Mitigation Assessment Team Report

Midwest Floods of 2008 in Iowa and Wisconsin

Building Performance Observations, Recommendations, and Technical Guidance

FEMA P-765 / October 2009

FEMA

MITIGATION ASSESSMENT TEAM REPORT





MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

In response to the 2008 Midwest floods, the Federal Emergency Management Agency (FEMA) deployed a Mitigation Assessment Team (MAT) to evaluate and assess the damages caused by the riverine flooding in Iowa and southern Wisconsin. This report documents the MAT's observations, conclusions, and recommendations on the performance of buildings and other structures impacted by the flooding. The MAT included FEMA Headquarters and Regional Office staff, representatives from other federal agencies and academia, and experts from the design and construction industry.

The conclusions and recommendations in this report are intended to provide decision makers with information and technical guidance that can be used to reduce future flood damage.

Downtown Cedar Rapids, Iowa

MITIGATION ASSESSMENT TEAM REPORT

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FEMA P-765 / October 2009

INTERNATIONAL CODE COUNCIL

Institute for Business & Home Safety

FEMA

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MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

Executive Summary

In June 2008, much of the midwestern United States received over 12 inches of rainfall as several storm systems sequentially impacted the region. The Midwest had experienced wet conditions for several months prior to the precipitation experienced in June; therefore, the June rains fell upon saturated soils resulting in runoff that directly flowed into streams. Resulting stream depths reached historic highs across the Midwest, particularly in many areas of Iowa and southern Wisconsin.

The Federal Emergency Management Agency (FEMA) Mitigation Directorate deployed a Mitigation Assessment Team (MAT) to Iowa and Wisconsin. The purpose of the MAT was to assess damages to residential and commercial buildings and critical facilities as a result of the 2008 Midwest floods. This report presents the MAT's field observations, a general assessment of mitigation programs within FEMA and their application in Iowa and Wisconsin, and subsequent conclusions and recommendations.

Overall Impact of the 2008 Midwest Floods

In Iowa, numerous communities experienced flood crests exceeding historic levels, and some areas flooded well outside of the 1-percent-annual-chance floodplain (also known as the 100-year floodplain). Billions of dollars in damage occurred as homes, businesses, and critical facilities were inundated. In Cedar Rapids, a flood crest more than 12 feet higher than the previous record flooded areas well outside of the 1-percent-annual-chance floodplain, inundating an area of over 9 square miles. In Iowa City, floodwater affected residential neighborhoods, the University of Iowa campus, and other areas.

In Wisconsin, the Rock, Kickapoo, and Baraboo Rivers experienced flooding above record flood stage at multiple locations, causing extensive damage. As homes and roads flooded, residents were forced to evacuate. Sanitary sewer systems experienced high inflow and infiltration, and sewer backups were reported in many critical facilities. Several flooded manufacturing facilities were forced to lay off workers.

Information provided in this report illustrates the extent of ground saturation prior to and during the spring months, the level of precipitation measured during the month of June, and the counties in Iowa and Wisconsin that subsequently received federal disaster declarations. The report also includes timelines of the flooding in Iowa and Wisconsin, outlining and detailing key events in each state along with the estimated flood recurrence interval for several locations visited by the MAT. The field observations detail how the majority of the areas visited experienced a flood that exceeded the 1-percent-annual-chance, and several locations even exceeded the 0.2-percent-annual-chance flood (also known as the 500-year flood).

Damage Assessment Observations

Several types and causes of flooding occurred during the 2008 floods, including:

- Greater than expected river crests and inundation areas
- Backup through storm and sanitary sewers
- Underground tunnel flooding
- High-velocity flows

Thousands of homes and facilities that were prepared for one type or cause of flooding were impacted by another.

The damage to both new and existing single- and multi-family residences were evaluated. Although most of the damage resulted from slowly rising inundation, damages in a few locations were the result of high-velocity flows, particularly in or near the floodway and/or near breached or overtopped levees. The MAT also observed several examples of residential elevation and acquisition projects funded through FEMA's Hazard Mitigation Assistance programs. Acquisition projects, in particular, were noted for their effectiveness in avoiding damages to property and the potential for loss of life.

Damages observed at critical and commercial facilities were primarily related to architectural (non-structural) components, interior finishes, electrical systems, and mechanical systems rather than structural damages. From the exterior, the damages appeared limited; however, several of these structures experienced significant interior damage, which required replacement of most interior components and led to significant repair costs and extensive functional down time. The MAT observed that the performance of utility and water treatment facilities varied based upon the level of flooding, and most locations experienced damages as a result of exposures and vulnerabilities of critical functions.

The following representative types of damages were observed:

- The most common form of structural damage to residential buildings was the failure of foundation walls, especially those constructed from unreinforced masonry. Foundation failures were caused, in most cases, by hydrostatic forces and, in some cases, by hydrodynamic forces.
- Many residential buildings lacked sufficient openings in the foundation walls. In residential buildings that did have openings in their foundation walls, the openings were often too high or were obstructed.
- Critical facilities were damaged not only by rising floodwater but also by water entering through below-grade openings including access tunnels from adjacent parking garages and connecting buildings, utility tunnels, and sewer systems.
- Development in the floodplain and other activities, such as placing unanchored propane tanks and houseboats in the floodplain, led to damaging sources of debris as floodwater rose.

Throughout the field investigations, the MAT noted a lack of new construction (houses built over the last 10 years) in the 1-percent-annual-chance floodplain. Although encouraging in terms of floodplain management and losses avoided, it made it difficult to evaluate what the effectiveness of new building codes and construction techniques would have been under the 2008 flooding conditions.

Recommendations

The recommendations in this report are based on the observations and conclusions of the MAT. They are intended to assist the States of Iowa and Wisconsin and their communities, businesses, and individuals in the reconstruction process; and to help reduce future damage and impacts from similar flood events. The following recommendations are presented in further detail in Chapter 7:

- Basements in the Special Flood Hazard Area (SFHA) should be removed if the house is substantially damaged and the community is not approved for basement exceptions. Consideration should be given to filling in the basement when rebuilding, reinforcing foundation walls during repairs, and conducting community outreach to alert homeowners to the hazard involved in prematurely pumping water out of their basements. Basements in houses located outside the SFHA should also be considered for removal if there is a potential for flooding.

- The importance of continuous load paths with regard to foundations should continue to be emphasized as this is important in properly securing existing buildings that are being elevated on new foundations. In addition, local officials must enforce opening requirements in foundation walls in accordance with published FEMA guidance and minimum National Flood Insurance Program (NFIP) requirements.
- Pre-disaster planning should be conducted by local officials to prepare for increased inspection workload following a flood event.
- Elevation, as it relates to new construction, should be considered and freeboard requirements should be adopted for additional protection. Local communities should also consider the adoption of cumulative substantial damage clauses for substantial improvements.
- Critical facilities should be located outside the 0.2-percent-annual-chance flood hazard area. If this is not possible, equipment and utilities in exposed facilities should be protected to the 0.2-percent-annual-chance flood level. Systematic reduction of inflows from major users should be considered for facilities such as wastewater treatment facilities. Staging of emergency equipment (such as pumps, generators, fuel, etc.) should be planned for locations outside of mapped flood hazard areas.
- Mitigation grant programs should continue to be utilized to the greatest extent possible. Acquisition projects and relocation projects were seen to be highly effective mitigation techniques.
- Wise floodplain management practices should continue to evolve and should place stronger emphasis on flood risk communication, promotion of the NFIP's Community Rating System, reduction of debris sources in the floodplain, creation and support of locally operated programs that fund mitigation projects, and promotion of flood insurance.

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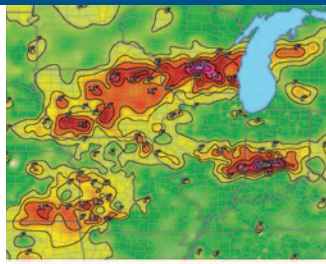

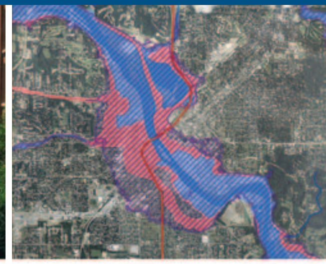


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MIDWEST FLOODS of 2008 IN IOWA & WISCONSIN

1 Introduction

In August and September, 2008, the Mitigation Directorate of the Federal Emergency Management Agency (FEMA) within the Department of Homeland Security (DHS) formed and deployed a Mitigation Assessment Team (MAT) to the States of Iowa and Wisconsin to assess damage caused by riverine flooding from the 2008 Midwest floods. This report presents the MAT's observations, conclusions, and recommendations resulting from field investigations.

This chapter provides an introduction, a discussion of the event, and historical information and background on the MAT process. Chapter 2 presents a discussion of the codes, standards, and regulations that apply to construction in the floodplains of Iowa and Wisconsin. Chapters 3 and 4 provide a basic assessment and characterization of damages to noncritical and critical facilities. Mitigation programs including mitigation planning, grant programs, and flood insurance, and their application in Iowa and Wisconsin are detailed in Chapter 5. Chapter 6 presents the MAT's conclusions and discusses past mitigation successes, and Chapter 7 provides the MAT's recommendations. Appendices include acknowledgments, references, and acronyms/glossary of terms as well as recovery advisories detailing specific technical issues related to this event.

1.1 Midwest Floods – The Event

The Midwest has a long history of flooding, with major floods occurring several times over the last century including 1927, 1961, 1993, and 2007. Minor flooding is a regular occurrence. In June 2008, much of the Midwestern portion of the United States received over 12 inches of rainfall as several storm systems sequentially impacted the region. This rainfall exacerbated the existing saturation level of the soil from the wet conditions throughout the 2007–2008 winter and spring. The Midwest had experienced the wettest January–June period on record for 106 locations and from the second to fifth wettest for another 180 locations, causing the soil to be so saturated that additional rainfall quickly became runoff as the season progressed.[1] The National Oceanic and Atmospheric Administration (NOAA) issued a Spring Flood Outlook in March 2008 (Figure 1-1) noting evidence of ground saturation and above-normal flood potential across much of the Midwest including parts of Iowa as well as a potential for moderate to major flooding across parts of Wisconsin as a result of heavy winter snow combined with rain.[2]

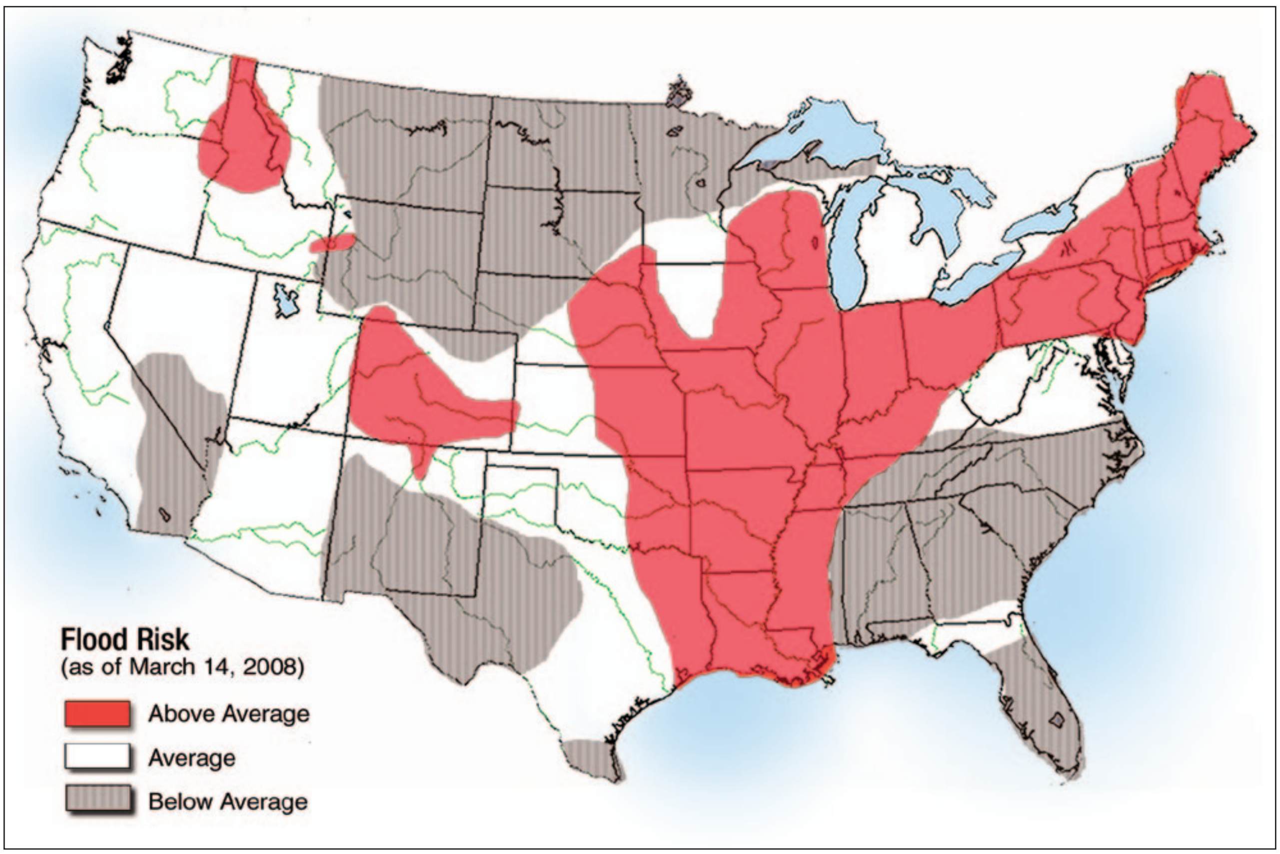


Figure 1-1. NOAA Spring Flood Outlook – March 2008
SOURCE: NOAA

1 National Climatic Data Center, Climate of 2008 Midwestern U.S. Flood Overview. July 9, 2008. http://www.ncdc.noaa.gov/oa/climate/research/2008/flood08.html

2 National Oceanic and Atmospheric Administration "*Current Major Flooding in U.S. a Sign of Things to Come.*" March 20, 2008. http://www.noaanews.noaa.gov/stories2008/20080320_springoutlook.html

When the rain fell in June, the vast majority of precipitation across the region was channeled directly into the lakes, rivers, and streams as runoff. Resulting streamflows reached historic highs across the Midwest, particularly in many areas of Iowa, southern Wisconsin, and northern Illinois. According to NOAA's Midwestern Regional Climate Center, precipitation across much of Missouri, Iowa, southern Wisconsin, central Illinois, southern Indiana, central Ohio, and northern Lower Michigan was more than 200 percent above normal for the month of June, exceeding 12 inches in much of the region (Figure 1-2).[3] Flooding began in early June, lingered for weeks in many areas, and broke historic records for flood levels. According to National Climatic Data Center estimates, the flooding across seven states in the Midwest killed 24 people[4] and many of these deaths resulted when people attempted to drive across flooded roads and bridges.

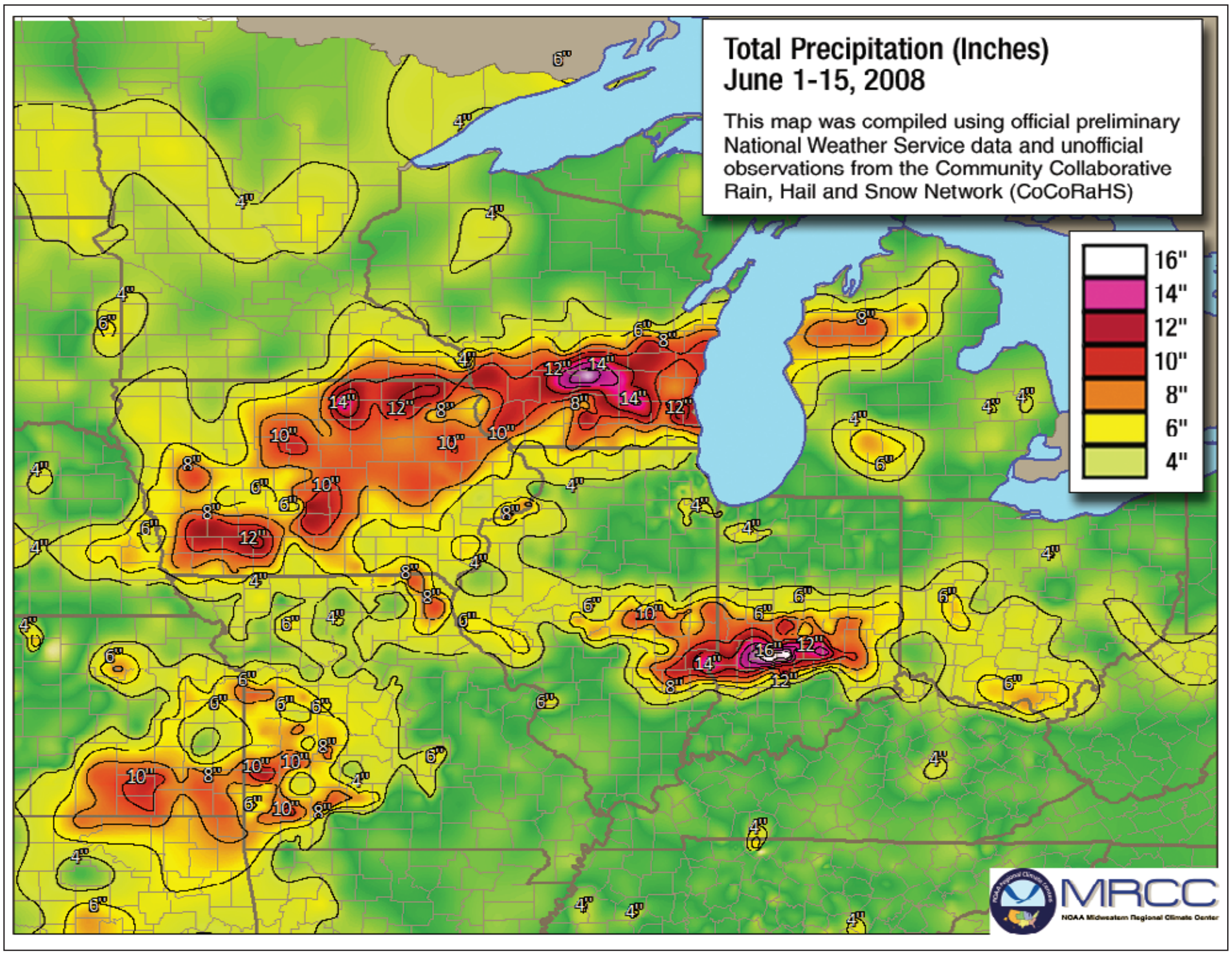


Figure 1-2. Total precipitation in the Midwest, June 1-15, 2008
SOURCE: NOAA MIDWESTERN REGIONAL CLIMATE CENTER

3 NOAA Midwestern Regional Climate Center, Midwest Overview – June 2008. http://mrcc.sws.uiuc.edu/cliwatch/0806/climwatch.0806.htm

4 National Climatic Data Center, Climate of 2008 Midwestern U.S. Flood Overview. July 9, 2008. http://www.ncdc.noaa.gov/oa/climate/research/2008/flood08.html

In Iowa, a presidential disaster declaration made on May 27, 2008, for severe storms and tornadoes was amended as a result of the June flooding. The presidential disaster declaration was increased from 4 counties to include a total of 85 counties as shown in Figure 1-3. A state disaster declaration by Iowa Governor Chet Culver included 86 counties. As a result of the flooding in Wisconsin, Governor Jim Doyle requested a joint federal/state preliminary damage assessment on June 10, and, as a result, 31 counties were declared as federal disaster areas as shown in Figure 1-4.

