Loss Avoidance Study

Wisconsin, Property Acquisition and Structure Demolition

September 2009

FEMA

Federal Emergency Management Agency
U.S. Department of Homeland Security
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U.S. DEPARTMENT OF HOMELAND SECURITY

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Executive Summary:

Every year, Federal, State, and local agencies, as well as private entities, contribute funding to mitigation projects that will reduce or eliminate the long-term risks posed to people, the built environment, and the economy by natural hazards. The Department of Homeland Security's Federal Emergency Management Agency (FEMA) awards mitigation grants on the basis of whether the proposed mitigation projects are cost-effective.

Tools that have been used by FEMA in the past for determining the effectiveness of a project are based on the analysis of a probabilistic hazard event, completed prior to project funding and prior to project construction. With such significant investment in mitigation being made, policy makers have taken great interest in the effectiveness of mitigation during actual hazard events. In response, FEMA developed methodology using a quantitative approach to assess the performance of mitigation projects based on actual post-construction hazard events.

Since 1982, every county in Wisconsin has experienced at least one flood event, and 19 counties have experienced more than 20 flood events each (Wisconsin Emergency Management, 2009). In response to the flooding, local governments in Kenosha, Jefferson, and Crawford counties, with Federal and State assistance, acquired a total of 92 repetitive-loss properties from 1989 to 2008 at a cost of approximately $11 million. FEMA partnered with the State of Wisconsin and used the quantitative approach to complete a loss avoidance study for the acquisition projects.

FEMA calculated the value of the losses that had been avoided by the implementation of the mitigation projects and compared the losses avoided with the acquisition costs. The aggregate losses avoided were valued at $14.5 million, and the aggregate project cost was valued at approximately $11 million (both values in 2009 dollars), resulting in a Return on Investment of 132%. The results of the study demonstrate the cost-effectiveness of the selected acquisitions.

This report provides detailed documentation of the methodology implemented during the Wisconsin study and can be used as guidance for the preparation of future loss avoidance studies specific to acquisition projects. Additionally, it describes considerations and recommended practices that were identified during the completion of the study.

Section One:

INTRODUCTION

Because of frequent flooding in Wisconsin, a number of flood mitigation projects, specifically acquisition/demolition and acquisition/relocation projects, have been implemented in recent years along the Rock, Fox, and Kickapoo rivers. To evaluate the mitigation projects for cost-effectiveness, FEMA partnered with the State of Wisconsin to conduct a loss avoidance study (LAS or study). The intent of the study was to compare the losses avoided in all floods since the implementation of the mitigation to the cost of the mitigation projects. This report contains the results of the study.

1.1 BACKGROUND

Mitigation is defined by the Department of Homeland Security's Federal Emergency Management Agency (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 projects that will reduce or eliminate risks from natural hazar through Hazard Mitigation Assistance grants, which include pos disaster grants under the Hazard Mitigation Grant Program (HMG and pre-disaster grants under the Pre-Disaster Mitigation Progr the Flood Mitigation Assistance Program, the Repetitive Flood Claims Program, and the Severe Repetitive Loss Program.

Mitigation refers to any sustained action taken to reduce or eliminate long-term risk from hazards and their effects

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 project. The methodology provides a way to assess the benefits of a mitigation project in terms of its actual performance. 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 LAS methodology used for this study is consistent with the methodology described in Loss Avoidance: Riverine Flood Methodology Report (FEMA, in press[b]).

