4). Depth-damage curves from FEMA's BCA Version 4 software were used (see Appendix B).

Project files contained information on most of the building characteristics, such as type, number of stories, foundation type, finished or unfinished basement, and garages. Where necessary, values were estimated for single-family homes based on the American Housing Survey for the St. Louis metropolitan area (HUD,

2005 and 2007). For more information, see Section 6.1.2. Table 5.2 presents a breakdown of each community by building type.

The BRV for each building was based on Marshall & Swift (2008), which takes into account information specific to the living space, basement, and garage to estimate a cost per square foot to replace the building.

The USACE generic building damage curves and the Federal Insurance Administration mobile home damage curves (FEMA, 2008a), were used to calculate damages to the building and contents for single-family homes and mobile homes, respectively. Since present-day BRVs were estimated, and damages are a function of the BRV, it was not necessary to inflate the damage estimates to 2008 dollars. Based on methodology established in the FEMA BCA Version 4 software and the damage curves, the content values were estimated to be 100% of the BRV for single-family homes and 50% of the BRV for mobile homes.

5.1.2.2 Missouri Study: Loss of Function

Physical damage to buildings and their contents resulted in displacement and disruption time for the residents. Because all buildings acquired were residential, loss of business income, lost wages, and loss of public service damages were not calculated.

FEMA BCA Version 4 software guidance for displacement time was used to estimate the repair time in days for each building. Displacement cost was estimated based on the repair time and the default values of a $500 one-time displacement costs and $1.44/square foot/month rental costs.

For disruption, FEMA BCA Version 4 software guidance provides a national average wage of $28.11 per hour per person. The time of disruption was calculated using the estimate that each adult occupant is disrupted 40 hours plus 8 hours for every 1% in building damage (FEMA, 2006). Assuming a conservative estimate of two adults per building, these standards were used to calculate the disruption time for residents.

5.1.2.3 Missouri Study: Total Losses avoided

After calculating the losses avoided for each building for the spring and summer 2008 events, the cumulative amount of losses avoided for each structure were calculated for both the MP_A and MP_C scenarios. The total losses in the MP_C scenario were then subtracted from the total losses in the MP_A scenario for each building to

determine the total losses avoided. However, as previously noted, no losses were calculated for the MP_C scenario because the buildings no longer existed. As shown in Table 5.3, the total losses avoided for communities were valued at $93,626,111.

Appendices C through J provide detailed tables of damages by building in each project.

5.2 Calculating Return on Investment

Calculating the ROI is the final task in determining losses avoided. The results vary depending on the number of events evaluated for each building and the resulting level of damage. Figure 5.3 provides an illustration of the formula used in calculating ROI.

The denominator, Project Investment (PI), is the total project investment for the project being evaluated, or in the case of acquisition projects, the fair market cost to acquire and demolish the building and restore the property. Project investment does not represent the Federal investment alone. Rather, it is the total investment for the project made by all parties involved. The investment total must be representative of the acquisition costs. Also, all of the losses avoided are calculated in present-day values; therefore, the actual costs to acquire each building should also be adjusted to present-day values.

The numerator, Losses Avoided (LA), represents the total losses avoided for the mitigation project being evaluated. The ROI may be calculated for one or many MP_C flood events. If a storm event did

Figure 5.3

Return on Mitigation Investment

$$\frac{\$\ LA}{\$\ PI} = \%ROI$$

Where **LA** = Losses Avoided
Where **PI** = Project Investment
Where **ROI** = Return on Investment

not occur that was large enough to have caused damage in the MP_A scenario, the losses avoided are zero. If multiple events are being evaluated for each mitigation project, then the LA would represent the total losses avoided for all the flood events. Therefore, the ROI would represent the cumulative ROI.

An ROI can be calculated for each individual building, for a mitigation project (which could include multiple buildings), by storm event, or for the whole study area (which could include multiple projects). If an ROI is calculated for multiple buildings, taking an average of the ROI for each building is not appropriate. The total losses avoided for all of the buildings should be added together and divided by the total construction costs. This is referred to as aggregation.

5.2.1 Missouri Study: Calculating ROI

Appendices C through J contain a comparison of the losses avoided and the original project investment for each building. The actual project investment may have come from several sources. The amounts shown in Table 5.2 reflect the combined investment from all sources, inflated to current day values.