Flooding occurred even outside of mapped Special Flood Hazard Areas (SFHAs) (i.e., areas that have a 1-percent or greater chance of being flooded in any given year, also known as 100-year floodplains). Though the SFHA is used as the minimum regulatory area for National Flood Insurance Program (NFIP) purposes and floodplain development standards, the natural floodplain extends beyond this regulatory area and can be flooded in more infrequent events.[5] The emphasis placed on the SFHA often creates a misperception that flooding cannot occur outside of this designated area, which leads to a lack of awareness and preparedness for properties located outside of the SFHA on FEMA's Flood Insurance Rate Maps (FIRMs)[6] (refer to Section 1.2 and Table 1-1 for flood crest observation information).

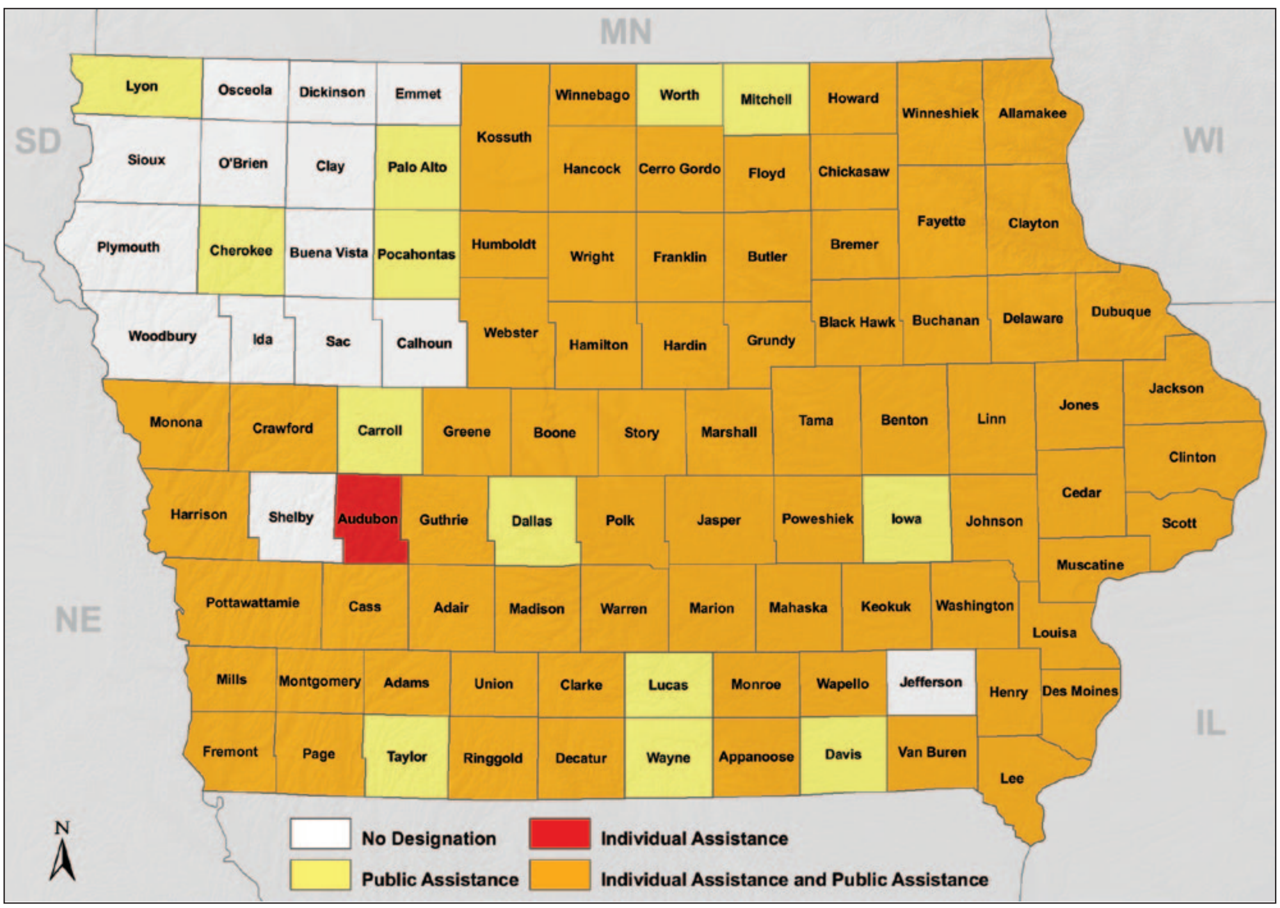


Figure 1-3. Iowa federal disaster declaration areas

5 FEMA 309, *Addressing Your Community's Flood Problems*. June 1996.

6 Montgomery, Malcolm K. and Lively, Francis P. *The Rising Tide – Flood Insurance in an Active Hurricane Era.* Winter 2006.

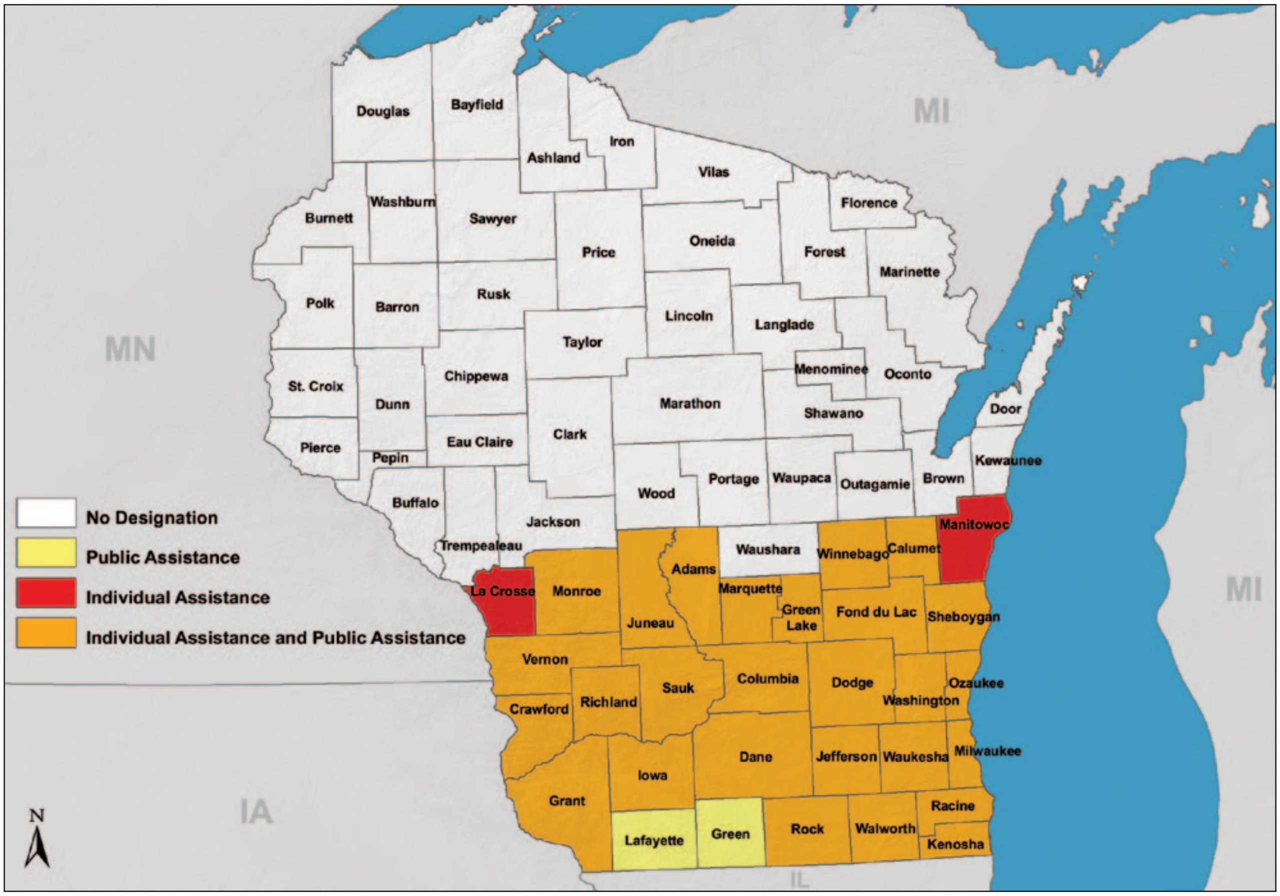


Figure 1-4. Wisconsin federal disaster declaration areas

Many homeowners, businesses, other building owners, and volunteers attempted to avoid flood damages in several ways. Most of the flood preparation efforts were ineffective in protecting against the flood; however, some techniques helped to significantly reduce flood damage including:

- Moving contents to higher floors
- Sandbagging around entrances of critical facilities, over manhole covers, and to build temporary dikes
- Pumping water out of buildings and critical facility sites before, during, and after rivers crested
- Using elevator pits for sumps at several locations
- Drilling drainage holes in floors and walls to relieve hydrostatic pressure by allowing water to pass through

In general, these techniques could not entirely protect against flood damage. Water that was higher than expected or coming in from unanticipated sources undermined remediation efforts, rendering them mostly futile. Surcharge of sanitary sewage systems can occur from a number of causes (as outlined in Section 1.1.1) and could have been anticipated from the conditions described above. However, as noted in the summary of damages, both frequent and costly damages occurred from sewer back-up that could have been prevented with appropriate preparation.

1.1.1 Summary of Iowa Flooding and Damages

The flooding experienced in Iowa during early June was record breaking in terms of water depths and discharges, with floodwaters reaching 0.2-percent-annual-chance levels in many locations (refer to Section 1.2 and Table 1-1 for flood crest observation information). Approximately 1.2 million acres of corn and soybeans were lost, nearly 10 percent of the tillable land in Iowa was under water, and estimated crop losses surpassed $3 billion.[7] Iowa highways were also impacted as 24 state roads, 20 highways including Interstates 80 and 380, and more than 1,000 secondary roads were closed at some point during the course of the flooding.[8] Iowa City was impacted as floodwater affected 304 residences across the city and caused significant damage to 19 buildings and some infrastructure elements at the University of Iowa campus. Wastewater treatment facilities in several cities were compromised. In addition, surcharge (i.e., more sewage and stormwater coming in than can be handled) resulted in sewer back-ups into toilets, sinks, and drains in schools, police stations, hospitals, and homes. This situation can occur from a number of causes. Even when sewage systems are entirely separate from stormwater systems, they are still not water tight and surface water can infiltrate the sanitary sewer system through cracks and small holes in pipes and manhole lids. Systems are most frequently surcharged when stormwater and sewage are combined. Discharges of stormwater into sanitary sewers (from rain leaders or other sources) is a common practice in some areas (however current design practices no longer permit this technique), but when this occurs it can also result in excessive flow into a sanitary sewer.

A timeline of the Iowa flood is presented in Figure 1-5.

7 *Agriculture and Environment Task Force Report To the Rebuild Iowa Advisory Commission,* Rebuild Iowa Office, August 2008. http://www.rio.iowa.gov/task_forces/ag-enviro/ag-enviro_report_08-2008.pdf.

8 *Flood Recovery and Reinvestment Plan*, City of Cedar Rapids, Iowa, March 3, 2009. http://www.corridorrecovery.org/city/plan.

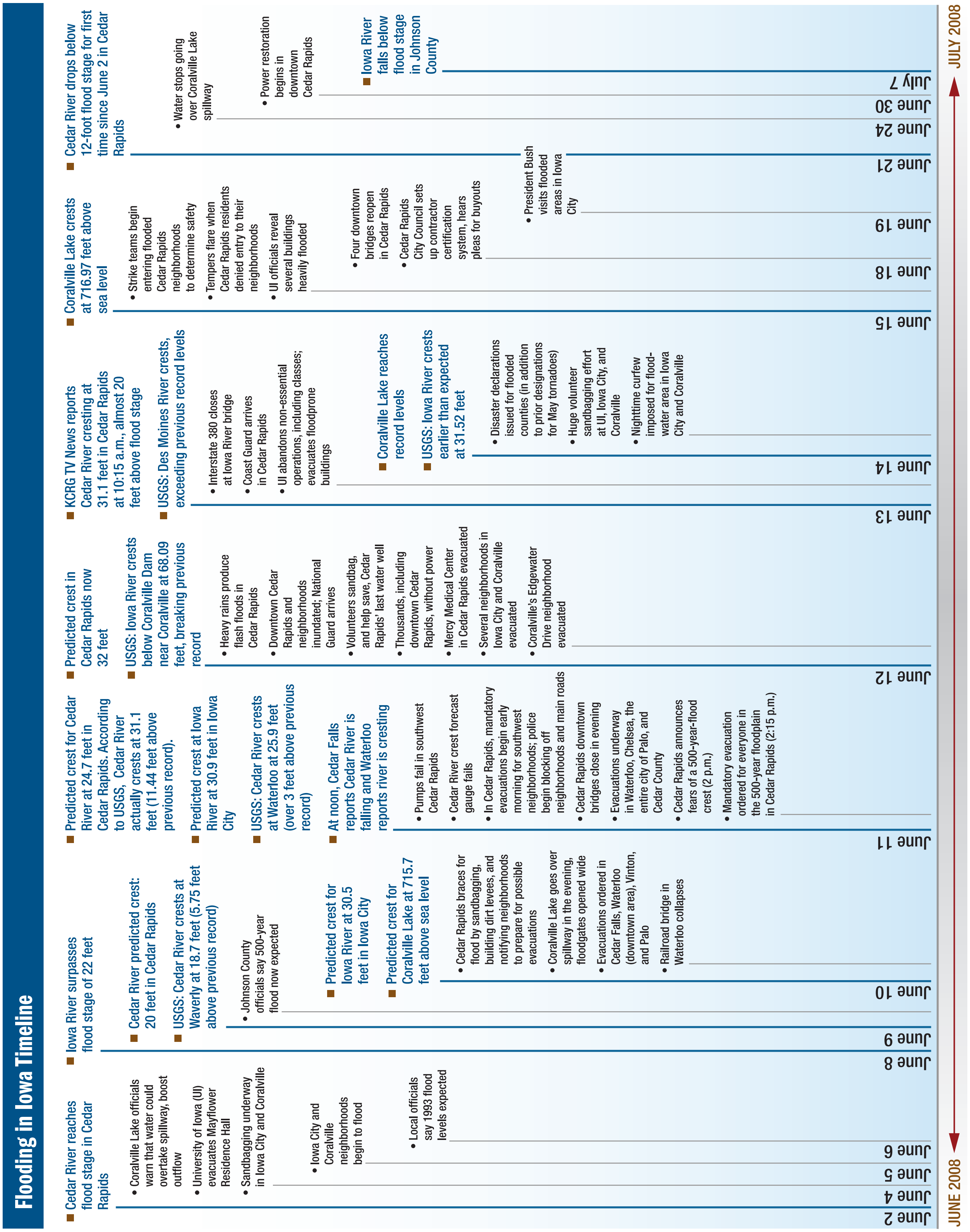
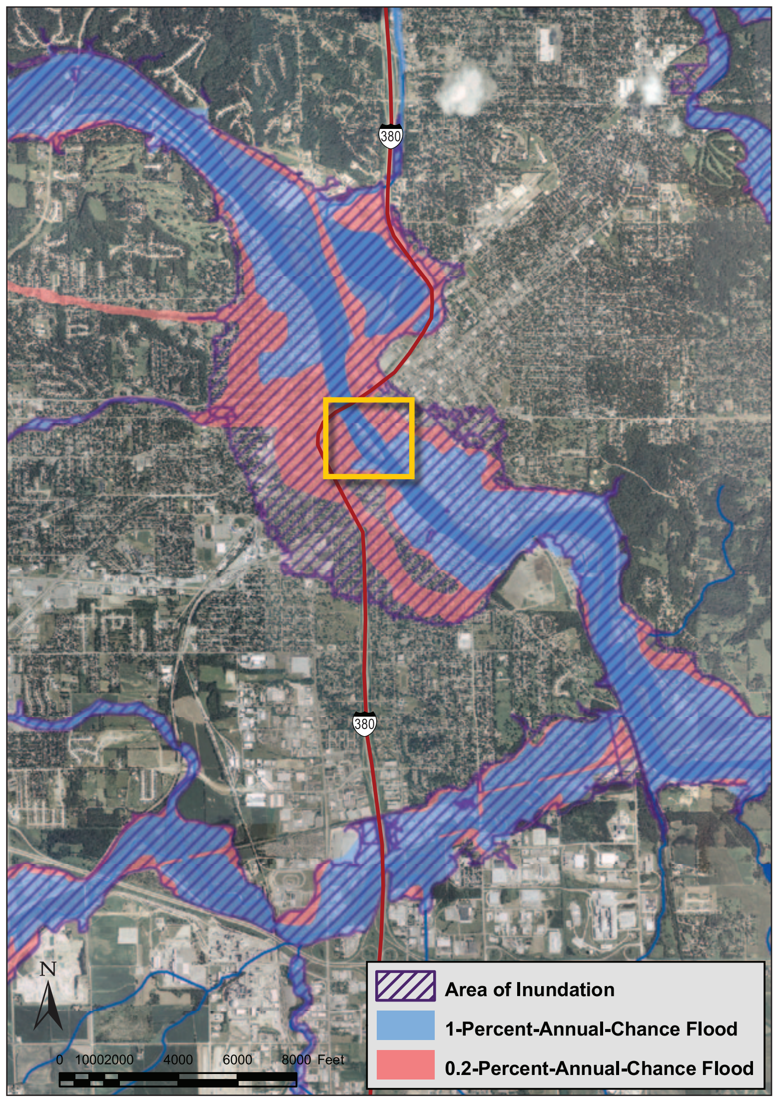


Figure 1-5. Iowa flood timeline

SOURCES: KCRG TV NEWS, USGS

In Cedar Rapids, a flood crest more than 12 feet above the previous record of 19.66 feet set in 1961 flooded areas well outside of the designated floodplain (Figure 1-6). A portion of the downtown area with several government facilities including City Hall is located on Mays Island in the Cedar River, which flooded (Figure 1-7). Levees were overtopped, flooding neighborhoods that were thought to be adequately protected. Three food manufacturing plants in Cedar Rapids (Quaker, Swiss Valley Farms, and Penford Products) were closed because of flood inundation to facilities as well as access roads. By June 23, floodwater was moving swiftly across overtopped banks and levees along the Cedar River. The City of Cedar Rapids reported over $5.4 billion in flood losses with inundation affecting 9.2 square miles, 1,300 city blocks, 3,894 single family residences, and 818 commercial properties and government buildings in this jurisdiction alone.[9] Structures such as the Linn County Sheriff's Office and Mercy Medical Center were subject to riverine flooding even though they were located outside of the 0.2-percent-annual-chance floodplain (also known as the 500-year floodplain) on the FIRM.