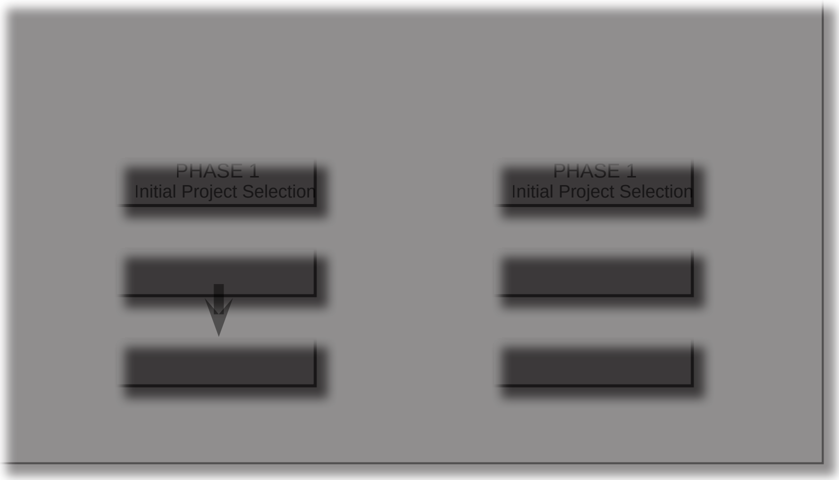
1.2 Purpose

The purposes of the Wisconsin study are to verify the effectiveness of the acquisition projects that were analyzed and to document their economic performance. The study is intended to answer the question, “How much damage could have been caused by a storm event if the acquisition projects had not been completed?” Further, the study provides comprehensive documentation of the losses avoided (damages avoided or project benefits) that were determined utilizing quantitative methods.

1.3 Methodology Overview

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 minor, localized flood reduction projects. Building modification projects mitigate damages by modifying a building to reduce its risk of flooding 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 reduction 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. This study is focused on the performance of acquisition projects.

Loss avoidance studies are divided into three phases (see **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.”



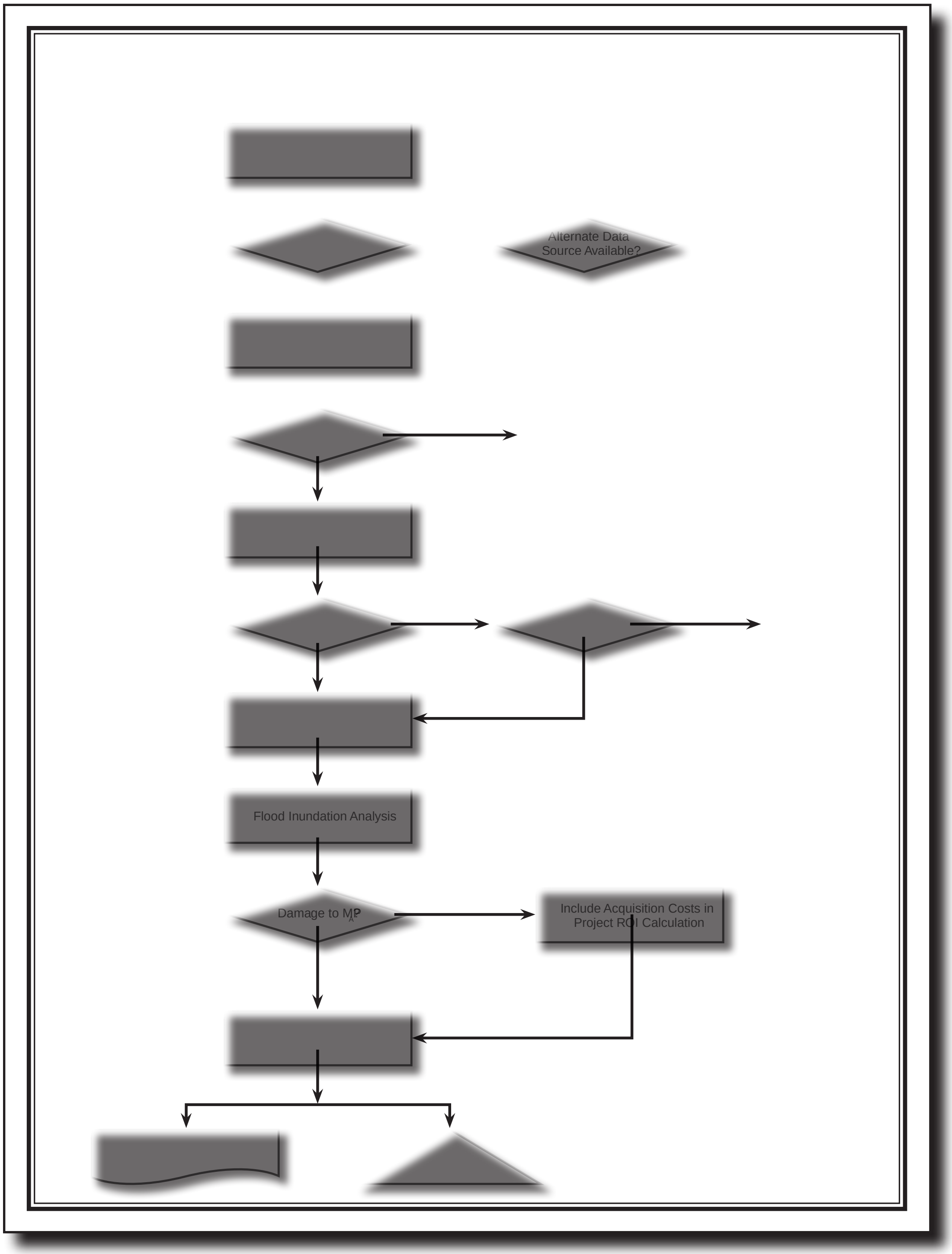
This study focuses on the acquisition/demolition, and acquisition/relocation of buildings in Wisconsin. No damage is calculated for the MP_C condition for acquisition projects because the buildings have been demolished or relocated.