For the projects in the study, ROI ranged from 0 to 600%. Although not all projects in the study had an ROI greater than 100%, the ROI reflects only the losses avoided for the spring and summer 2008 events for each project and will increase as additional storm events occur. The total losses for the spring 2008 event were $15,152,736 with an ROI of 34%, while the total losses for the summer 2008 event were $78,483,375 with an ROI of 178%.

The ROI is influenced by data quality, storm severity, and the relative costs of properties. The use of an above-ground offset versus an FFE in conjunction with sparse topographic information was the most significant contributor to differences in ROI. However, in general, communities with a more severe event (lower recurrence interval) yielded higher ROIs. The relative costs of properties also have a major impact on the ROI. In addition, some communities such as Arnold had a large number of vacant lots (or empty mobile home pad) purchases, which do not include losses avoided but increase the project investment. Similarly, the communities in St. Charles County and Marble Hill included properties that did not experience flooding in 2008 that would have caused damages in the MP_A scenario. Therefore, there were no losses avoided for those buildings, but the acquisition and demolition costs are included in the ROI calculation. All these factors influence the final ROI.

Table 5.3 shows that the aggregate ROI for all eight communities in the eastern Missouri study was 212%, using the combined losses avoided of $96,636,111 and a combined project investment of $44,153,436. The ROI reflects only the losses avoided for the spring and summer 2008 events for each project and will increase as additional storm events occur.

Table 5.2

Loss Estimation Analysis Results

Analysis Information			Results by Loss Categories								Total Losses Avoided
			MP_A Scenario Damages				MP_C Scenario Damages				
			Physical Damage		Loss of Function		Physical Damage		Loss of Function		
Community	Disaster, Project Number, and Event	Number of Buildings Included in Analysis	Building Damage	Contents Damage	Displacement Costs	Disruption Costs	Building Damage	Contents Damage	Displacement Costs	Disruption Costs	
Arnold	995-0002 (spring)	79	$3,175,228	$1,230,240	$724,396	$880,433	$0	$0	$0	$0	$6,010,297
	FMA-PJ-07MO-1997002 (spring)	1	$48,198	$26,934	$6,910	$12,205	$0	$0	$0	$0	$94,246
	FMA-PJ-07MO-1998002 (spring)	3	$48,890	$29,378	$2,411	$15,752	$0	$0	$0	$0	$96,430
	FMA-PJ-07MO-1999001 (spring)	6	$25,506	$18,603	$0	$10,171	$0	$0	$0	$0	$54,280
La Grange	995-0027 (summer)	11	$481,105	$211,538	$124,431	$447,950	$0	$0	$0	$0	$1,265,024
Cape Girardeau	1054-0001 (spring)	79	$380,568	$238,370	$34,488	$190,280	$0	$0	$0	$0	$843,706
	1054-0002 (summer)	79	$871,864	$473,788	$131,176	$453,816	$0	$0	$0	$0	$1,930,644
	1403-0004 (spring)	2	$0	$0	$0	$0	$0	$0	$0	$0	$0
	1403-0005 (summer)	2	$1,036	$994	$0	$2,832	$0	$0	$0	$0	$4,863
St. Charles County	995-0001 (summer)	467	$27,669,023	$13,143,136	$6,028,505	$8,911,969	$0	$0	$0	$0	$55,752,634
City of St. Charles	995-0017 (summer)	9	$0	$0	$0	$0	$0	$0	$0	$0	$0
Hannibal	995-0004 (summer)	90	$6,704,530	$2,707,484	$1,677,624	$2,224,599	$0	$0	$0	$0	$13,314,236
Winfield	995-0015 (summer)	49	$2,964,386	$1,275,161	$638,307	$1,338,120	$0	$0	$0	$0	$6,215,974
Piedmont	995-0045 (spring)	15	$796,451	$314,055	$175,955	$600,524	$0	$0	$0	$0	$1,886,986
	995-0007 (spring)	19	$791,186	$347,461	$191,006	$487,771	$0	$0	$0	$0	$1,817,425
	1203-0005 (spring)	2	$190,473	$74,234	$42,612	$64,007	$0	$0	$0	$0	$371,325
	1054-0008 (spring)	10	$474,636	$211,914	$107,885	$245,035	$0	$0	$0	$0	$1,039,470
	1403-0008 (spring)	10	$195,866	$113,477	$33,684	$138,653	$0	$0	$0	$0	$481,680
	FMA-PJ-07MO-1997003 (spring)	10	$834,854	$299,017	$185,758	$420,962	$0	$0	$0	$0	$1,740,591
	FMA-PJ-07MO-1998003 (spring)	6	$320,542	$128,019	$74,559	$193,182	$0	$0	$0	$0	$716,302
Marble Hill	1403-0011 (spring)	26	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Total	$45,974,342	$20,843,802	$10,179,708	$16,638,259	**$0**	**$0**	**$0**	**$0**	$93,636,111