Figure 1-6.
Cedar Rapids, Iowa, areas of flood inundation. The downtown area, including Mays Island, is highlighted by the yellow box.



9 *Flood Recovery and Reinvestment Plan*, City of Cedar Rapids, Iowa, March 3, 2009. http://www.corridorrecovery.org/city/plan

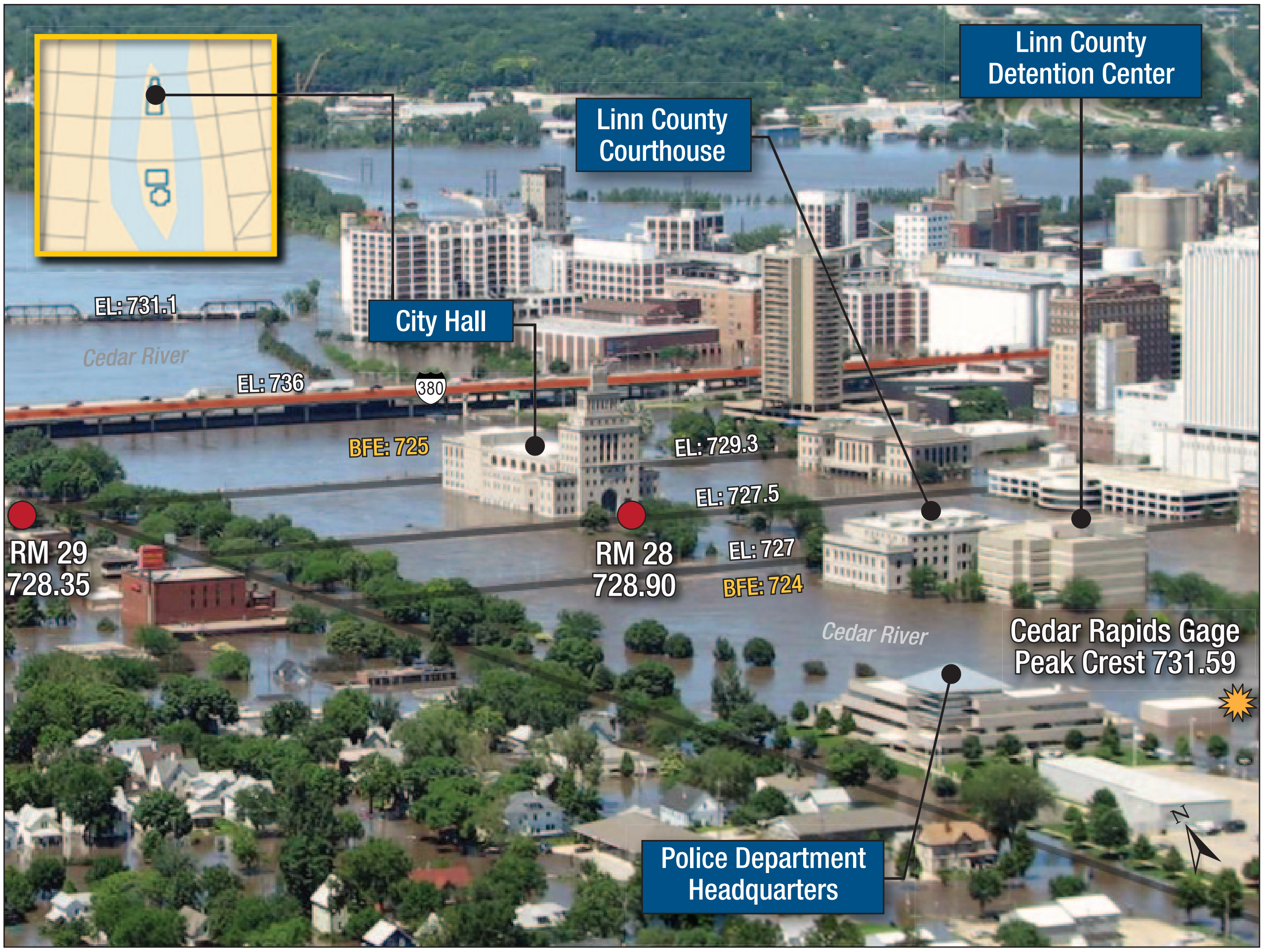


Figure 1-7. Inundation in Cedar Rapids, Iowa, exceeded 1- and 0.2-percent-annual-chance flood elevations.

1.1.2 Summary of Wisconsin Flooding and Damages

As a result of flooding across southern Wisconsin, hundreds of people were forced from their homes as several highways were closed and homes became inundated. The Rock, Kickapoo, and Baraboo Rivers were greatly impacted by the rainfall and experienced significant flooding, with floodwaters reaching 0.2-percent-annual-chance levels and breaking flood records in some locations (refer to Section 1.2 and Table 1-1 for flood crest observation information). Low-lying farm fields were inundated, and millions of dollars in crops were lost. Several manufacturing facilities impacted by the flood, including Tyson and Avalanche Organics, laid off workers. A timeline of the flooding in Wisconsin is presented in Figure 1-8.

DEFINITIONS

EL = Elevation Above Sea Level (Top of Deck for Bridges Shown)

RM = Reference Mark (FIRM Elevation Benchmark)

BFE = Base Flood Elevation. The BFE is the elevation of the 1-percent-annual-chance flood.

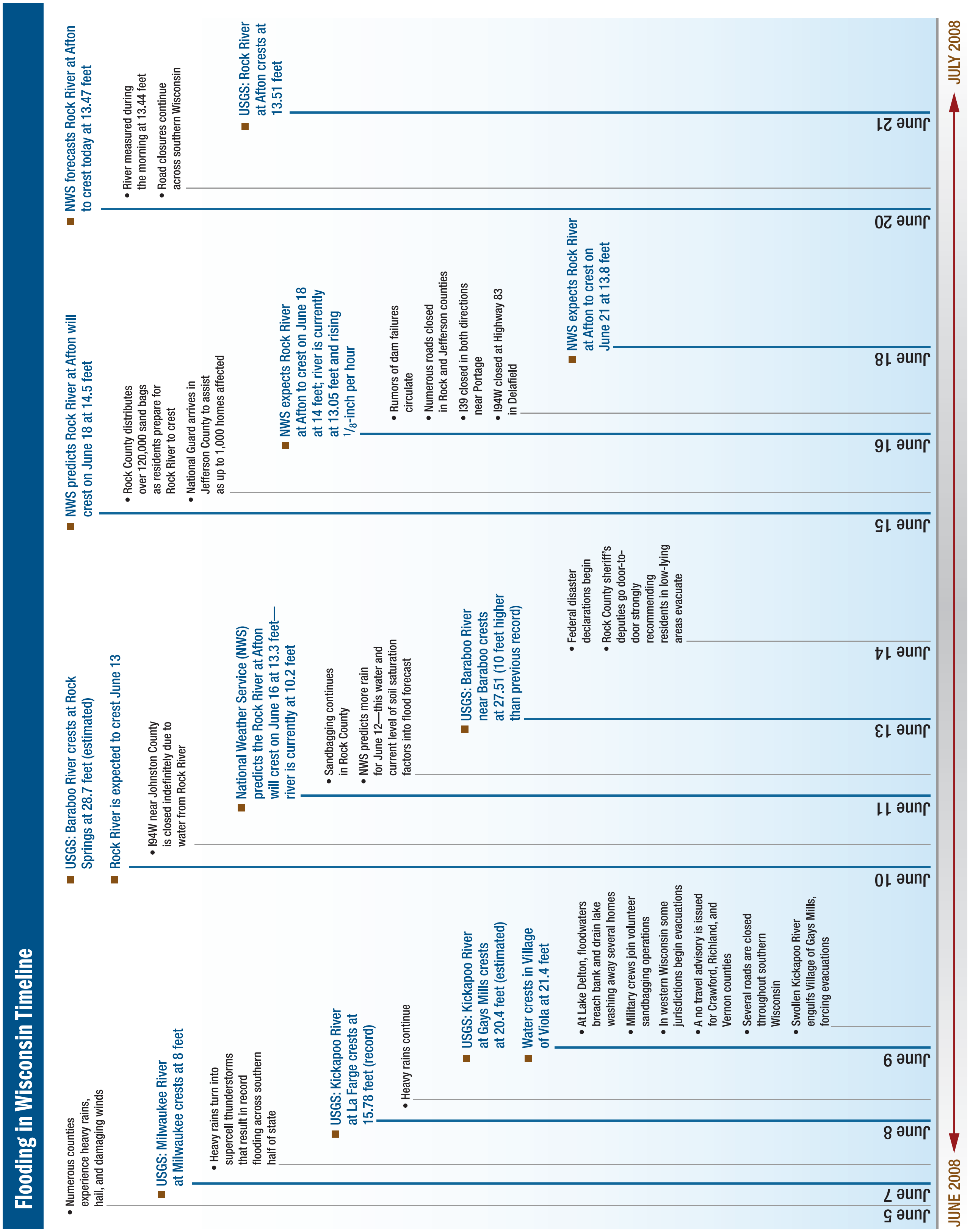


Figure 1-8. Wisconsin flood timeline

SOURCES: WCLO NEWS, USGS, WISCONSIN RECOVERY TASK FORCE REPORT TO THE GOVERNOR

Many areas in Wisconsin experienced record snowfall in early 2008 and with the spring rains, ground saturation was higher than average. With soil infiltration rates lowered, the volume of stormwater runoff increased. Older structures and developments were not designed to manage stormwater as well as they are today. Some structures experienced inches and others several feet of standing water. Sanitary sewer systems experienced high inflow and infiltration through cracks in the system, and sewer backups were reported in many critical facilities. Wastewater treatment facilities dealt with multiple complications: high inflow from stormwater infiltration exceeding plant operational treatment capacities, plant inundation from surface flows and riverine flooding resulting in a complete plant shutdown, and limited fuel and power capabilities needed to keep generators running and pumps operating at full capacity.

Most of the downtown area of Gays Mills was flooded in June 2008.[10] In August 2007, just 10 months before the June 2008 flood, the Kickapoo River had inundated the western portion of Gays Mills with record flooding. Several homes were awaiting pending buyouts and some businesses had not yet reopened when the new flooding occurred. Rock Springs was inundated by 7 feet of water throughout the downtown area. Figures 1-9 and 1-10 illustrate the scale of inundation across Gays Mills and Rock Springs in June 2008.

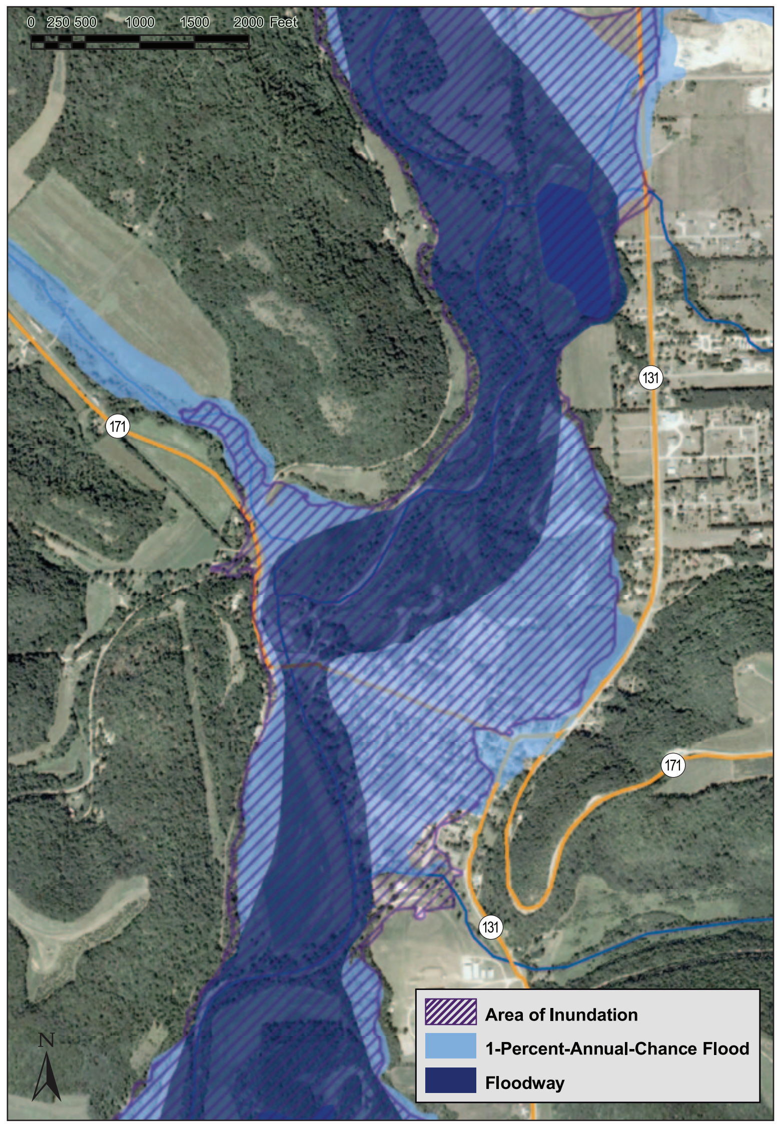


Figure 1-9.
Gays Mills, Wisconsin, areas of flood inundation

10 Wisconsin Recovery Task Force, Report to the Governor, November 2008.

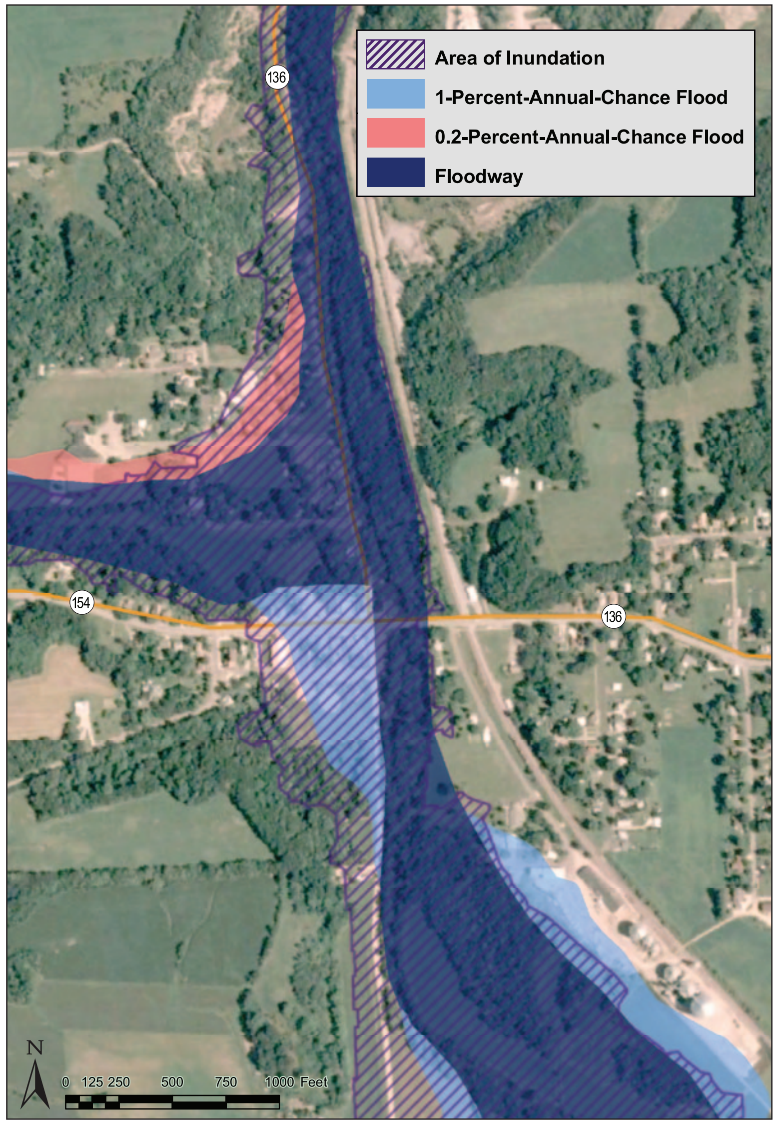


Figure 1-10.
Rock Springs, Wisconsin, areas of flood inundation

1.2 Flood Crest Predictions and Observations

As the Midwest braced for flooding in June, citizens monitored crest predictions as they made decisions on how to prepare. Although warnings and preparation activities took place, many residents found themselves confused by changing crest predictions as well as actual flood crest levels several feet higher than predictions.