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 any storm event occurred since the mitigation project was implemented that would have caused damages in the MP_A scenario. A Hydraulic Analysis is performed to determine the extent and depth of flooding in those events. 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 that 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 for acquisition projects, damages are calculated for the MP_A conditions. Because no damages would have occurred for the MP_C condition, the MP_A damages are equivalent to the losses avoided. The Return on Investment (ROI) is calculated by comparing the losses avoided to the project investment. The definition of ROI used in this study is not the same as a financial ROI, which is a measure of net profit, expressed relative to the dollars invested. For the LAS, an ROI of greater than 100 percent indicates that project benefits have exceeded project costs, and the project is considered cost-effective.

The LAS methodology for building acquisitions is shown in Figure1.2.


Alternate Data
Source Available?
Flood Inundation Analysis
Damage to MPA?
Include Acquisition Costs in
Project ROI Calculation

Section Two:

MITIGATION PROJECT INFORMATION

Because Wisconsin is highly susceptible to flooding, the State of Wisconsin has initiated a number of flood mitigation projects to reduce the need for costly emergency response and repairs. The mitigation projects include the acquisition, elevation, and relocation of flood-prone properties and have been funded by FEMA and other public agencies and by private sources.

This study is focused on 73 residential building acquisitions in Kenosha County, 18 residential building acquisitions in Jefferson County, a one public building acquisition and relocation in Crawford Count between 1989 and 2008. The acquisitions occurred in the cities Wheatland, Silver Lake, and Salem (Kenosha County); Fort Atkin (Jefferson County); and Gays Mills (Crawford County), which a affected by flooding from the Fox, Rock, and Kickapoo rivers.

The study consisted of residential building acquisitions in Kenosha and Jefferson counties and one public building acquisition in Crawford County.

2.1 HISTORY

The State of Wisconsin has long been vulnerable to severe storms, tornadoes, and flooding. Each year, flooding causes residents, businesses, and taxpayers millions of dollars in damage even though not every flood is severe enough to be declared a disaster. Since 1982, every county in Wisconsin has experienced at least one flood event, and 19 counties have experienced more than 20 flood events each (Wisconsin Emergency Management, 2009). Table 2.1 shows the number of major disaster declarations and emergency declarations that have occurred in Wisconsin in recent decades.

Table 2.1

WISCONSIN DISASTER HISTORY

DECLARATION TYPE	TIME PERIOD	DECLARATIONS
Major Disaster Declarations	1965 - 2008	32
Emergency Declarations	1976 - 2008	6

Source: FEMA, Wisconsin State Disaster History, 2009

Between 1990 and 2000, the two Wisconsin flood events that affected the most counties occurred in 1990 and 1993 (Wisconsin Emergency Management, 2004). The 1990 flood was accompanied by tornadoes and affected 17 counties across southern Wisconsin. Total damages exceeded $21 million (Wisconsin Emergency Management, 2004).