Table 5.3

AGGREGATE RETURN ON MITIGATION INVESTMENT

Analysis Information			Results by Loss Category				Total Losses Avoided	Project Investment	Project ROI	Community ROI
Community	Disaster, Project Number, and Event	Number of Buildings Included in Analysis	Building Damage	Contents Damage	Displacement Cost	Disruption Cost				
Arnold	995-0002 (spring)	79	$3,175,228	$2,876,203	$724,396	$880,433	$6,010,297	$7,054,582	85%	77%
	FMA-PJ-07MO-1997002 (spring)	1	$48,198	$26,934	$6,910	$12,205	$94,246	$104,435	90%	
	FMA-PJ-07MO-1998002 (spring)	3	$48,890	$29,378	$2,411	$15,752	$96,430	$328,901	29%	
	FMA-PJ-07MO-1999001 (spring)	6	$25,506	$18,603	$0	$10,171	$54,280	$675,865	8%	
La Grange	995-0027 (summer)	11	$481,105	$296,942	$124,431	$447,950	$1,265,024	$243,811	519%	519%
Cape Girardeau	1054-0001 (spring)	79	$380,568	$238,370	$34,488	$190,280	$843,706	$2,803,431	30%	49%
	1054-0001 (summer)	79	$871,864	$547,830	$131,176	$453,816	$1,930,644	$2,803,431	69%	
	1403-0004 (spring)	2	$0	$0	$0	$0	$0	$60,629	0%	
	1403-0004 (summer)	2	$1,036	$994	$0	$2,832	$4,863	$60,629	8%	
St. Charles County	995-0001 (summer)	467	$27,669,023	$19,899,004	$6,028,505	$8,911,969	$55,752,634	$22,572,245	247%	247%
City of St. Charles	995-0027 (summer)	9	$0	$0	$0	$0	$0	$423,247	0%	
Hannibal	995-0004 (summer)	90	$6,704,530	$5,898,533	$1,677,624	$2,224,599	$13,314,236	$2,220,253	600%	600%
Winfield	995-0015 (summer)	49	$2,964,386	$2,349,148	$638,307	$1,338,120	$6,215,974	$1,387,803	448%	448%
Piedmont	995-0045 (spring)	15	$796,451	$608,444	$175,955	$600,524	$1,886,986	$387,547	487%	304%
	1006-0007 (spring)	19	$791,186	$577,325	$191,006	$487,771	$1,817,425	$724,121	251%	
	1023-0005 (spring)	2	$190,473	$155,464	$42,612	$64,007	$371,325	$47,708	778%	
	1054-0008 (spring)	10	$474,636	$356,478	$107,885	$245,035	$1,039,470	$446,518	233%	
	1403-0008 (spring)	10	$195,866	$113,477	$33,684	$138,653	$481,680	$490,375	98%	
	FMA-PJ-07MO-1997003 (spring)	10	$834,854	$739,297	$185,758	$420,962	$1,740,591	$365,773	476%	
	FMA-PJ-07MO-1998003 (spring)	6	$320,542	$266,868	$74,559	$193,182	$716,302	$189,425	378%	
Marble Hill	1403-0011 (spring)	26	$0	$0	$0	$0	$0	$762,707	0%	0%
		TOTAL	$45,974,342	$34,999,291	$10,179,708	$16,638,259	$93,636,111	$44,153,436		212%

Section Six:

Considerations and Recommended Practices

This section is a summary of the special considerations and recommended practices that have resulted from of the study. The information is provided so that it can be used in future loss avoidance studies. The information is divided into data collection and availability and analysis methodology.

6.1 Data Collection and Availability

Multiple types of data are collected throughout a loss avoidance study. The availability and quality of the data can affect the accuracy of the study significantly. The following sections describe the data-related challenges that were encountered in the eastern Missouri study and the recommendations for data collection in future loss avoidance studies.