Flood gauges located along streams and rivers monitored water levels periodically to gather data regarding rising floodwaters to be used by the National Weather Service (NWS) to predict crest levels. However, the preliminary crest estimates provided by the NWS were exceeded in several areas. As the flood grew larger, flood heights exceeded predicted levels, and many historical records were broken (Table 1-1). Figure 1-11 shows an example of a location where the observed recurrence interval is supported by the corresponding flood elevation provided in the Flood Insurance Study.

Table 1-1. USGS River Gauge Data for MAT Observation Locations in Iowa and Wisconsin

Stream and Place of Determination	MAT Observation Locations within 10 miles of Gauge	Maximum prior to June 2008 Flood			Maximum during June 2008 Flood				New record stage/ discharge set in 2008?
		Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Estimated recurrence interval* (percent)	
IOWA									
Beaver Creek at New Hartford	New Hartford, Waterloo	06/13/1947	13.50	18,000	06/08/2008	15.71	25,900	0.2-1	Yes
Cedar River at Cedar Rapids	Cedar Rapids, Palo	03/31/1961	19.66	73,000	06/11/2008	31.1	150,000	<0.2	Yes
Cedar River at Janesville	Cedar Falls, New Hartford	07/22/1999	17.15	42,200	06/10/2008	19.45	53,400	0.2-1	Yes
Cedar River at Waterloo	Waterloo	03/29/1961	21.86	76,700	06/11/2008	25.39	105,000	0.2-0.5	Yes
Cedar River at Waverly	Waverly	04/14/2001	12.95	25,600	06/09/2008	18.7	49,200	<0.2	Yes
Des Moines River at 2nd Avenue, Des Moines	Des Moines	06/24/1954	30.16	60,200	06/13/2008	31.57	47,300	0.2-1	Yes
Des Moines River below Racoon River at Des Moines	Des Moines	07/11/1993	34.29	116,000	06/13/2008	35	117,000	0.2-1	Yes
Fourmile Creek at Des Moines	Des Moines	06/18/1998	15	5,600	06/09/2008	17.34	11,800	>2-4	Yes
Iowa River at Iowa City	Coralville, Iowa City	06/01/1851	24.1	70,000	06/14/2008	31.52	41,900	<0.2	Yes
Iowa River at Lone Tree	Columbus Junction	07/07/1993	22.94	57,100	06/15/2008	23.10	53,700	0.2-1	Yes
Iowa River at Wapello	Oakville	07/08/1993	28.1	111,000	6/14/2008	32.15	188,000	<0.2	Yes
Iowa River below Coralville Dam near Coralville	Coralville, Iowa City	07/19/1993	63.95	25,800	06/12/2008	68.09	40,800	<0.2	Yes
Shell Rock River at Shell Rock	Clarksville, New Hartford, Shell Rock	03/28/1961	16.26	33,500	06/10/2008	20.36	60,400	<0.2	Yes
Wapsipinicon River at Independence	Independence	05/18/1999	22.35	31,100	06/11/2008	18.86	23,700	>4	No

Note: Figures 1-13 and 1-14 show gauge locations with return intervals in relation to MAT observation locations

* By definition, the recurrence interval corresponding to a particular flood probability is equal to one divided by the flood probability. For example, the flood probability of 0.2 percent corresponds to the 500-year flood.

Table 1-1. USGS River Gauge Data for MAT Observation Locations in Iowa and Wisconsin (continued)

Stream and Place of Determination	MAT Observation Locations within 10 miles of Gauge	Maximum prior to June 2008 Flood			Maximum during June 2008 Flood				New record stage/ discharge set in 2008?
		Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Estimated recurrence interval* (percent)	
WISCONSIN									
Baraboo River near Baraboo	Baraboo	03/26/1917	17.5	7,900	06/13/2008	27.51	18,000	<0.2	Yes
Kickapoo River at Gays Mills	Gays Mills	02/10/1966	16	10,600	06/09/2008	20.4	19,200-22,000	>1	Yes
Kickapoo River at La Farge	La Farge, Viola	07/01/1978	14.92	14,300	06/08/2008	15.78	22,100	0.2-0.5	Yes
Kickapoo River at Steuben	Gays Mills	07/03/1978	14.81	16,500	06/10/2008	19.16	28,700	0.2-0.5	Yes
Milwaukee River at Milwaukee	Milwaukee	06/21/1997	10	16,500	06/07/2008	8.07	10,400	4-10	No
Oak Creek at South Milwaukee	Milwaukee	08/06/1986	9.88	1,140	06/07/2008	11.56	2,370	<0.2	Yes
Rock River at Afton	Janesville	03/23/1929	11.81	13,000	06/21/2008	13.51	16,700	0.2-0.5	Yes
Rock River at Indianford	Janesville, Milton, Newville	04/05/1979	16.23	11,900	06/21/2008	18.33	14,900	1-2	Yes

Note: Figures 1-13 and 1-14 show gauge locations with return intervals in relation to MAT observation locations

* By definition, the recurrence interval corresponding to a particular flood probability is equal to one divided by the flood probability. For example, the flood probability of 0.2 percent corresponds to the 500-year flood.

Flood predictions varied widely in the days leading up to the floods, resulting in some confusion among residents and local officials. In Iowa City, river flow predictions jumped by as much as 10,000 cubic feet per second (cfs), or 33 percent, when an estimate calculation error was corrected in the final days before the flood. Significant preparation was required to protect the University of Iowa campus from flooding, and an entire day of preparation was lost as a result of the estimation error. The Johnson County, Iowa, Emergency Operations Center (EOC) worked with the University of Iowa to use HAZUS-MH (FEMA's loss estimation software) to develop estimates of potential impacts based on predicted crest levels to aid with planning and decision making, including the estimation of road closures, government building vulnerability, and displaced households. At the wastewater treatment facility in Reedsburg, Wisconsin, real-time flood level predictions were not available due to the absence of flood gauges. As a result, officials had to rely on information relayed to them by neighboring towns.

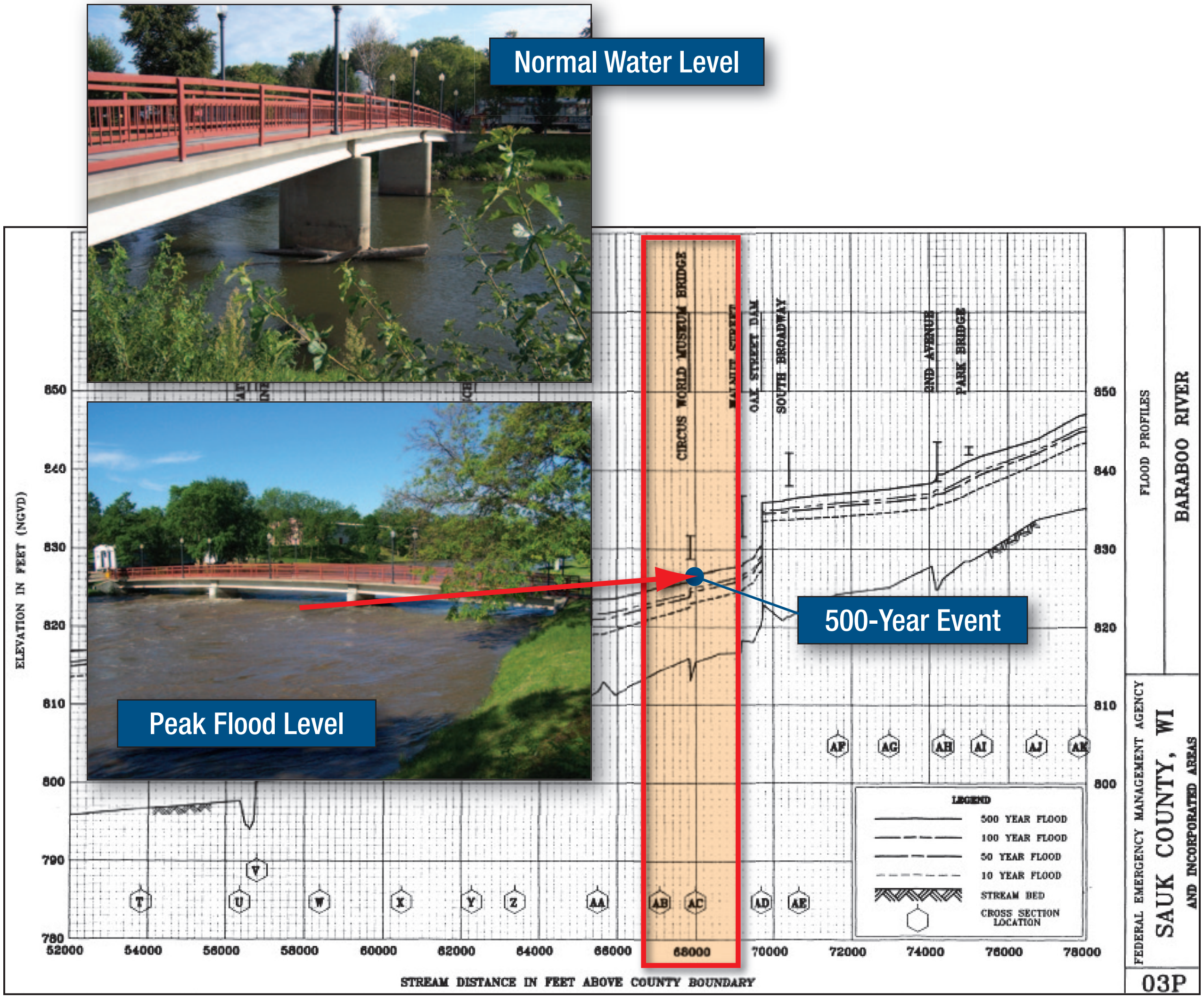


Figure 1-11.
Observed flood levels at the Circus World Museum Bridge along the Baraboo River, which were just below the estimated 0.2-percent-annual-chance flood elevation, validate the estimated recurrence intervals (Baraboo, Wisconsin).

According to the U.S. Geological Survey (USGS), the Cedar River at Cedar Rapids, Iowa, crested on June 11, 2008, at 31.10 feet (after increasing nearly 10 feet during the previous 24 hours), over 11 feet higher than the previous record of 19.66 feet set on March 21, 1961.[11] Only 48 hours before this record crest, the river had been projected to crest at 20 feet, and even on the morning of June 11, the crest was predicted to be only 24.7 feet, which is 7.7 feet lower than the actual flood crest level. At this location, the Cedar River was above flood stage for nearly two weeks. Several riverside neighborhoods, including some protected by a levee, experienced flooding of 10–12 feet, covering homes up to the rooflines. The Linn County Detention Center in Cedar Rapids was forced to implement an immediate evacuation of over 350 inmates as water began to enter the building and cover access bridge routes.

11 USGS Iowa Water Science Center. High Flow Statistics – Flood 2008. http://ia.water.usgs.gov/flood08/high_flow_stats.htm

In October 2008, the U.S. Army Corps of Engineers (USACE) convened a Rainfall-River Forecast Summit of representatives of the USACE, NWS, and the USGS. A public meeting was also held as part of the summit to elicit public comment. Summit participants concluded that significantly more rain fell than was predicted, resulting in record river flood stages that were not forecast with sufficient lead time to allow for appropriate emergency response preparations. Although the coordination and data exchange generally went well, it was concluded that discrepancies of reported data created forecasting challenges and raised doubts of forecast reliability. River gauges damaged or swept away by the floodwaters resulted in data gaps during critical periods. As a result, some river forecasts were inaccurate. Better coordination, communication, and collaboration, as well as more and better data measurements, were recommended by the summit participants.[12]

1.3 Economic and Social Impacts of Midwest Floods

Due to the extensive nature of the 2008 Midwest floods, Iowa and Wisconsin reported that impacted areas incurred billions of dollars in economic and agricultural losses, and many residents lost homes and suffered the social and psychological impacts of the disaster. Critical facilities across both states suffered interruptions and experienced significant losses, including water system facilities, city hall, police facilities (including detention cells), fire stations, schools, and libraries.

1.3.1 Loss Estimates

Cedar Rapids, Iowa, estimated that 18,623 persons were in the impacted flood area and approximately 5,390 residential properties were damaged or destroyed. As many as 1,500 properties were slated to be demolished, although only 71 were demolished within the first 6 months after the flood. Approximately 1,360 job losses resulted from the flood. Children and their parents were affected as 45 registered day-care providers were damaged as well as several schools, displacing 3,347 children. Eight cultural assets (e.g., museums, theaters, cultural centers) were displaced and/or destroyed.[13] Over 80,000 tons of residential debris had been collected and removed from impacted areas across the city by the end of 2008 at a cost of $9 million; the city estimates that, when removal is complete, the total volume of removed debris will likely be equivalent to filling four football fields. It is estimated that, at the time of the flood, only 36 percent of the residences in the SFHA that were impacted by the flood were insured through the NFIP, with total coverage at over $107 million.[14]

By April 2009, over 23,200 households in Iowa were approved for federal and state assistance totaling $121.5 million. Over $651 million was approved for public assistance projects to state and local government agencies.[15] By March 2009 in Wisconsin, over $55.6 million in federal and state disaster grants and over $48 million in loan assistance was obligated to individuals and business owners, and over $70 million was obligated for approved public assistance projects to state and local government agencies.[16]

12 Interagency Levee Task Force "U.S. Geological Survey—Rainfall-River Forecast Summit" in Raising the Standard, Oct./Nov. 2008 newsletter, available at http://www.iwr.usace.army.mil/ILTF/docs/ILTF_Newsletter_OctNov_08.pdf.

13 City of Cedar Rapids Corridor Recovery, April 2009. http://www.corridorrecovery.org/stats.asp

14 City of Cedar Rapids Corridor Recovery, April 2009.

15 Rebuild Iowa Office. "Facts and Figures." April 15, 2009. http://www.rio.iowa.gov/resources/facts.html

16 Gray, Roxanne. Wisconsin State Hazard Mitigation Officer.

1.3.2 Economic and Social Impacts

Many areas in Iowa and Wisconsin experienced economic impacts as a result of the floods. Cedar Rapids, Iowa, and the Lake Delton area of Wisconsin are two examples of areas that experienced significant economic losses to commercial businesses. In Cedar Rapids, Iowa, approximately 700 area businesses were damaged, destroyed, or suffered substantial economic loss as a direct result of the flood. Many businesses, especially in the areas directly adjacent to the Cedar River downtown, were forced to close for several months as the significant damage was repaired. In many cases, commercial businesses required significant personal expense to return to normal operations (Figure 1-12). In the tourism-reliant Wisconsin Dells area of south central Wisconsin, Lake Delton was severely impacted by the heavy and persistent rainfall in early June, which caused the land between the lake and the Wisconsin River to quickly erode and the 267-acre manmade lake to quickly empty into the nearby river on June 9. Erosion of the land between the lake and the river created a new channel, and, as a result, several homes were destroyed and many lake-based tourist attractions were inoperable causing significant income losses to the local tourism industry.

Figure 1-12. Downtown Cedar Rapids, Iowa was inundated by several feet of water in June 2008, causing significant business interruption losses and recovery time (Cedar Rapids, Iowa).

Disaster-stricken communities have often shown economic growth in the years following the event, due in part to recovery efforts that stimulate industries including clean-up, construction, and remodeling. However, this growth is not necessarily a good indicator of the actual economic activity that takes place after a disaster. Rick Mattoon of the Federal Reserve Bank of Chicago explains:

> In most cases the rebuilding merely replaces lost capital stock—meaning that, in the long term, the nation's product will not exceed what would have been produced without the disaster. While the immediate burst of economic activity is quite evident, the losses from the foregone output of interrupted and diminished business activity may go largely undetected because the diminished growth takes place in small amounts spread over many years.[17]

17 Assessing the Midwest Floods of 2008 (and 1993), Mattoon, Rick, Federal Reserve Bank of Chicago, July 10, 2008. http://midwest.chicagofedblogs.org/archives/2008/07/mattoon_flood_b.html

Following the 2008 floods, Iowa State University published a preliminary paper titled *Economic Impacts of the 2008 Floods in Iowa*[18] that outlines the expected social and economic impacts of the event. The paper considers four social categories in the Midwest that were affected: households, farmers, businesses, and communities. Families faced the loss of personal items, household goods, vehicles, and homes in addition to the possible loss of wages or even jobs. The floods affected corn and soybean acres so much that anticipated gross sales for Iowa's crop farmers might be as much as $1.5 billion less than it could have been based on preliminary calculations in June 2008. Business owners faced loss of inventory, sales, productivity, and profits. Many communities experienced a disruption in public service delivery including water and wastewater systems, public infrastructure repair, and clean-up activities, and it is expected that local property tax revenues might decline as damaged homes await repair or demolition.

Recovery prospects for any community depend on its relative health before the flood event. By June 2008, some households in the affected areas had already experienced economic stress due to higher fuel and food prices nationwide. Furthermore, people residing in floodprone areas tend to have lower than average incomes and fewer resources to aid recovery.[19] These two factors could result in lower homeownership rates throughout affected areas as post-disaster recovery takes place. Similarly, commercial districts in small communities were experiencing economic stress before the flood due to the profusion of larger regional trade centers. Without a wide economic base, these districts may have difficulty returning to pre-flood operation. Independent and locally owned businesses may also have a hard time resuming operation without the large support network of businesses owned or operated by large chains.[20]

1.4 FEMA Mitigation Assessment Teams

FEMA conducts scientific and engineering studies before and after disasters to better understand natural and manmade events impacting the built environment. These studies are conducted with the intent of reducing the number of lives lost to these events and minimizing the economic, social, and psychological impacts on the communities where these events occur. Additionally, lessons learned are applied to the education of residents and to the rebuilding effort after disasters to enhance the disaster resistance of new building stock and apply mitigation measures to existing buildings.