The Great Flood of 1993 was the result of two to three times the normal amount of rainfall across the entire state following a winter with greater than average snowfall. In the summer, every major river in Wisconsin flooded, and 20 dams were overtopped, broken, or washed away. Crop and soil damages, residential damages, and business losses totaled at least $877 million. More than half (46) of the state•s 72 counties were designated in the declaration (Wisconsin Historical Society, 2009).

The flooding in southern Wisconsin in June 2008 was the most costly natural disaster in the state•s recorded history (Wisconsin Emergency Management, 2009). Damages were estimated to exceed $1.5 billion (Fitzpatrick et al., 2008). The June 2008 floods were aggravated by saturated soils persisting from a combination of record-breaking snowfalls in the winter of 2007/2008 and heavy rains in spring 2008 (Fitzpatrick et al., 2008). Extensive flooding along the Baraboo, Kickapoo, Crawfish, and Rock rivers caused particularly severe damages in surrounding communities. The Governor of Wisconsin declared a state of emergency in 30 counties.

2.2 FUNDING AND TIMELINE

Although building acquisitions have been occurring since long before 1993, the Great Flood of 1993 was the impetus behind a collaborative effort between the State of Wisconsin and FEMA to increase the acquisition of flood-prone properties. As of July 2008, more than 300 properties in Wisconsin had been acquired to prevent future flood damages (FEMA, 2008b).

In 1994, Kenosha County officials developed the Fox River Flood Mitigation Program in an effort to help residents move out of the 100-year floodplain of the Illinois Fox River. As of August 2008, the program had won grants totaling approximately $7.4 million from sources including the HMGP, Wisconsin Emergency Management, Wisconsin Department of Natural Resources, and Community Development Block Grants from the Wisconsin Department of Commerce (FEMA, n.d.[b]). Approximately 75 buildings were acquired between 1995 and July 2008 (FEMA, n.d.[a]). In the first 10 years of the program, 56 buildings had been acquired, with FEMA contributing $2.5 million in HMGP and Flood Mitigation Assistance grants and $3 million from Community Development Block Grants sponsored by the Wisconsin Department of Commerce (FEMA, n.d.[c]).