6.1.1 First Floor Elevations

Obtaining surveyed FFEs, ideally in the form of FEMA elevation certificates, is always a challenge for a loss avoidance study, especially when analyzing acquisition projects in which the buildings have not been in existence for many years. In this study, when FFEs were not available, detailed topographic data were collected and a standard HAZUS-MH offset of feet above ground was used depending on the building's foundation type (see Table 3.2). This method made it possible to analyze each building so that no properties had to be removed because of lack of FFE data. However, the lack of accuracy in the topographic data may have greatly affected the results.

The recommendation for future studies when FFE data are not readily available is to exhaust all options before using theoretical data. This approach should be used only as a last resort and if the study sponsor accepts the approach.

A trained structural engineer or surveyor can estimate the FFE (in feet above grade) visually from a photograph by counting the number of steps or concrete blocks used for the building's foundation. A moderate level margin of error exists, and this method would be time-consuming in projects with a large number of buildings.

Following a flood-related disaster, FEMA often tasks USACE with recording HWMs, which can be digitized in GIS to create a flood surface. The National Emergency Management Information

System (NEMIS) stores water depth inside buildings as part of the information that is used to record and assess FEMA's Individual Assistance program applications following a federally declared disaster. Once the location of a building is found on the NEMIS and HWM list, the FFE for a specific building can be reconstructed by deducting the water depth inside the building from the HWM elevation for that property. This method can be implemented quickly because all calculations are completed within the GIS environment.

6.1.2 Building Data

As part of Phase 3, some building data had to be estimated because an appraisal was not available and the project file did not contain detailed information. One Census Bureau data source not used in past studies was the American Housing Survey (HUD, 2005 and 2007), which covers different metropolitan areas. The surveys are conducted in major metropolitan areas in the United States every 5 to 10 years and collect more detailed housing characteristic data than other census surveys. For the eastern Missouri study, the 2004 and 1996 surveys of the St. Louis metropolitan area provided statistical data for single-family homes as a supplement when actual data were not available. The statistical analysis can be done in several ways. The survey data provide information on many characteristics for the total number of buildings in the survey. A measure of central tendency, such as the mean or median, can be determined and used for all buildings with unknown characteristic. Measures of factor distribution (e.g., standard deviations, maximums, minimums) or quartiles can also be used to generate characteristic values to approximate the distribution of the unknown characteristics.

Table 6.1

Statistical Building Foundation Type Percentages

Foundation Type	Single-Family Home
Basement	85%
Crawl	7.20%
Slab	7.80%

Source: American Housing Survey Table 1-2, Height and Condition of Building and Table 1-1, Introductory Characteristics

The foundation type of a building was a characteristic that affected the assumed above-ground offset, which was used in lieu of an FFE. Table 6.1 indicates the statistical distribution of buildings with each foundation type. For buildings with a basement foundation, it was assumed that 50% had finished basements and 50% had unfinished basements.

Number of stories, square footage of the building, and the building type are all characteristics that affected the depth-damage curve used in the analysis. According to guidance from HUD (2005 and 2007), it was assumed that 17% of the acquired single-family homes were one-story buildings and 83% had two or more stories. Tables 6.2 and 6.3 show the statistical distributions of building square footages and the presence of garages (used in square footage calculations).

Table 6.2

Statistical Building Square Footage Quartiles

Quartile	Single-Family Home (sq ft)
0%	600
25%	1,365
50%	2,012
75%	2,924
100%	4,600

Source: American Housing Survey Table 2-24, Units in Structure by Selected Characteristics

For the eastern Missouri study, if the statistical approach showed that a single-family home had a basement, 800 square feet was the assumed basement area. The statistical approach was used to determine whether a single-family home had a garage and whether the garage was attached or detached and one- or two-car. To calculate the garage area, 400 square feet per car was assumed.

The recommendation for future studies is to use a statistical approach as described above when insufficient actual data exist. Actual data may be available in tax assessor information from the demolished buildings. The theoretical approach should be used only as a last resort. If statistical data are needed, American Housing Surveys may provide more detailed data than nationwide or regional sources.

Table 6.3

Statistical Percentages of Buildings With or Without garages

Garage	Single-Family Home
With	63.8%
Without	36.2%

Source: American Housing Survey Table 1-6, Housing and Neighborhood Quality

6.2 Analysis Methodology

All analysis methods used for the eastern Missouri study have been used in previous loss avoidance studies with the exception of USACE flood profile data.