Since the mid-1980s, FEMA has sent MATs to presidentially declared disaster areas to evaluate building performance, assess damage, and provide recommendations to reduce future damage. Based on estimates from preliminary information about the potential type and severity of damage in the affected area(s) and the magnitude of expected hazards, FEMA determines the potential need to deploy MATs to observe and assess damage to buildings and structures caused by the

18 *Economic Impacts of the 2008 Floods in Iowa*. Iowa State University Extension, June 2008. http://www.econ.iastate.edu/research/webpapers/paper_12954.pdf

19 *Implementing Floodplain Land Acquisition Programs in Urban Localities*, The Center for Urban & Regional Studies, University of North Carolina at Chapel Hill, December 2003. http://people.vanderbilt.edu/~james.c.fraser/publications/Floddplain%20Project%20Report.Final.pdf

20 *Economic Impacts of the 2008 Floods in Iowa*

event. These teams are deployed when FEMA believes the findings and recommendations derived from field observations will provide design and construction guidance that will not only improve the disaster resistance of the built environment in the impacted state or region but will also be of national significance to regions exposed to similar hazards. Most past MATs have focused on coastal flooding and wind in relation to hurricane impacts. Riverine flooding occurs frequently across the United States, but, prior to the Midwest floods, it had never been the focus of a MAT. The Midwest flood disaster provided an opportunity for a MAT to formally evaluate a number of planning and building construction practices related to riverine flooding and to provide insight on the effectiveness of recovery and mitigation efforts that were undertaken after the 1993 flood.

1.4.1 Methodology

In response to requests for technical support from FEMA Joint Field Offices in Urbandale, Iowa, and Madison, Wisconsin, FEMA's Mitigation Directorate formed and deployed a MAT to Iowa and Wisconsin to evaluate both building performance during the flooding and the adequacy of current building codes, other construction requirements, and building practices and materials. Building performance issues including floodproofing, flood resistant materials, basement exceptions, elevations, and critical facilities performance were investigated. Effectiveness of mitigation measures and floodplain management practices were also reviewed. Additionally, the MAT was tasked with reviewing, updating, and developing mitigation educational materials for future use during disaster declaration activities.

The flood levels for this event in most impacted areas of Iowa and Wisconsin far exceeded the current minimum standard design flood event (i.e., the 1-percent-annual-chance flood event), as illustrated on the FEMA FIRMs, and there were occurrences of overtopped levees in some locations. This presented a unique opportunity to investigate long-term impacts of riverine flooding on structural and non-structural elements of buildings, as well as floodplain management issues.

A Pre-MAT was deployed to conduct the first field inspection; further refine FEMA's initial estimates of the types and extent of damage; and determine the value of the information likely to result from deployment of a MAT, and, if deployed, what the composition of the team should be. The Pre-MAT conducted preliminary field investigations to assess building conditions in flood impacted areas across Iowa between August 8 and 15, 2008. Based on damage information collected by the Pre-MAT, including joint FEMA-state Preliminary Damage Assessments (PDAs), the area of focus for the full MAT was more fully defined.

The full MAT was deployed to Iowa on August 15, 2008, for one week, conducting ground observations from Ames, Cedar Falls, Cedar Rapids, Clarksville, Coralville, Columbus Junction, Des Moines, Independence, Iowa City, La Porte City, New Hartford, Oakville, Palo, Shell Rock, Vinton, Waterloo, and Waverly, as shown in Figure 1-13. This figure also illustrates the estimated return period of the event for certain locations, where available.

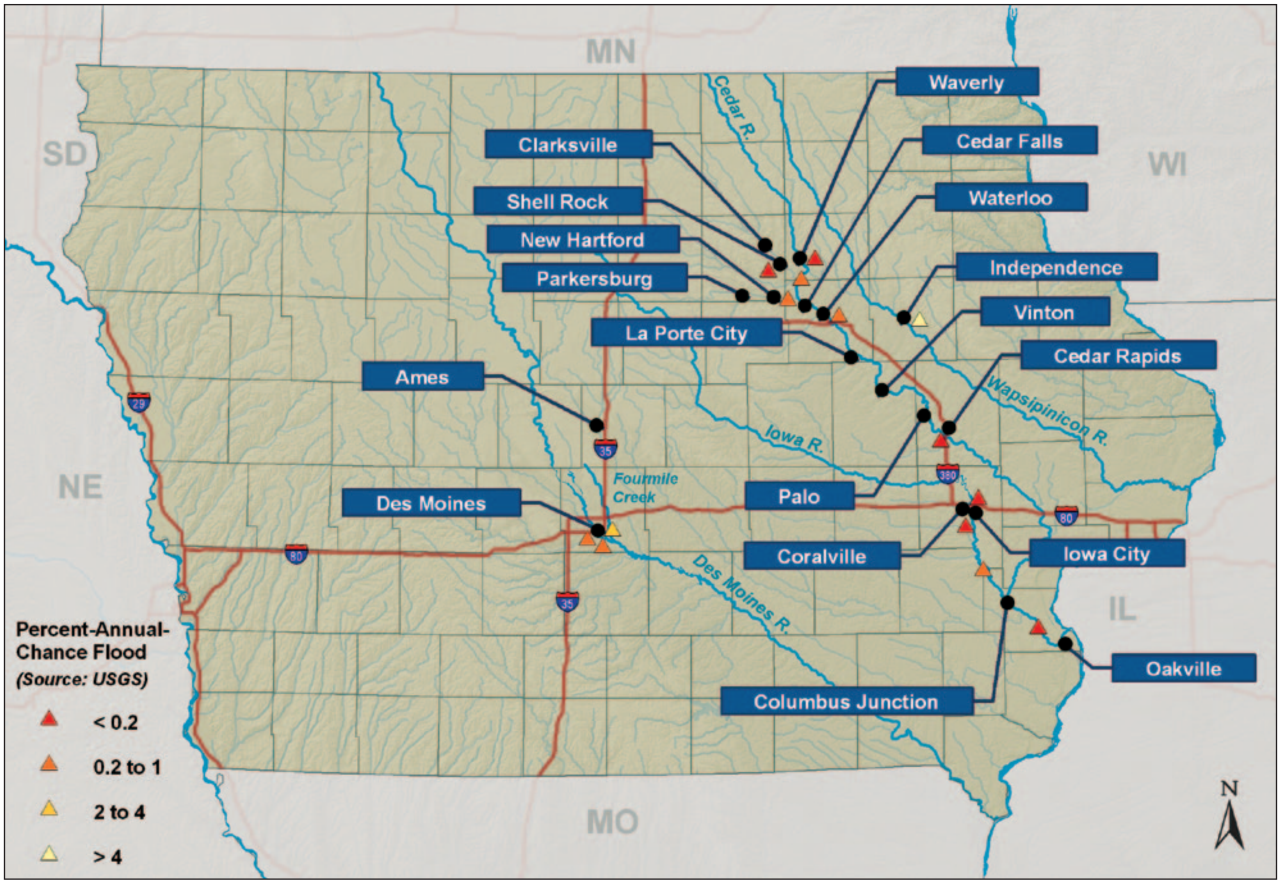


Figure 1-13. Iowa MAT field observation locations

Preliminary field investigations to assess building conditions in Wisconsin were conducted between August 13 and 22, 2008. Based on the data collected through the preliminary field investigations, the area of focus for the full MAT was more fully defined. The full MAT was deployed to Wisconsin on September 7, 2008, for one week, conducting ground observations from Baraboo, Blackhawk Island, Clark Creek, Elm Grove, Fond du Loc, Fort Atkinson, Gays Mills, Janesville, Jefferson, La Farge, La Valle, Lake Delton, Koshkonong, Milwaukee, Milton, Newville, North Freedom, North Shore, Oshkosh, Portage, Reedsburg, Richland Center, Rock Springs, Soldiers Grove, Spring Green, Viola, Wauwatosa, Wisconsin Dells, and Wonewoc, as shown in Figure 1-14. This figure also illustrates the estimated return period of the event for certain locations, where available. The MAT also visited Darlington to document lessons learned and success stories from previous floods.

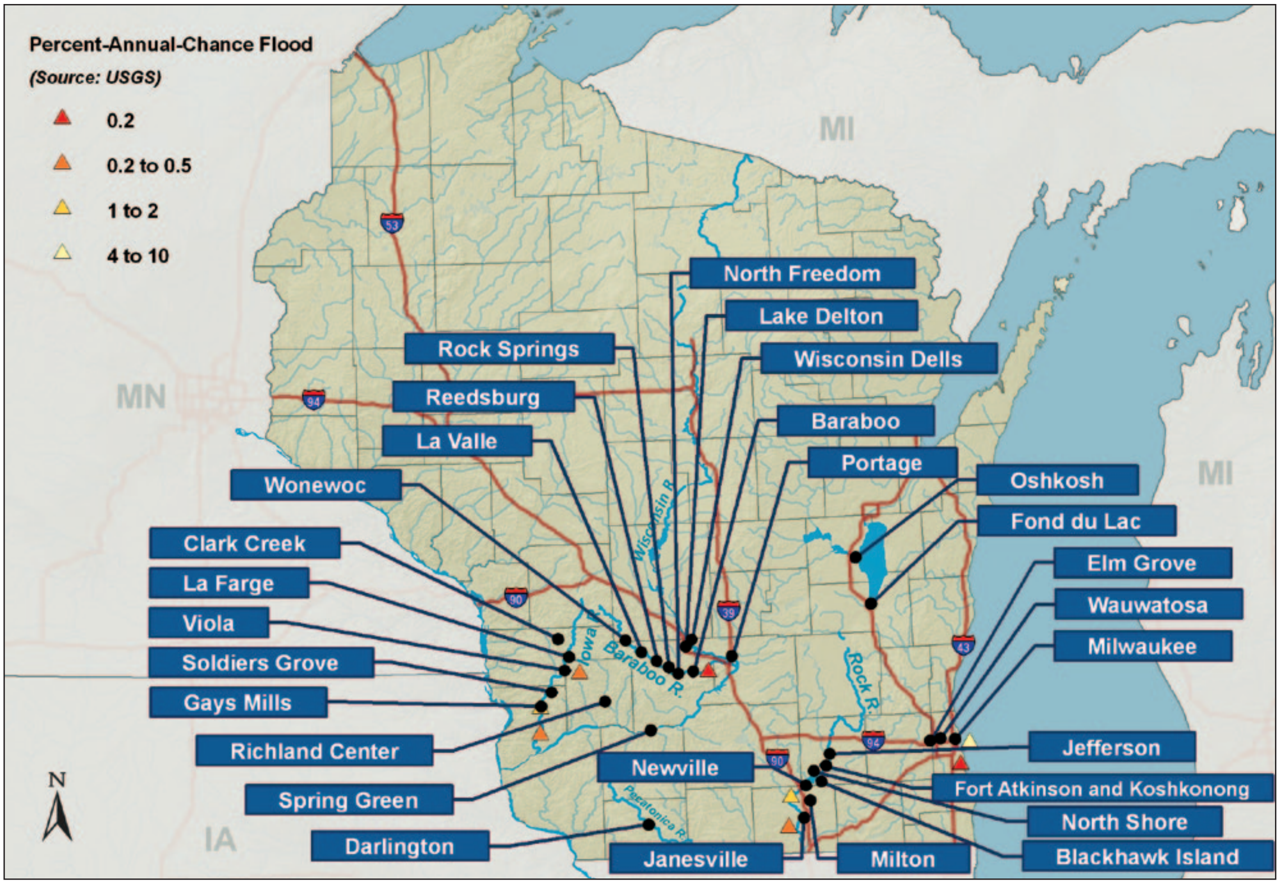


Figure 1-14. Wisconsin MAT field observation locations

Damages were observed to single- and multi-family buildings, manufactured housing, commercial properties, and historic buildings. Additionally, critical and essential facilities such as EOCs, fire and police stations, hospitals, schools, critical infrastructure (i.e., wastewater treatment facilities), and city halls were evaluated in order to document building performance as well as loss of function from flooding. Documentation of observations is presented in this report, including photographs and figures to illustrate successes and failures with expected building performance in the flooded areas.

The MAT's conclusions about observed damages are set forth in Chapter 6, and its specific recommendations for minimizing future damages from flooding are provided in Chapter 7.

1.4.2 Team Composition

The MAT included staff from FEMA Headquarters and FEMA Regions V and VII as well as experts from the design and construction industry. Team members included structural engineers, architects, civil engineers, building code experts, floodplain mapping experts, hazard mitigation planners, GIS specialists, and technical writers. In addition, representatives from the USACE, Colorado State University, the International Code Council (ICC), and the Institute for Business & Home Safety (IBHS) participated.

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2 Floodplain Management Regulations, Building Codes, and Standards

This chapter discusses the floodplain management regulations, building codes, and standards adopted and enforced by the communities in Iowa and Wisconsin that were studied by the MAT. These codes and standards enable communities to manage risk through adopting and enforcing regulations.

The floodplain management regulations applicable to the areas affected by the Midwest floods of 2008 are discussed in Section 2.1. Section 2.2 presents the building codes used to regulate construction. Building code requirements specific to floods are discussed in Section 2.3. Sections 2.4 and 2.5 discuss building standards used to regulate construction. Section 2.6 discusses how to reduce flood losses through the use of International Codes. Floodplain management performance issues observed by the MAT are presented in Section 2.7.

2.1 Floodplain Management Regulations

The NFIP minimum floodplain management regulations are set forth in Title 44, Parts 59 and 60, of the Code of Federal Regulations (44 CFR §59 and 60). The key objectives of 44 CFR §59 and 60 are to reduce the risk of flood loss and minimize the impact of floods on human health, safety, and welfare.

NFIP floodplain management requirements coupled with strong building codes and development requirements can minimize flood damages, save property owners significant dollars in the long term, and reduce social disruptions and injuries. NFIP floodplain requirements form the basis of a community's efforts to guide development in flood hazard areas. These requirements are incorporated into a community's floodplain management ordinance. The NFIP requirements pertaining to building standards have been integrated into national consensus standards, national building codes and state building codes that are adopted by communities. Figure 2-1 illustrates how NFIP regulations interact with building codes to affect building design in communities with adopted building codes. All of the communities visited by the MAT have adopted floodplain management regulations that meet or exceed the minimum NFIP requirements.

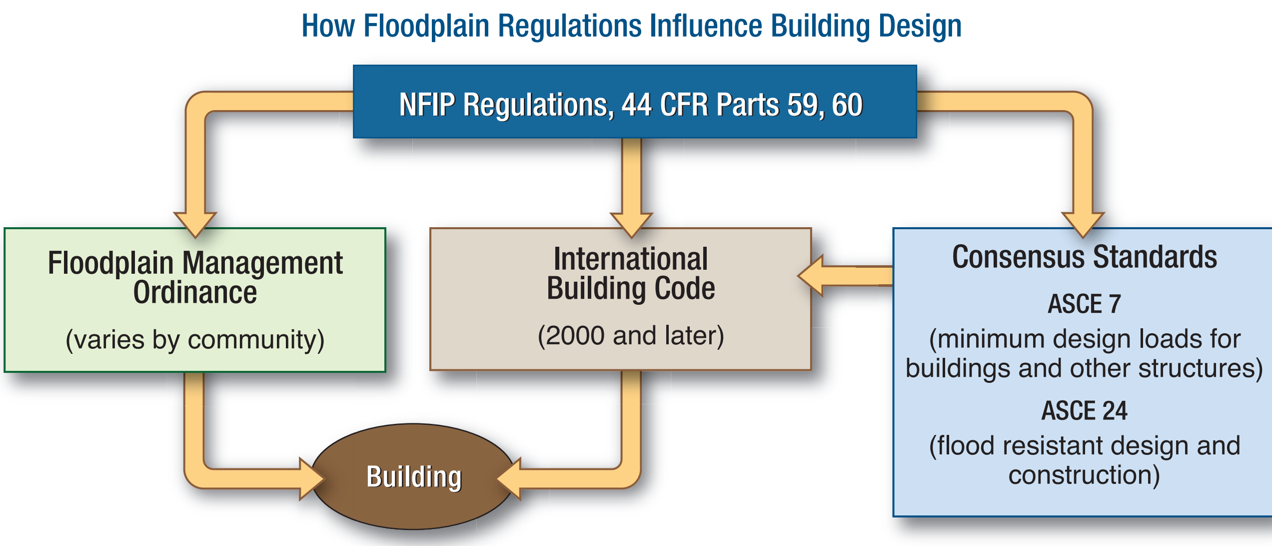

Figure 2-1. Floodplain management regulations and building design in communities with adopted building codes

2.1.1 Iowa Floodplain Management Regulations

Iowa has required permits for development in floodplains since 1965. The Legislature of the State of Iowa has in Chapter 335, Code of Iowa, as amended, delegated the power to communities to enact zoning regulations to secure safety from flood and to promote health and the general welfare. Therefore, the Iowa Department of Natural Resources (DNR) can delegate authority to a community to issue permits in the SFHA if the community has a detailed Flood Insurance Study (FIS) and is capable of exercising that authority. In communities without the delegated permit authority, all development in the SFHA requires a permit from the Iowa DNR in addition to the local permit. There are currently 595 Iowa communities with identified SFHAs.

Of these, only 136 have delegated permit authority from Iowa DNR. Projects that require a hydraulic analysis (bridges, dams, etc.) require an Iowa DNR permit prior to the granting of a local permit.

The Iowa DNR regulations require that new or substantially improved structures be elevated with the lowest floor 1 foot above the 1-percent-annual-chance flood elevation. Also, the Iowa DNR requires new or substantially improved buildings that are considered to be critical (such as hospitals and other medical care facilities; buildings containing documents, data, or instruments of high public value; buildings containing materials dangerous to the public; fuel storage facilities; etc.) to be elevated 1 foot above the 0.2-percent-annual-chance flood elevation.

Iowa Floodplain Management Regulations are available via the Iowa Legislature Search: http://search.legis.state.ia.us/NXT/gateway.dll?f=templates&fn=default.htm

2.1.2 Wisconsin Floodplain Management Regulations

The floodplain management regulations in Chapter NR 116 of the Wisconsin Administrative Code, which have been in force since 1968, are more stringent than the minimum NFIP floodplain management requirements. Wisconsin's floodplain management regulations prohibit building structures in, on, or over floodway areas if the structure is designed for human habitation. Only structures that are associated with open space use and low flood damage potential are allowed in the floodway. These low flood damage potential structures, however; are still subject to NFIP encroachment analyses and are not allowed if the project will increase flood elevations upstream or downstream by 0.01 foot or more. By contrast, minimum NFIP floodplain management requirements allow the construction of residential structures within the regulatory floodway as long as the Base (1-percent-annual-chance flood) Flood Elevation (BFE) is not increased by the construction.