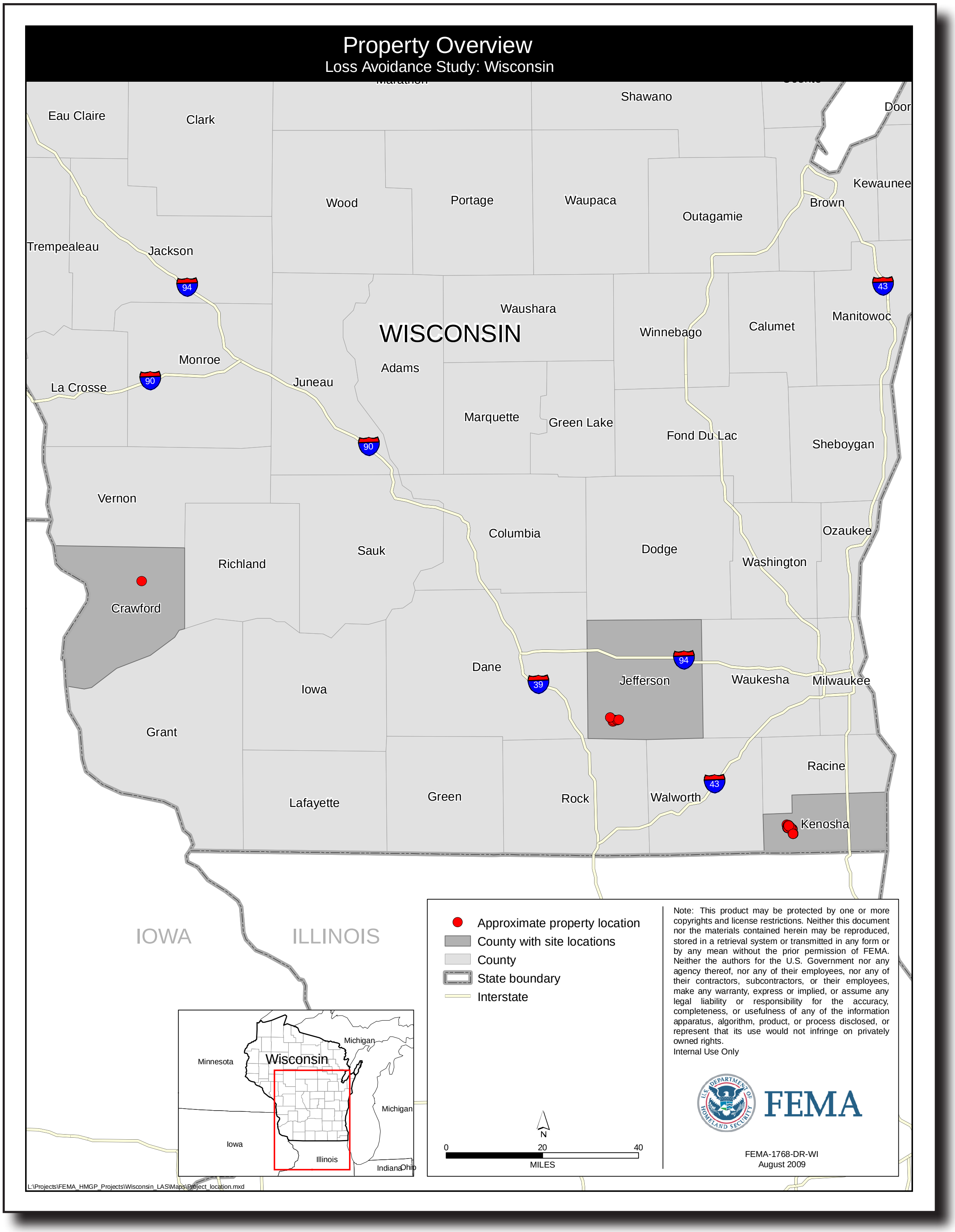
Jefferson County developed the Flood Mitigation Buyout Program, a voluntary program aimed at reducing the costs associated with damage caused by severe weather events. Since 1995, Jefferson County has acquired 35 buildings with the assistance of the HMGP. The HMGP requires a 75/25% cost split for each project. FEMA funds 75%, the State of Wisconsin funds 12.5%, and Jefferson County funds the remaining 12.5%. Jefferson County has used multiple sources of funding, including a Lake Protection Grant from the Wisconsin Department of Natural Resources and a Community Development Block Grant from the Wisconsin Department of Commerce (Wisconsin Emergency Management, n.d.[a]). Since 1995, the Federal portion has totaled more than $1.5 million (Wisconsin Emergency Management, n.d.[b]).

Crawford County has also initiated a number of flood mitigation projects, including floodproofing of buildings, acquisitions, and relocations. This study includes the acquisition and relocation of the Crawford County Highway Shop in the city of Gays Mills. The $2.7 million project involved acquiring, demolishing, and clearing the property and rebuilding out of the floodplain. FEMA funded 75% of the cost, and the State and County funded the remaining 25% (FEMA, n.d.[d]).

2.3 LOCATION

The locations of the 92 acquisition projects assessed in the study are shown in Figure 2.1. The breakdown of the acquisition projects by county are as follows: 73 in Kenosha County, 18 in Jefferson County, and 1 in Crawford County. The Kenosha County acquisitions were affected primarily by flooding from the Fox River, the Jefferson County acquisitions by the Rock River, and the Crawford Country acquisition by the Kickapoo River.