6.2.1 Use of Flood Profile Data

Past loss avoidance studies were conducted primarily for communities with flooding sources smaller and less complex than the Mississippi River. In the eastern Missouri study, five communities were affected by flooding from the Mississippi River, which is managed by USACE through a series of locks and dams in Missouri. USACE provides detailed flood profile data that reflect the locks and dams and are more recent and comprehensive than FEMA FISs for individual communities.

The recommendation for future studies involving large flooding sources is to first gather any available hydraulic modeling information that is more recent and up-to-date than a FEMA FIS. Where more recent modeling is not available, USACE data can be used as a supplement or replacement for a FEMA FIS.

Acronyms:

BCA
Benefit-Cost Analysis

BRV
building replacement value

DEM
Digital Elevation Model

FEMA
Department of Homeland Security's Federal Emergency Management Agency

FFE
first floor elevation

FIS
Flood Insurance Study

FMA
Flood Mitigation Assistance

GIS
Geographic Information System

HAZUS-MH
Hazards U.S.–Multihazard

HMA
Hazard Mitigation Assistance

HMGP
Hazard Mitigation Grant Program

HWM
high water mark

LA
Losses Avoided

LAS
loss avoidance study

MO
Missouri

MSEMA
Missouri State Emergency Management Agency

MPA
Mitigation Project Absent

MPC
Mitigation Project Complete

NEMIS
National Emergency Management Information System

NFIP
National Flood Insurance Program

PA
Public Assistance

PDM
Pre-Disaster Mitigation

RFC
Repetitive Flood Claims

PI
Project Investment

ROI
Return on Investment

SPRING AND SUMMER 2008 EVENTS
severe flood events that occurred in eastern Missouri during March 2008 and June and July 2008

SRL
Severe Repetitive Loss

STUDY
Loss Avoidance Study

TIN
Triangulated Irregular Network

USACE
U.S. Army Corps of Engineers

USGS
U.S. Geological Survey

WSE
water surface elevation

References:

R.1 FEMA Published Studies

Federal Emergency Management Agency (FEMA). 2007a. Loss Avoidance Study: Southern California Flood Control Mitigation. Part One: General Overview. HMTAP Task Order 393.

Federal Emergency Management Agency (FEMA). 2007b. Loss Avoidance Study: Southern California Flood Control Mitigation. Part Two: Detailed Methodology. HMTAP Task Order 393.

Federal Emergency Management Agency (FEMA). 2008b. Northern California Loss Avoidance Study: Structural Flood Control Mitigation Projects in Northern California. Contract No. HSFEHQ-06-D-0162, Task Order 63.

Federal Emergency Management Agency (FEMA). 2008c. Loss Avoidance Study: Sonoma County, California Elevated Structures. Contract No. HSFEHQ-06-D-0162, Task Order 63.

R.2 Technical Manuals and Software

Federal Emergency Management Agency (FEMA). 2001. What Is a Benefit? Guidance on Benefit-Cost Analysis of Hazard Mitigation Projects. Draft. Revision 2

Federal Emergency Management Agency (FEMA). 2006. HAZUS-MH MR3 Technical Manual.

Federal Emergency Management Agency (FEMA). 2008a. Benefit-Cost Analysis software, Version 4.

R.3 USACE Guidance

U.S. Army Corps of Engineers. 2004. Upper Mississippi River System Flow Frequency Study: Final Report.

U.S. Army Corps of Engineers.2008. Flood Frequency Query: Upper Mississippi River. http://www2.mvr.usace.army.mil/flow_freq/flow_freq.cfm (accessed September 2008).

R.4 Other

Federal Emergency Management Agency (FEMA). 2002. Success Stories from the Missouri Buyout Program. Kansas City, Missouri: FEMA Region VII.

Marshall & Swift. 2008. Residential Cost Handbook.. September.

U.S. Department of Housing and Urban Development. 2005. American Housing Survey for the St. Louis Metropolitan Area: 2004.

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R.5 General Resources

FEMA Flood Insurance Studies
http://msc.fema.gov

Environmental Systems Research Institute StreetMap 2008
http://www.esri.com/data/streetmap/index.html

GoogleMaps
http://maps.google.com

National Weather Service Advanced Hydrologic Prediction Service
http://www.weather.gov/ahps/

USGS Stream Gage Data
http://waterdata.usgs.gov/nwis