According to section 116.15(3) of Wisconsin's floodplain management regulations, no modifications or additions to any buildings located in the floodway fringe are allowed unless: 1) a permit, special exception, conditional use, or variance has been granted, and 2) the modification or addition is placed on fill or is floodproofed and in compliance with section 116.13(2) of Wisconsin's floodplain management regulations.

An addition to an existing room in a nonconforming building or a building with a nonconforming

def-ə-

DEFINITION

A **regulatory floodway** is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations. For streams and other watercourses where FEMA has provided BFEs, but no floodway has been designated, the community must review floodplain development on a case-by-case basis to ensure that increases in water surface elevations do not occur, or identify the need to adopt a floodway if adequate information is available.

use may be allowed in the floodway fringe area on a one-time basis only if: 1) the addition has been granted by a permit, special exemption, conditional use or variance, 2) the addition does not exceed 60 square feet in area, and 3) the addition is 50 percent of the present assessed value of the building.

Wisconsin's requirements for new and substantially improved structures in the floodway fringe are more restrictive than those of the NFIP. The NFIP requires that new or substantially improved structures in the floodway fringe must be elevated to or above the BFE; however, Wisconsin requires 2 feet of freeboard above the BFE and dry land access for all new and substantially improved floodway fringe structures.

For development in a Zone A (an area subject to inundation by the 1-percent-annual-chance flood event where detailed hydraulic analyses have not been performed and no BFEs have been determined), the NFIP requires communities to obtain, review, and reasonably utilize BFE data and floodway data from a federal, state, or other source. However, the Wisconsin DNR regulations require an approved engineering study (in which BFEs, floodway, and floodway fringe are determined) before building permits can be issued in all SFHAs, including Zone A.

The Wisconsin DNR requires that development in a Zone A not cause an obstruction to flow or storage capacity of the floodplains and that any rise in BFEs be less than 0.01 foot. This regulation is more stringent than the corresponding minimum NFIP regulation, which allows a rise of no more than 1 foot, when developing in the floodplain (44 CFR §60.3[d] [10]). The Wisconsin DNR regulation significantly restricts any development within a SFHA designated as Zone A.

DEFINITIONS

In areas that fall within the 1-percent-annual-chance floodplain, but are outside the floodway (termed the **floodway fringe**), development will, by definition, cause no more than a 1.0-foot increase in the 1-percent-annual-chance water-surface elevation. Floodplain management through the use of the floodway concept is effective because it allows communities to develop in floodprone areas if they so choose, but limits the future increases of flood hazards to no more than 1.0-foot.

The Wisconsin Department of Natural Resources defines a **nonconforming building** as an existing lawful building that is not in conformity with the dimensional or structural requirements of the floodplain zoning ordinance for the area of the floodplain which it occupies.

Dry land access is defined as a vehicular access route above the regional flood elevation connecting floodway development in the floodplain to land outside the floodplain.

The term **regional flood** refers to a flood determined to be representative of large floods known to have occurred in Wisconsin or that may be expected to occur on a particular lake, river, or stream once in every 100 years, on average.

Wisconsin Floodplain Management Regulations are available online at http://www.legis.state.wi.us/rsb/code/nr/nr116.pdf

2.1.3 NFIP Participation and Community Rating System

All of the communities in Iowa and Wisconsin studied by the MAT participate in the NFIP and have adopted floodplain management regulations that meet or exceed minimum NFIP requirements. One of the 17 communities visited in Iowa, and one of the 21 communities visited in Wisconsin participate in the NFIP's Community Rating System (CRS) and range from Class 6 to Class 10. These two communities conduct floodplain management activities beyond the minimum requirements of the NFIP.

Des Moines, in Polk County, Iowa, participates in the CRS program and has a CRS rating of 7. Examples of the floodplain management regulations implemented by Des Moines to earn this CRS status include:

- 1-foot freeboard requirement with new construction
- Substantial improvement regulations, which do not allow any additions to a structure in the floodplain that would increase the total square footage of the structure by 25 percent
- Protecting sanitary sewer systems from the 1-percent-annual-chance flood. Sanitary sewer systems must be watertight or located on higher ground than the BFE.
- All new construction should have dry land access during the 1-percent-annual-chance flood event
- Open space credits for any open spaces in the SFHA (such as parks, natural preserves, etc.) that prohibit construction of structures

> The NFIP's CRS is a voluntary incentive program that recognizes community floodplain management activities that exceed the NFIP requirements. CRS classifications range from 1 to 10, with 1 representing the most active and the most flood hazard-resistant communities. For CRS-participating communities, flood insurance premium rates are discounted in increments of 5 percent. Thus, a class 1 community receives a 45-percent premium discount, while a class 9 community receives a 5-percent discount (a class 10 receives no discount). The CRS classifications for communities are based on 18 creditable activities, organized under 4 categories: (1) public information, (2) mapping and regulations, (3) flood damage reduction, and (4) flood preparedness. Of the more than 900 communities nationwide that participate in the CRS, over 90 percent have a rating of 7, 8, or 9.

Elm Grove, in Waukesha County, Wisconsin, also participates in the CRS program and has a CRS status of 6. Examples of the floodplain management regulations implemented by Elm Grove to earn this CRS status include:

- 2-foot freeboard requirement with new construction
- Cumulative substantial damage/improvement—a regulation that cumulatively sums the damage/improvements over the life of a structure and requires compliance with the floodplain management regulations once the substantial damage/improvement threshold is reached
- All flammable explosive and chemical substances should be out of the floodplain (elevated or relocated)
- All weather access—any new roads built need to be above the BFE

- Acquisition mitigation regulations – the acquisition of floodprone structures
- Open space credits for any open spaces in the SFHA (such as parks, natural preserves, etc.) that inhibit construction of structures

def-ə-

DEFINITIONS

Pre-FIRM buildings are those built before the effective date of the first FIRM for a community. This means they were built before detailed flood hazard data and flood elevations were provided to the community and usually before the community enacted comprehensive floodplain management regulation.

Post-FIRM buildings are new construction and structures built after the effective date of the first FIRM for a community.

Coralville, in Johnson County, Iowa, had once participated in the CRS program, but due to a violation of the NFIP requirements, the CRS rating was changed to a 10. A CRS rating of 10 is equivalent to communities that are part of the NFIP, but do not participate in the CRS program.

Tables 2-1 and 2-2 show the NFIP emergency and regular entry dates and effective FIRM date for each of the communities visited by the MAT in Iowa and Wisconsin.

Table 2-1. NFIP Status for Iowa Communities Visited by the MAT

Jurisdiction	NFIP Emergency Entry Date	NFIP Regular Entry Date	Effective FIRM Date
Benton County	N/A	09/10/08	06/03/08
Vinton	07/18/74	03/02/81	06/03/08
Black Hawk County	10/20/75	11/17/82	11/17/82
Cedar Falls	07/23/71	02/01/85	02/01/85
La Porte City	02/02/76	01/02/81	03/16/04
Waterloo	05/07/71	07/03/85	07/03/85
Bremer County	08/12/90	07/16/90	03/04/08
Waverly	05/02/75	03/02/81	03/04/08
Buchanan County	12/17/90	09/01/91	07/16/08
Independence	09/24/71	05/16/77	07/16/08
Butler County	07/05/94	11/06/00	11/06/00
Clarksville	10/28/85	09/06/89	09/06/89
New Hartford	11/06/74	09/29/86	09/29/86
Shell Rock	10/01/91	05/01/92	07/05/01

Table 2-1. NFIP Status for Iowa Communities Visited by the MAT (continued)

Jurisdiction	NFIP Emergency Entry Date	NFIP Regular Entry Date	Effective FIRM Date
Johnson County	08/01/79	08/19/85	02/16/07
Coralville	08/23/74	09/29/78	02/16/07
Iowa City	02/04/72	05/02/77	02/16/07
Linn County	01/05/79	12/15/82	12/15/82
Cedar Rapids	08/13/71	12/15/82	12/15/82
Palo	06/25/76	11/17/82	11/17/82
Louisa County	10/16/74	06/01/87	02/06/91
Columbus Junction	07/29/76	02/06/91	02/06/91
Oakville	08/05/75	08/01/86	02/06/91
Polk County	09/06/78	03/01/84	03/01/84
Des Moines	09/06/74	02/04/81	07/15/88
Story County	06/01/78	06/01/83	02/20/08
Ames	07/24/74	01/02/81	02/20/08

SOURCE: NFIP, CRS, CIS

Table 2-2. NFIP Status for Wisconsin Communities Visited by the MAT

Jurisdiction	NFIP Emergency Entry Date	NFIP Regular Entry Date	Effective FIRM Date
Columbia County	07/31/75	04/15/80	04/02/08
Wisconsin Dells	07/17/75	12/18/84	06/17/08
Crawford County	03/19/71	04/20/73	05/18/00
Gays Mills	04/12/73	06/15/78	03/05/90
Soldiers Grove	04/09/71	04/03/84	03/05/90
Jefferson County	04/02/71	09/29/78	10/16/84
Jefferson	04/23/71	05/26/72	08/01/84
Fort Atkinson	11/13/70	08/06/71	06/01/84
Juneau County	07/03/75	09/18/91	09/18/91
Wonewoc	07/18/75	09/30/88	09/18/91
Lafayette County	03/10/72	09/15/78	11/05/03
Darlington	08/18/72	09/15/78	11/05/03
Milwaukee County	N/A	12/01/78	09/26/08
Milwaukee	01/30/74	03/01/82	11/19/08
Wauwatosa	02/12/74	12/01/78	09/26/08

Table 2-2. NFIP Status for Wisconsin Communities Visited by the MAT (continued)

Jurisdiction	NFIP Emergency Entry Date	NFIP Regular Entry Date	Effective FIRM Date
Richland County	06/16/75	09/27/91	09/27/91
Viola	12/05/74	06/04/90	06/04/90
Rock County	02/08/74	08/01/83	08/19/08
Janesville	03/26/71	03/31/72	08/19/08
Sauk County	09/07/73	09/17/80	03/07/01
Baraboo	06/01/73	08/01/79	03/07/01
La Valle	03/05/75	09/19/84	03/07/01
North Freedom	04/22/75	09/19/84	03/07/01
Reedsburg	05/21/75	03/04/85	03/07/01
Rock Springs	04/30/75	09/18/85	03/07/01
Spring Green	08/27/75	02/01/86	03/07/01
Vernon County	09/01/72	09/29/78	11/16/90
La Farge	05/08/75	11/16/90	11/16/90
Waukesha County	05/25/73	08/01/83	11/19/08
Elm Grove	05/01/75	07/19/82	11/19/08

SOURCE: NFIP, CRS, CIS

2.2 Building Codes

Model building codes include provisions pertaining to anticipated hazards such as wind, seismic, snow, and flood loads, as well as soil conditions. When a model building code, such as the 2006 International Building Code (IBC) or the 2006 International Residential Code for One- and Two-family Dwellings (IRC), is adopted by a jurisdiction, it is a legal document that provides regulations for the construction of buildings.

The IBC is considered a performance-based model code with limited prescriptive-based requirements. The IRC is considered a prescriptive-based model code with some performance-based code requirements. Performance-based codes state the intended functional result of a code requirement, separate the intent from the means of compliance, and identify tools and methodologies to evaluate the functional result. Prescriptive-based codes contain descriptions of the requirements that have been empirically derived utilizing the accumulated judgment of a group of experts or by actual field experience.

Both the IBC and IRC refer to standards, such as *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) and F*lood Resistant Design and Construction* (ASCE 24), in order to maintain a specific level of performance throughout the building codes. The reference standard ASCE 7, which is briefly described in Section 2.4, specifies the structural load requirements for design and includes means for determining dead, live, soil, flood, snow, and earthquake loads. The reference standard ASCE 24, which is briefly described in Section 2.5, provides minimum requirements for flood-resistant design and construction of structures located in flood hazard areas. The IBC and IRC are consistent with the minimum provisions of the NFIP that pertain to design and construction of buildings.

Copies of the 1997 UBC, 2006 IBC, and 2006 IRC are available through the ICC website at http://www.iccsafe.org/.

Copies of ASCE 7 and ASCE 24 can be obtained from the American Society of Civil Engineers (ASCE) website at https://www.asce.org. (Note: These are referred to as "ASCE 7-05" and "ASCE 24-05" when the reference is to the specific version updated in 2005.)

The Wisconsin Uniform Dwelling Code (UDC) is available at http://www.legis.state.wi.us/rsb/code/comm/comm020.html.

The Wisconsin Commercial Building Code (CBC) is available at http://www.legis.state.wi.us/rsb/code/comm/comm060.html.

2.2.1 Iowa Building Codes

The majority of municipalities in Iowa have adopted either the 2003 or 2006 editions of the IBC and IRC. Other communities in Iowa have adopted alternative building codes such as the 1997 Uniform Building Code (UBC). A few communities in Iowa have not yet adopted commercial and residential building codes. Table 2-3 shows adopted codes for the municipalities in Iowa that were visited by the MAT. Flood requirements from the IBC and IRC are discussed in detail in Sections 2.3.1 and 2.3.2.

Table 2-3. Commercial and Residential Building Codes Adopted in Iowa

Location	Commercial Building Code	Residential Building Code
Benton County		
Unincorporated Areas	No Building Codes	No Building Codes
Vinton	IBC 2006	IRC 2006
Blackhawk County		
Unincorporated Areas	IBC 2003	IRC 2003
Cedar Falls	IBC 2003	IRC 2003
La Porte City	UBC 1997	UBC 1997
Waterloo	IBC 2003	IRC 2003
Bremer County		
All Areas	IBC 2006	IRC 2006
Waverly	IBC 2006	IRC 2006
Buchanan County		
Unincorporated Areas	No Building Codes	No Building Codes
Independence	IBC 2003	IRC 2003

Table 2-3. Commercial and Residential Building Codes Adopted in Iowa (continued)

Location	Commercial Building Code	Residential Building Code
Butler County		
Unincorporated Areas	No Building Codes	No Building Codes
Clarksville	No Building Codes	No Building Codes
New Hartford	No Building Codes	No Building Codes
Shell Rock	No Building Codes	No Building Codes
Johnson County		
All Areas	IBC 2006	IRC 2006
Coralville	IBC 2006	IRC 2006
Iowa City	IBC 2006	IRC 2006
Linn County		
Unincorporated Areas	IBC 2006	IRC 2006
Cedar Rapids	IBC 2006	IRC 2006
Palo	IBC 2006	IRC 2006
Louisa County		
Unincorporated Areas	No Building Codes	No Building Codes
Columbus Junction	No Building Codes	No Building Codes
Oakville	No Building Codes	No Building Codes
Polk County		
Unincorporated Areas	IBC 2006	IRC 2006
Des Moines	IBC 2006	IRC 2006
Story County		
Unincorporated Areas	No Building Codes	No Building Codes
Ames	IBC 2006	IRC 2006

2.2.2 Wisconsin Building Codes

Wisconsin has adopted a statewide building and residential code. All communities must comply with the Wisconsin Uniform Dwelling Code (UDC) for residential construction and the Wisconsin Commercial Building Code (CBC) for commercial construction. The purpose of the Wisconsin UDC is to establish uniform statewide construction standards and inspection procedures for one- and two-family dwellings and manufactured dwellings. The purpose of the Wisconsin CBC is to protect the health, safety, and welfare of the public by establishing minimum standards for the design, construction, maintenance, and inspection of public buildings, including multi-family dwellings and places of employment. The Wisconsin CBC is similar to the 2006 IBC, but has revisions that apply solely to the State of Wisconsin. The Wisconsin CBC does not explicitly address flood design and flood load regulations. Flood requirements from the Wisconsin UDC and the Wisconsin CBC are discussed in detail in Sections 2.3.3 and 2.3.4.

2.3 Flood Requirements in Building Codes

In order to make federally backed flood insurance available in a community, the community must adopt and enforce floodplain management regulations that meet or exceed the minimum requirements of the NFIP. One way for communities to regulate new or substantially improved structures in mapped flood hazard areas is by adopting building codes such as the IBC, IRC, and the International Existing Building Code (IEBC) (referred to collectively as the I-Codes). These codes, in particular, contain provisions that are consistent with the minimum flood-resistant design and construction requirements of the NFIP.

2.3.1 Flood Requirements in the 2006 International Residential Code

The IRC applies to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, removal, and demolition of detached one- and two-family dwellings and townhouses not more than three stories above grade in height with a separate means of egress, and their accessory structures. The IRC provides minimum requirements to safeguard the public safety, health, and general welfare through structural strength, means of egress, facilities, stability, sanitation, light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment.

In terms of flood-resistant construction, buildings and structures constructed in flood hazard areas should be designed and constructed in accordance with Section R324 of the IRC. Section R324 discusses flood provisions for:

- Structural systems (R324.1.1)
- Flood-resistant construction (R324.1.2)
- Establishing the design flood elevation (R324.1.3)
- Lowest floor elevations (R324.1.4)
- Protection of mechanical and electrical systems (R324.1.5)
- Protection of water supply and sanitary sewage systems (R324.1.6)
- Flood-resistant materials (R324.1.7)
- Manufactured housing (R324.1.8)
- Elevation requirements (R324.2.1)
- Enclosed areas below design flood elevations (R324.2.2)
- Foundation design and construction (R324.2.3)
- Flood hazard areas (R324.2)
- Coastal high-hazard areas (R324.3)

When a residential structure is being constructed in a flood hazard area, construction documents should include the delineation of flood hazard areas, design flood elevation, and all proposed floor elevations depending on the flood zone in which the residential structure is being constructed (R106.1.3).

2.3.2 Flood Requirements in the 2006 International Building Code

The IBC is applied to multi-family and non-residential structures. This code applies to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures. A portion of the IBC discusses construction within flood hazard areas.

The IBC explains how to establish flood hazard areas for a community (Section 1612.3). A community/municipality must first adopt a flood hazard map and supporting data for the area in question. This map should include SFHAs identified by the FEMA FIS.