Figure 2.1



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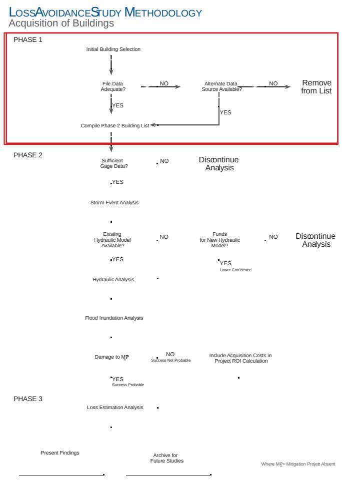
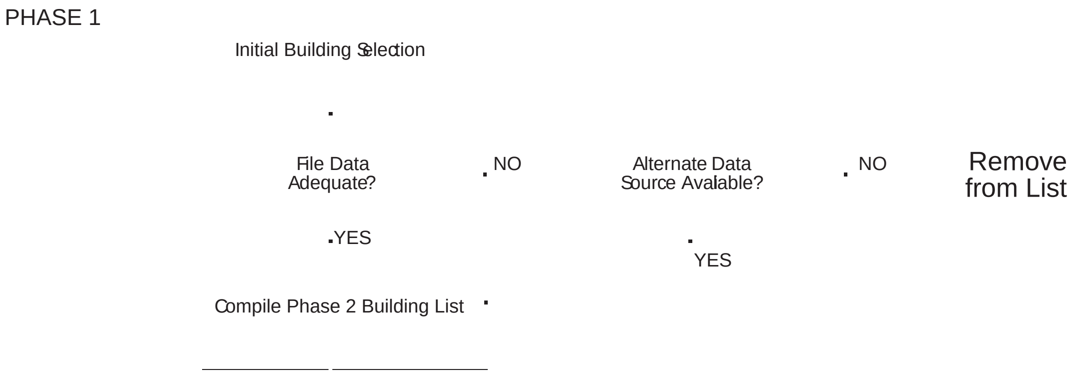
Section Three:

Phase 1 … Initial Project Selection and Screening



This section contains a discussion of Phase 1 (Initial P Selection) for an LAS (see Figure 3.1). In Phase 1, an initial candidate projects is selected, and data are collected for a of the projects. Buildings are analyzed and screened indivi within an acquisition project based on the availability of the that are required for Phase 1, and a list of buildings advanci 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 and coastal flood.
- Project Type: Many 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 reduction projects).

- 4UVEZ#BTFMJOF 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, assessor's costs, and any other costs associated with the project.
- 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.
- Building location information in the form of latitude/longitude data, address, and/or assessor parcel number.
- 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).

Data required for an acquisition project:

- Project cost
- Project completion date
- First floor elevation
- Building location information
- Building characteristics and replacement value

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. Because of the sensitivity of the damage calculations, even an error of 0.5 foot in the FFE can affect the damage calculations significantly. Surveyed FFEs are therefore preferred.

3.2 Wisconsin Study: Phase 1 Summary

FEMA and the Wisconsin State Emergency Management Agency initiated the Wisconsin LAS. The two agencies worked together to develop a project list for the study based on the following criteria:

- **Area of Interest:** Projects located in Kenosha, Jefferson and Crawford counties.
- **Hazard Type:** Riverine flooding.
- **Project Type:** Residential building acquisition in Kenosha and Jefferson counties; public building acquisition in Crawford County.
- **Study Baseline:** Acquisitions were completed between November 11, 1989, and June 27, 2008.

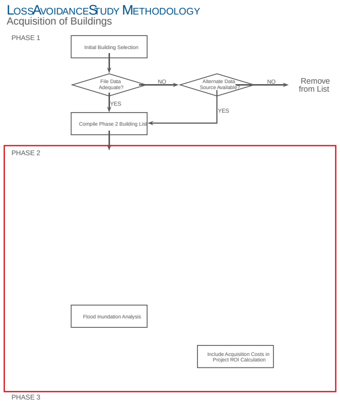
Acquisitions were completed between November 11, 1989, and June 27, 2008.