In terms of flood-resistant construction, buildings and structures constructed in flood hazard areas should be designed and constructed in accordance with the following sections of the IBC:

- Accessibility (1107.7.5)
- Elevation certificate (109.3.3)
- Existing structures (3403.1, 3407.2, 3410.2.4.1)
- Flood loads (1602.1, 1603.1, 1612, 3001.2, 3102.7)
- Flood resistance (1403.5, 1403.6)
- Flood-resistant construction (Appendix G)
- Grading and fill (1803.4, 1807.1.2.1)
- Interior finishes (801.1.3)
- Site plan (106.2)
- Ventilation, under floor (1203.3.2)

Codes and regulations regarding design and construction in flood hazard areas are not thoroughly explained in the IBC; however, they are incorporated through reference by appropriate engineering standards such as ASCE 7 and ASCE 24. IBC Sections 1203.3, 1612.4, 1612.5, 3001.2, G103.1, G401.3, and G401.4 require flood-resistant design and construction to comply with requirements in ASCE 24-05.

For construction in SFHAs that is not subjected to high-velocity wave action, regulations regarding openings in walls and the equalization of hydrostatic forces should be in accordance with Section 2.6.2.1 and 2.6.2.2 of ASCE 24-05 respectively. Dry floodproofing non-residential buildings should be documented to show that regulations conform to ASCE 24-05.

2.3.3 Flood Requirements in the Wisconsin Uniform Dwelling Code

The Wisconsin UDC is a uniform statewide code that sets minimum standards for fire safety; structural strength; energy conservation; erosion control; heating, plumbing, and electrical systems; and general health and safety in new dwellings. The Wisconsin UDC covers one- and two-family housing units that have been built since June 1, 1980, and their additions or alterations. For residential homes that were built before June 1, 1980, the state does not have specific building codes. For older residential homes, the municipality may adopt any or no code. If a code is adopted, and a portion of the house is modified, remodeled, or there is new construction, that part of the home must adhere to the code adopted by the municipality.

The Wisconsin UDC has a minimal amount of information regarding flood-resistant construction. It does, however, provide regulations with regard to constructing in the SFHA. All new construction in the floodway fringe must be elevated so that the lowest floor and all basement floor surfaces are located at or above the BFE. Additionally, the Wisconsin DNR requires that any increase in the flood elevation caused by development in the floodway fringe be less than or equal to 0.01 foot, based on a comparison of existing and proposed conditions, as discussed in Section 2.1.2 above.

According to the Wisconsin UDC, Section 21.33, a certified dry-floodproofed basement may be placed no more than 5 feet below the BFE if an engineer has designed it to be watertight and impermeable. The certified dry-floodproofed basement does not have any limitations regarding occupancy. After Section 21.33, the Wisconsin UDC states that the Wisconsin DNR and FEMA have applicable regulations and guidelines for basements built below the BFE. Section NR 116.13 (2)(a) of the Wisconsin DNR states that

> …an exception to the basement requirement may be granted by the department, but only in those communities granted such exception by the Federal Emergency Management Agency (FEMA) on or before [the effective date of this rule].

Enclosed spaces that are not certified dry-floodproofed may be used as spaces for means of egress, entrance foyers, stairways, or storage for incidental and mobile items. These fully enclosed spaces must be designed to allow the hydrostatic pressure to equalize on both sides of an exterior wall by allowing the entry and exit of floodwaters. In order to effectively accomplish this and in accordance with the NFIP minimum floodplain management standards as set forth in 44 CFR §60.3(c)(5), the following design criteria must be met:

- There must be a minimum of two openings on different sides of each enclosed area. If a building has more than one enclosed area, each area must have openings on exterior walls to allow floodwater to directly enter and exit.
- The total area of all openings must be at least 1 square inch for each 1 square foot of enclosed area.
- The bottom of each opening can be no more than 1 foot above the adjacent grade.
- Louvers, screens, or other opening covers must not block or impede the automatic flow of floodwaters into and out of the enclosed area and the cross-sectional area of such screens and louvers must be deducted from the opening's net area.

Other important regulations regarding construction in the floodplain found in the Wisconsin UDC include the following:

- For new construction, a registered land surveyor, architect, or engineer must certify the actual elevation in relation to the mean sea level of the lowest structural member required to be elevated by the provisions in the Wisconsin UDC.
- The structural systems of all residential structures must be designed, connected, and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads and stresses at the BFE.
- All electrical and mechanical equipment must be placed above the BFE or be designed to prevent contact with the equipment in case of a flood up to the BFE.
- Areas below the BFE need to be constructed using flood-resistant materials and methods designed to minimize flood and water damage.
- The Wisconsin DNR floodplain ordinance requires contiguous dry land access from a structure to land outside of the floodplain.

The Wisconsin UDC does not reference floodplain requirements from codes and standards such as IBC 2006, ASCE 7-05, and ASCE 24-05. Instead, the Wisconsin UDC references Chapter NR 116 of Wisconsin's Floodplain Management Program. Section NR 116.16 states:

> When floodproofing measures are required by either a municipal floodplain zoning ordinance or some other regulation which incorporates by reference the floodproofing requirements of this chapter, such measures shall be designed to withstand the flood depths, pressures, velocities, impact and uplift forces and other factors associated with the regional flood, to assure that the structures are watertight and completely dry to the flood protection elevation without human intervention during flooding.

Therefore, additional flood protection is required by the local floodplain management ordinance for Wisconsin.

2.3.4 Flood Requirements in the Wisconsin Commercial Building Codes

The Wisconsin CBC is similar to the IBC; however, it includes amendments specific to the State of Wisconsin. The four major differences for flood requirements between the two codes are related to flood design, flood loads, flood hazard areas, and grading/fill in flood hazard areas.

The Wisconsin CBC does not explicitly address:

- Flood design to be included in the construction documents (IBC 1603.1.6).
- Flood load (hydrostatic, high velocity, and wave loads) regulations (IBC 1612).
- Grading and fill in flood hazard areas from the IBC (IBC 1803.4).
- Floodproofing in flood hazard areas (IBC 1807.1.2.1).

Although the Wisconsin CBC does not explicitly state how full protection is provided to buildings located in SFHAs, it is accomplished by the use of notes explaining that the regulations and standards of other state agencies will apply to commercial buildings. Since the Wisconsin DNR's floodplain management regulations are mandated by the state, both the Wisconsin CBC and NR 116 must be followed. (See the NR 116 excerpt at the end of Section 2.3.3.)

2.4 Flood Requirements in ASCE 7-05

ASCE 7-05 provides minimum load requirements for the design of buildings and other structures. It discusses the provisions that should be applied to buildings and other structures located in areas prone to flooding as defined on a FEMA flood hazard map. Since 1995, ASCE 7 has included flood load provisions. The following sections of ASCE 7-05 address flood loads.

- Section 2.3 (*Load Combinations,* including different load combinations for Zone V and Coastal Zone A)
- Section 5.3 (*Design Requirements,* which covers design loads, erosion and scour, and loads on breakaway walls)
- Section 5.4 (*Flood Loads*, which covers hydrostatic, hydrodynamic, wave, and impact loads, and load criteria for breakaway walls)

The IBC references the ASCE 7-05 standard only when discussing dry floodproofing. It defines dry floodproofing as a combination of design modifications that results in a building or structure, including the attendant utility and sanitary facilities, being watertight with walls substantially impermeable to the passage of water and with structural components having the capacity to resist loads as identified in ASCE 7-05.

The IRC does not explicitly refer to ASCE 7-05; however, the IRC has adopted ASCE 7-05 by reference, meaning that flood loads must be considered for buildings following the IRC. The Wisconsin UDC and Wisconsin CBC do not refer to this standard.

2.5 Flood Requirements in ASCE 24-05

ASCE 24-05 provides minimum requirements for flood-resistant design and construction of structures that are subject to building code requirements and that are located in whole or in part in flood hazard areas. The first edition of ASCE 24 was published in 1998 and is referenced in the 2000 and 2003 editions of the IBC. The 2005 edition is a major revision and expansion of the standard, which is referenced in the 2006 IBC. The IBC states: "The design and construction of buildings and structures located in flood hazard areas, including flood hazard areas subject to high-velocity wave action, shall be in accordance with ASCE 24-05."

ASCE 24-05 specifies minimum requirements for flood-resistant design and construction of buildings and structures located in flood hazard areas, including floodways, coastal high-hazard areas, and other high-risk flood hazard areas such as alluvial fans, flash flood areas, mudslide areas, erosion-prone areas, and high-velocity areas. The basic design requirements that are addressed in ASCE 24-05 are:

- Flood loads (references ASCE 7-05)
- Load combinations (references ASCE 7-05)
- Elevation of the lowest floor
- Foundation requirements and geotechnical considerations
- Use of fill
- Anchoring and connections

Materials, wet and dry floodproofing, utility installations, building access, and miscellaneous construction provisions are also included in sections of ASCE 24-05. In addition, ASCE 24-05 includes specifications for the design of pile, post, pier, column, and shear wall foundations. Considerable detail is specified for pilings as a function of pile types and connections.

The IRC, Wisconsin UDC, and Wisconsin CBC do not refer to ASCE 24-05. These codes are prescriptive and do not require specific designs for buildings that are constructed in agreement with the code.

2.6 Reducing Flood Losses Through the International Codes (FEMA 9-7032)

With the publication of the I-Codes, the opportunity exists for communities to integrate building safety and floodplain management. In cooperation with the ICC, FEMA produced the guide *Reducing Flood Losses through the International Codes: Meeting the Requirements of the National Flood Insurance Program* to help communities decide how best to accomplish that integration in order to initiate or continue participation in the NFIP. The guide also includes detailed comparisons of the NFIP regulations and the flood resistant provisions of the I-Codes. It should be noted that this publication is neither a code nor standard.

2.7 NFIP and State Floodplain Management Regulations and Performance Issues

The MAT noted several building design issues that were associated with NFIP and state floodplain management regulations. These building design issues dealt with basements, foundation and enclosure wall openings, substantial improvements, and dry-land access requirements. The subsections below help explain these regulations. Specific examples of these performance issues are discussed in Chapter 3 of the MAT report.

2.7.1 Basements

According to NFIP requirements, a basement is defined as any area of the building having its floor below ground level on all sides. NFIP regulations require that the lowest floor of a residential structure, including basement, built within the SFHA be at or above the BFE (44 CFR §60.3[c][2]).

As noted in section 2.3.3, basements below the BFE, where the placement of engineered earthen fill was not used, are allowed only in communities that have obtained a basement exception from FEMA. Buildings with floodproofed basements must have their design certified by a registered engineer or architect and are more difficult and more expensive to construct than buildings elevated above the BFE. As of this date, only 54 communities nationwide are approved for residential basement exceptions, including Clive, Independence, and La Porte City in Iowa and Allouez, Ashwaubenon, Brown County, Depere, Green Bay, Howard, and Shiocton in Wisconsin.

The MAT visited properties in La Porte City, Iowa, to observe basement construction in a basement-exception community and noted good examples of properly floodproofed basements that performed well during the flood (Chapter 3, Figure 3-43). The MAT also observed pre-FIRM structures with basements that experienced basement wall collapse due to hydrostatic forces (Chapter 3, Figure 3-21).

2.7.2 Foundation and Enclosure Wall Openings

NFIP regulations require that foundation and enclosure walls subject to the 1-percent-annual-chance flood contain openings designed by a registered professional so as to permit the automatic entry and exit of floodwaters. These openings allow floodwaters to reach equal levels on both sides of the walls and thereby lessen the potential for damage from hydrostatic pressure. The requirement for openings applies to all new and substantially improved buildings in Zone A and is detailed in FEMA Technical Bulletin 1 (August 2008). NFIP regulations (44 CFR §60.3[c][5]) state that a community shall:

> Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access, or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters.

The MAT observed several examples of improper construction of flood openings in Iowa, particularly among new construction and recently completed elevations. In some cases, flood openings were too high, or opening sizes were inadequate in relation to the square footage of the structure. The MAT also observed cases where openings appeared to be blocked by finished materials, such as drywall, indicating a possible compliance issue with both flood opening requirements and the requirements for areas below the BFE. Finished materials blocking flood openings may indicate a conversion of lower level areas into habitable space, a violation of the NFIP regulations. Chapter 3, Figure 3-50, shows a newly elevated house, located in the SFHA, with inadequately sized vents, approximately 3 feet above grade.

2.7.3 Substantial Improvement

NFIP regulations (44 CFR §60.3) define substantial improvement as:

> Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage," regardless of the actual repair work performed. The term does not, however, include either:
>
> 1. Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions or
>
> 2. Any alterations of a "historic structure," provided that the alteration will not preclude the structure's continued designation as a "historic structure."

Floodplain management requirements for new construction apply to substantial improvements. Increased Cost of Compliance coverage is available only on a structure that the community has determined is substantially damaged due to flooding.

There may be some cases where, in addition to repairs to damaged buildings, property owners may also want to make improvements, such as building a room addition onto the structure. It is likely that many flood-damaged homes in heavily impacted areas will require substantial improvement to make them habitable. Communities need to evaluate such proposals to determine whether the combined work (repairs and improvements) is a substantial improvement. The enforcement of proper codes and NFIP requirements will be crucial in protecting these structures in the future.

2.7.4 Dry Land Access Requirement

Wisconsin regulations require dry land access to development within the floodway fringe. According to Wisconsin State Statute NR 116.13, both residential and commercial development within the floodway fringe must be elevated to or above the regional flood height and have dry land access to the principal structure. Certain commercial yards, parking lots, and other accessory structures not connected to the principal structure may be below the regional flood height and not require dry land access; however, they should not be inundated more than 2 feet or subjected to velocities greater than 2 feet per second during the occurrence of the regional flood.

Figure 2-2 shows a house and driveway in Edgerton, Wisconsin, that was elevated on fill approximately 2 feet above the BFE. Figure 2-3 shows the location and BFE (784 feet) of the structure on a FIRM. This house is an example of a location that met the dry land access requirement from the Wisconsin State Statute NR 116.13.

Figure 2-2. Elevated house and driveway on fill (Dane County, Wisconsin)

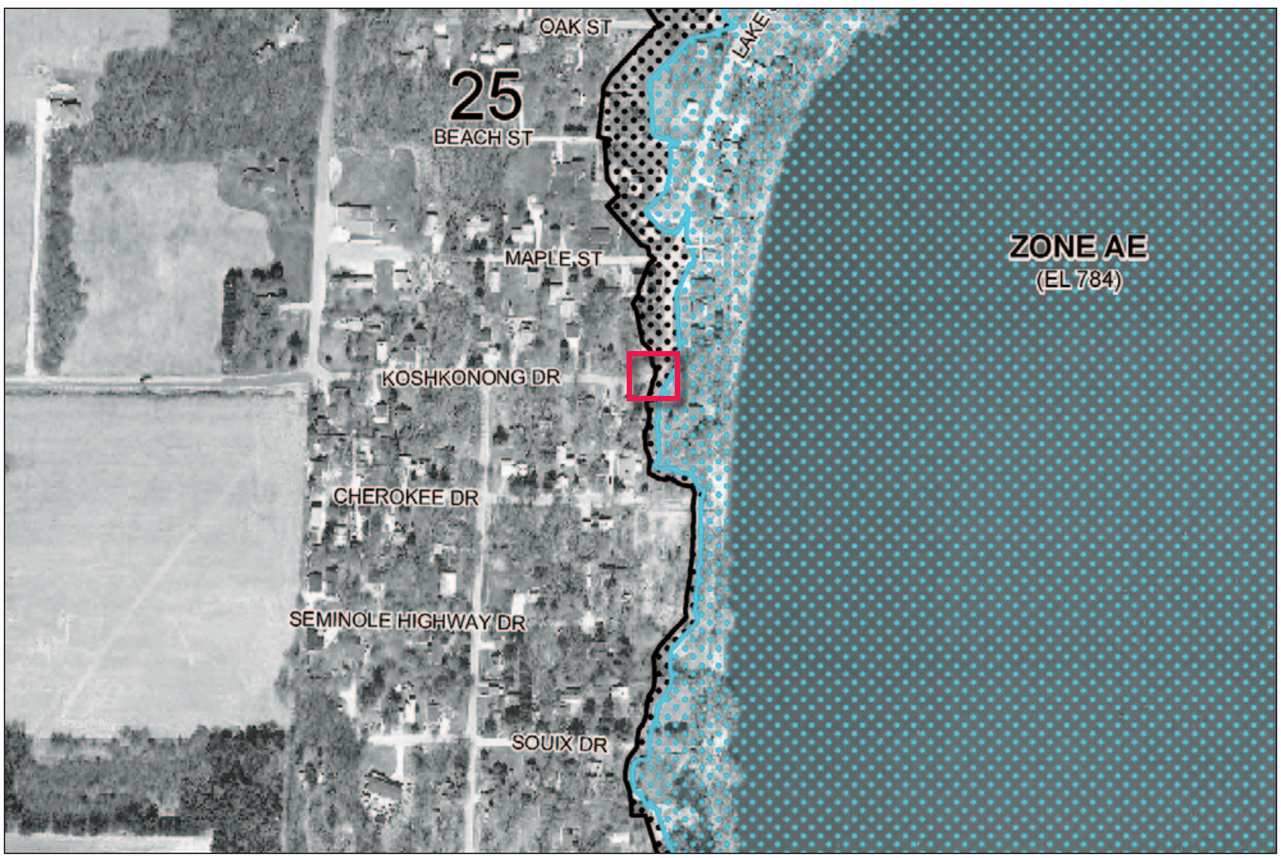

Figure 2-3. Location of elevated house

SOURCE: DANE COUNTY, WISCONSIN, FLOOD INSURANCE RATE MAP

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MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

3 Residential, Historic, and Commercial Buildings

Chapter 1 described the magnitude, duration, and geographic extent of damage of the 2008 Midwest floods. Many areas experienced the worst flood in their recorded history with rivers cresting at unprecedented levels and flood elevations exceeding those anticipated during a design event, forcing tens of thousands of people to be evacuated from their homes. While the flooding affected seven states in the Midwest (South Dakota, Minnesota, Wisconsin, Nebraska, Illinois, Indiana, and Iowa), the most damage occurred in Iowa and Wisconsin.

The MAT observed damages to residential, historic, and commercial buildings, as well as critical and essential facilities in the most affected Iowa and Wisconsin cities. Occupancy categories for buildings and other structures are defined by the American Society of Civil Engineers in two standards: ASCE 7, *Minimum Design Loads for Buildings and Other Structures,* and ASCE 24, *Flood Resistant*

Design and Construction. Chapter 3 of this MAT Report discusses Categories I and II (residential, historic, and commercial buildings); Chapter 4 discusses Categories III and IV (critical and essential facilities). Table 3-1 describes the ASCE occupancy categories.