The data collection efforts for the study included:

- **Project Cost Data:** Project cost data were provided by the counties for each building. The total acquisition cost for each building was inflated to 2009 dollars.
- **Building Location Data:** Building location data can be difficult to obtain for acquisition projects because the buildings no longer exist. In this study, although the buildings had been demolished up to 20 years earlier, building address, latitude, and longitude data were available and provided by the Counties. Building locations were plotted using latitude and longitude Geographic Information System (GIS) data and then verified using a web mapping service. Buildings that did not have matching latitude/longitude and address data were replotted using geocoding technology, namely Batch Geocode (www.batchgeocode.com) and Geocode US (www.geocoder.us) in order to generate an accurate latitude and longitude. Forty-one building locations had matching latitude/longitude and address data or the latitudes generated by geocoding technology were within 0.001 decimal degrees of latitude and longitude provided by the Counties. Fifty building locations were determined using the Batch Geocode, and one location was determined using Geocode US.
- **Building Information:** Building information such as construction type, number of floors, square footage, FFE, BRV, and acquisition completion date was provided by the Counties.
- **Building Screening:** No buildings were removed from the analysis during Phase 1. All 92 buildings had sufficient data to proceed to Phase 2.

Section Four:

PHASE 2 – PHYSICAL PARAMETER ANALYSIS



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

Figure 4.1

- Storm Event Analysis: A Storm Event Analysis is conducted to identify potentially damaging events that occurred since the study baseline and assess data availability. Data include high water marks (HWMs) or stream/precipitation gage readings.
- 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, it may not be necessary to use hydraulic modeling software.

- Flood Inundation Analysis: The Flood Inundation Analysis is conducted to determine the depth of flooding that would have occurred during storm events since the study baseline at each building location in the MP_A scenario.

For a more information on the general methodology for Phase 2, see the Loss Avoidance: Riverine Flood Methodology Report (FEMA, 2009).

4.1 Storm Event Analysis

An LAS for any flood-related project is dependent on the occurrence of an MP_A storm event after the study baseline that is 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 which storm event data are available. Data for the Storm Event Analysis may be collected in the form of HWMs from floods, stream gage discharge data, stream gage stage data, or precipitation gage data. Figure 4.2 provides the usual order of preference for storm event data. If no HWMs were recorded, the availability of sufficient stream gage data should be determined because stream gage data are the next 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 (WSE), discharge (flow rate), or both.

When no stream gages are available, precipitation gages must be located. 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. If no storm event data are available, the buildings along that flooding source must be eliminated from evaluation. A list of peak events since the first building was demolished 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 Wisconsin Study: Storm Event Analysis

4.1.1.1 Fox River

The earliest demolition completion date for the buildings in Kenosha County was July 21, 1995. An analysis of flow and stage data for the U.S. Geological Survey (USGS) gage (ID# 05545750) for the Fox River

Figure 4.2

PHASE2 DATA SOURCE PREFERENCE

Flood Mitigation Projects

Preferred Source

High Water Marks

Stream Discharge Gage in Flooding Source

Stream Stage Gage in Flooding Source

Stream Discharge Gage in Same Watershed

Stream Discharge Gage in Watershed with Similar Characteristics, Affected by Same Storm Event, and in Close Proximity

Precipitation Gage in Same Watershed

Precipitation Gage in Watershed Affected by Same Storm Event and in Close Proximity

None

Inadequate Data

near New Munster, Wisconsin, was performed to determine when damaging storms could have occurred along the Fox River after July 1995. The data available for the USGS gage at New Munster include instantaneous discharge (generally available every 15 minutes), daily mean discharge, annual peak stream flow, and annual peak gage height. The National Weather Service (NWS) also reports the top 10 peak gage heights as well as flood impacts corresponding to increasing water levels at the gage near New Munster.

Historical flooding information that had been summarized from application materials (such as for the HMGP) was available for a number of the buildings. Generally, this information provided only the month and/or year of flooding or indicated that the building experienced flooding every year. However, the USGS gage data and NWS information for the Fox River provided sufficient information regarding the potentially damaging floods. Table 4.1 lists the available peak water levels on the Fox River near New Munster and the flood impacts estimated by the NWS.

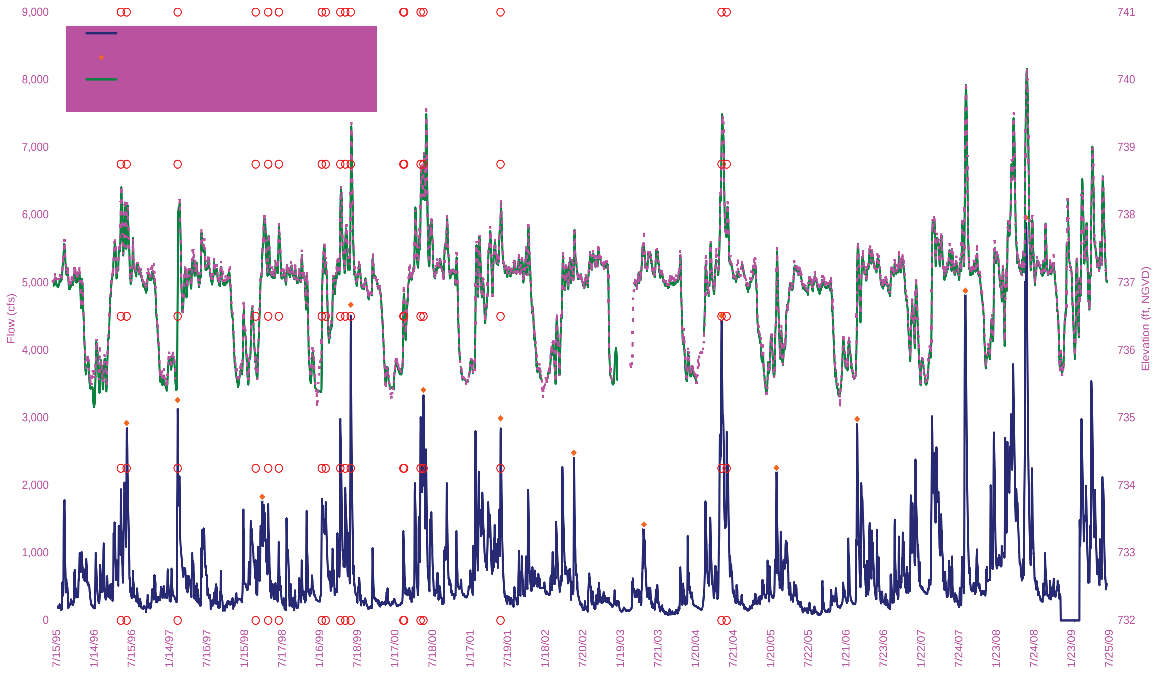
The daily and annual peak flow data and the dates of historical flooding are shown in Figure 4.3. A comparison of the peak flows and reported dates of historical flooding indicate that either the low

Table 4.1

PEAK WATER LEVELS AND CORRESPONDING FLOOD IMPACTS FOR THE FOX RIVER NEAR NEW MUNSTER, WISCONSIN

DATE[1]	REPORTED PEAK WATER LEVEL FOR FOX RIVER NEAR NEW MUNSTER (FEET, NGVD 29)[2]	FLOOD IMPACTS ESTIMATED BY THE NATIONAL WEATHER SERVICE

Figure 4.3



flows occurring frequently were causing flooding, which would not be logical, or the flooding was the result of one of the following:

- An incorrect month or year was reported in the application.
- Flooding was from overland flow rather than the Fox River.
- Backwater effects from downstream lake levels were leading to increased elevations in the Fox River upstream.

Additional analysis was performed to determine whether backwater effects were likely to be increasing the water level in the Fox River in the vicinity of the buildings near Silver Lake, Salem, and Wheatland. The Fox River flows into Grass Lake in Lake County, Illinois, approximately 9 miles downstream of the buildings in Silver Lake. Flow from Grass Lake continues to Nippersink and Fox lakes, then to Pistakee Lake before continuing farther downstream as Fox River.

The USGS reports mean daily lake levels (and instantaneous lake levels every 15 minutes for the past 60 days) for Nippersink Lake (ID# 05548000) and Fox Lake (ID# 05547500). The locations of the USGS gages are shown in Figure 4.4. The mean daily lake levels were also compared to the flow in Fox River near New Munster, as shown in Figure 4.3. The data were used in the Hydraulic Analysis

Figure 4.4