Table 3-1. ASCE Occupancy Categories

Category	Nature of Occupancy
I	Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: ■ Agricultural facilities ■ Certain temporary facilities ■ Minor storage facilities
II	All buildings and other structures except those listed in Categories, I, III, and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: ■ Buildings and other structures where more than 300 people congregate in one area ■ Buildings and other structures with day-care facilities with capacity greater than 150 ■ Buildings and other structures with elementary school or secondary school facilities with capacity greater than 250 ■ Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities ■ Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities ■ Jails and detention facilities ■ Power generating stations and other public utility facilities not included in Category IV Buildings and other structures not included in Category IV (including, but not limited to facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials considered to be dangerous to the public if released. Buildings and other structures containing hazardous materials shall be eligible for classification as Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in ASCE 24-05, *Flood Resistant Design and Construction*, Section 1.5.2 that a release of the hazardous material does not pose a threat to the public.
IV	Buildings and other structures designated as essential facilities including, but not limited to: ■ Hospitals and other health care facilities having surgery or emergency treatment facilities ■ Fire, rescue, ambulance, and police stations and emergency vehicle garages ■ Designated earthquake, hurricane, or other emergency shelters ■ Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response ■ Power generating stations and other public utility facilities required in an emergency

Table 3-1. ASCE Occupancy Categories (continued)

Category	Nature of Occupancy
IV (cont.)	■ Ancillary structures (including but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operations of Category IV structures during an emergency ■ Aviation control towers, air traffic control centers, and emergency aircraft hangars ■ Water storage facilities and pump structures required to maintain water pressure for fire suppression ■ Buildings and other structures having critical national defense functions Buildings and other structures (including but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing extremely hazardous materials shall be eligible for classification as Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in ASCE 24-05, *Flood Resistant Design and Construction*, Section 1.5.2 that a release of the extremely hazardous material does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structure also function as essential facilities.

In detailing the damages observed by the MAT, Chapter 3 points out the importance of adhering to construction regulations and guidance involving such issues as foundation construction and anchoring, openings in foundation walls, elevation of new and existing facilities, placement of utility equipment, load path continuity, basements, mold and contamination, and regulatory requirements and actions. Chapter 3 also notes opportunities for building mitigation.

As noted in Chapter 1, site visits were conducted in Iowa and Wisconsin in August and September of 2008. As part of these site visits, information was gathered from local officials, facility managers, and homeowners, and photographs were provided to and taken by team members.

The city of Cedar Rapids was the most heavily impacted of any community visited by the MAT. The city encountered some of the most dramatic and costly damage due to the amount of infrastructure in the inundation area as well as the depth and duration of the flood. Figure 3-1 shows the downtown area inundated by floodwater and the associated flood zone map.

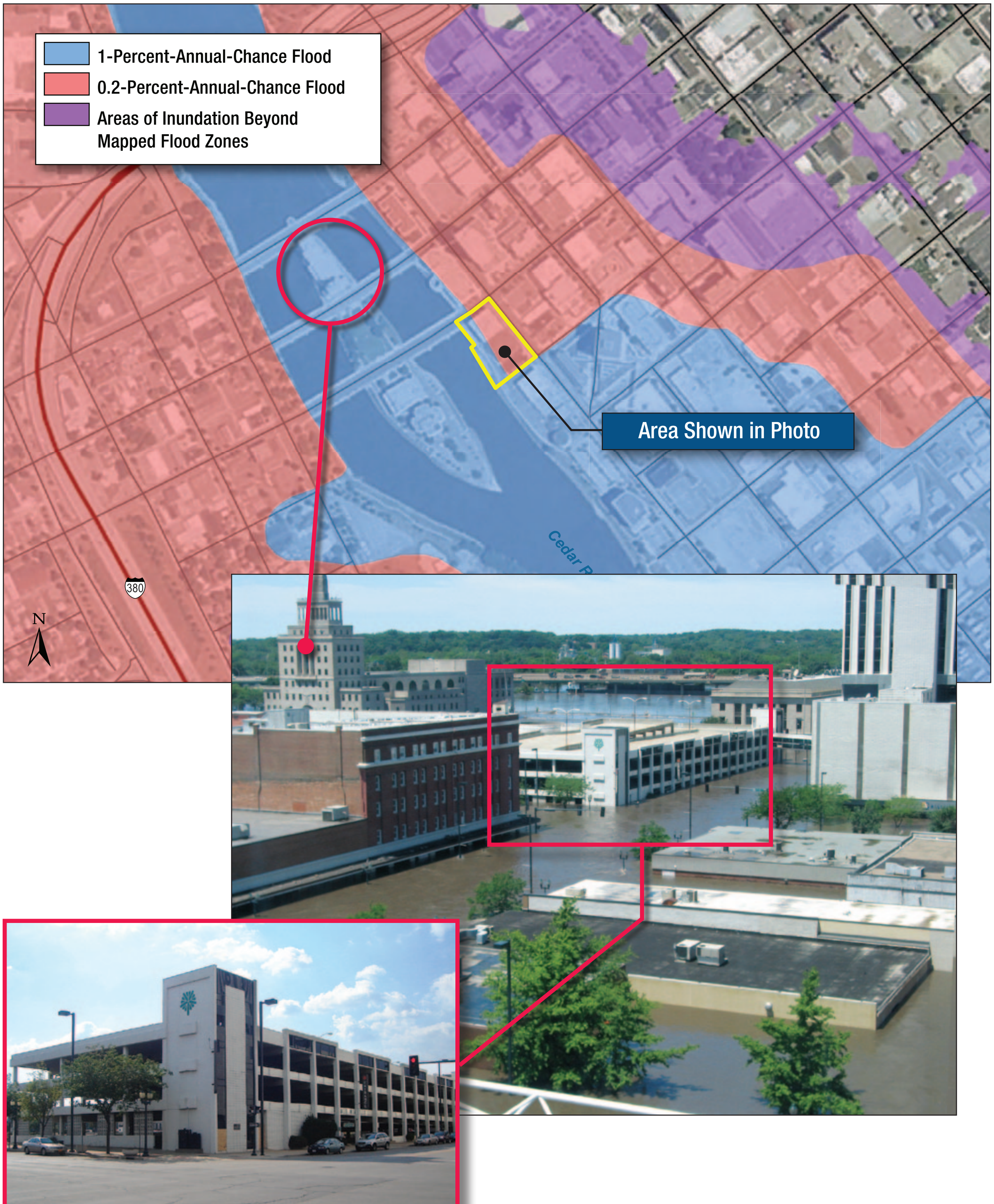


Figure 3-1.
Floodwater in the downtown Cedar Rapids commercial district exceeded 6 feet in several buildings, as shown by the parking facility and surrounding properties (Cedar Rapids, Iowa).

Figure 3-2 shows two buildings at the outer edge of the 0.2-percent-annual-chance flood zone (see also Figure 3-3). The waters were 4 feet above the first floor elevation at this location. This example highlights the residual risk and possibility of unexpected damage anywhere adjacent to even the 0.2-percent-annual-chance floodplain.

Figure 3-2.
Floodwaters covered 1,300 blocks and 9.2 square miles of Cedar Rapids (Cedar Rapids, Iowa).

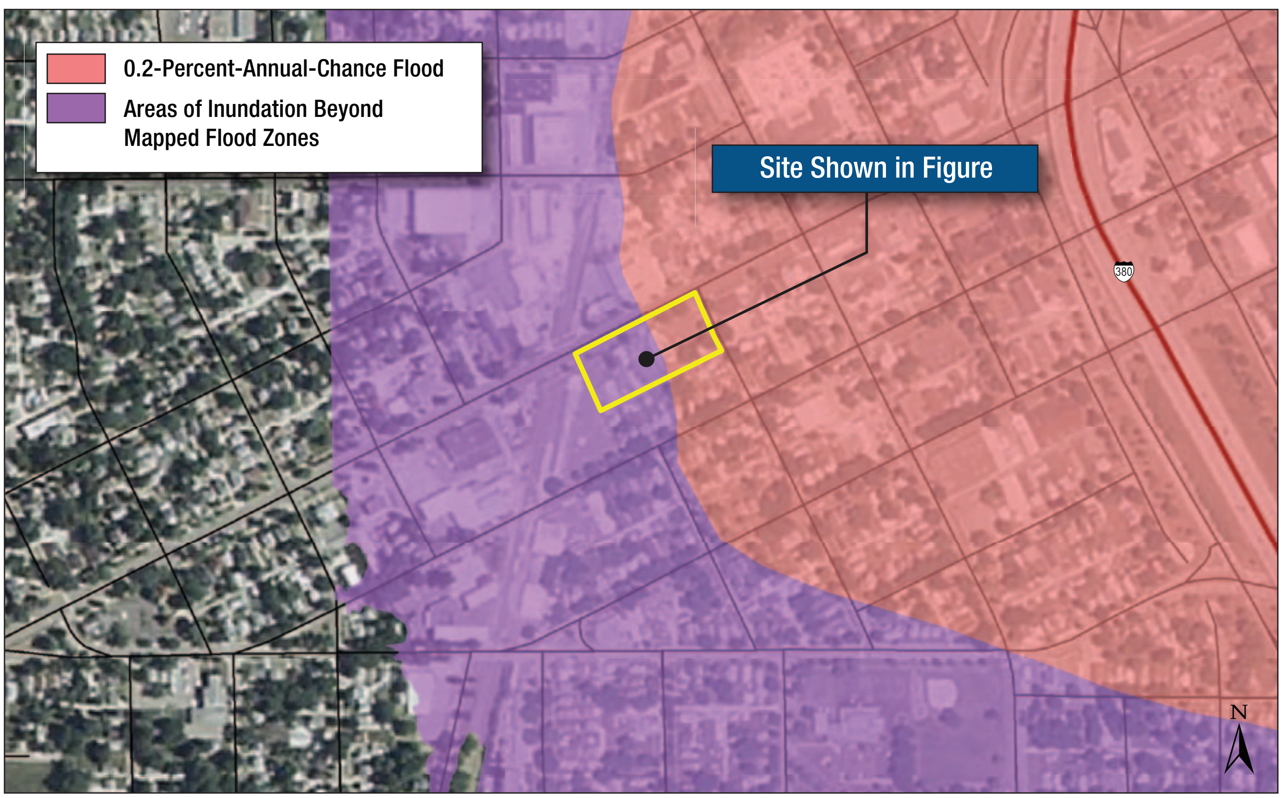


Figure 3-3.
Location of commercial buildings shown above at the outer edge of the 0.2-percent-annual-chance flood zone (Cedar Rapids, Iowa).

Several other communities visited by the MAT also experienced flooding, although not as widespread as in Cedar Rapids, that exceeded the 0.2-percent-annual-chance flood. Figures 3-4 to 3-10 illustrate different magnitudes of flooding throughout areas visited by the MAT.

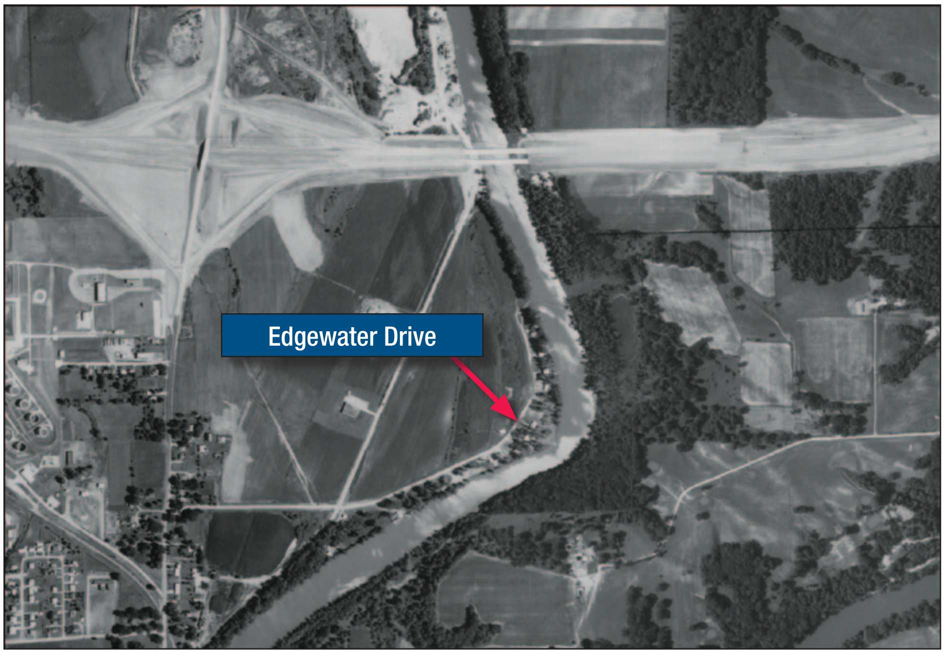
Figure 3-4.
Inundation in Gays Mills, Wisconsin, where most of the town including all of Main Street is located in the SFHA. Most buildings along Main Street experienced 3 to 5 feet of flooding.

Figure 3-5.
Commercial and residential buildings in Rock Springs, Wisconsin, along the Baraboo River where the flood was estimated to be a 0.2-percent-annual-chance flood were inundated with over 4 feet of water (dashed red line indicates the water line).

Figure 3-6.
This house in Oakville, Iowa, a community protected by a levee that was overtopped by the Iowa River, was flooded with over 7 feet of water.

Figure 3-7. Buildings located within the SFHA along the Rock River in Rock County, Wisconsin, where the flood is estimated to have exceeded the 1-percent-annual-chance flood, experienced 2 to 4 feet of flooding.

Figure 3-8.
The recently developed Coralville Conference Center (outlined in red) downstream of the Coralville Dam (outlined in blue) implemented emergency protective measures, primarily sandbags, to limit flooding to a few inches of water on the main floor (Coralville, Iowa).



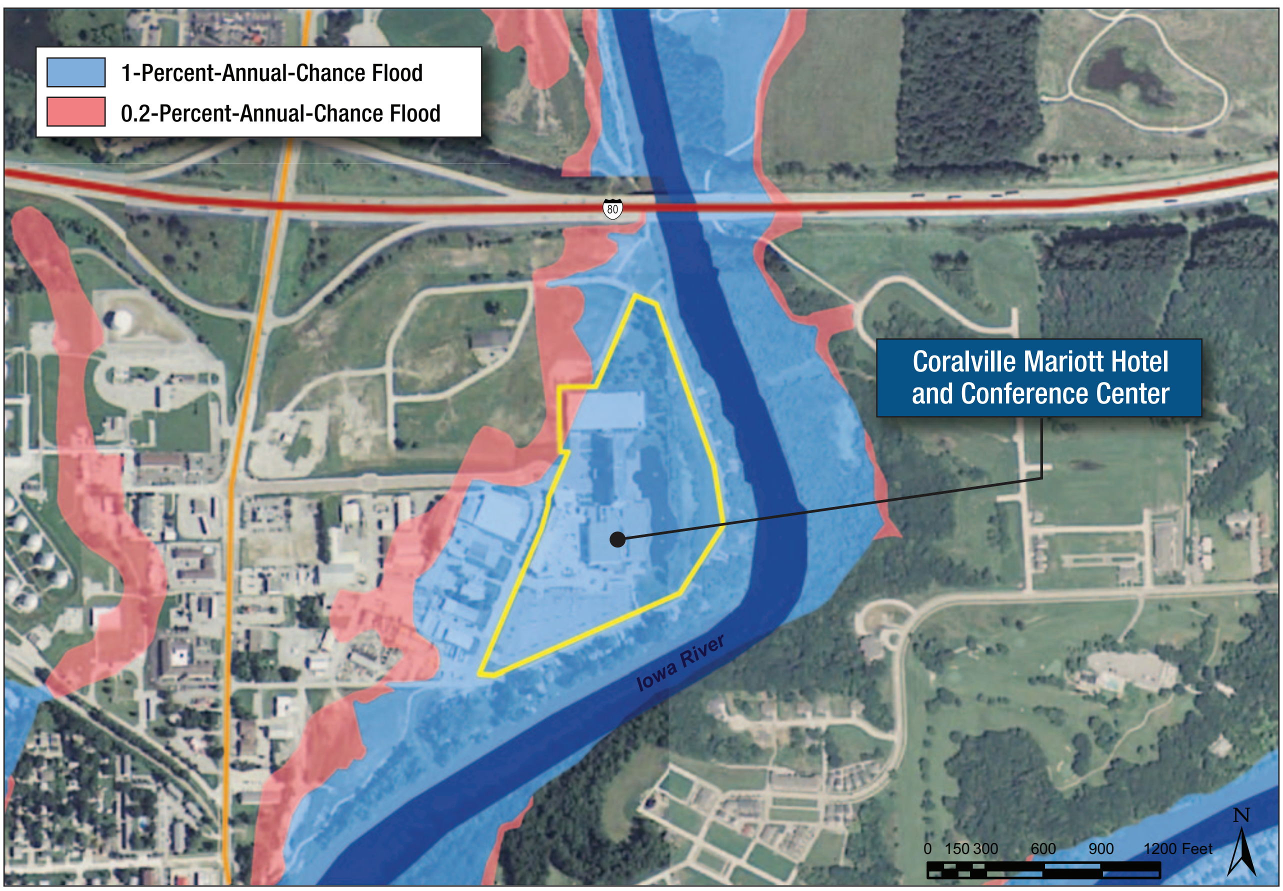


Figure 3-9.
The Coralville Conference Center is located on the former site of Edgewater Park and in the SFHA, 3 feet above the BFE. The two aerials reflect the development along Edgewater Drive over the past four decades (Coralville, Iowa).

Figure 3-10.
Although the Conference Center suffered minor damage, the adjacent buildings had extensive interior damage on the first floor (Coralville, Iowa).

3.1 Residential Properties

As previously noted in this report, residential structures were subject to a greater than design level of flooding in several communities visited by the MAT. Figure 3-11 shows a Cedar Rapids residential neighborhood in the 0.2-percent-annual-chance floodplain that had several feet of inundation. Flooding in Iowa and Wisconsin caused both velocity-flow and inundation damage; however, most of the damage was due to slow rising inundation. Due to high levels of soil saturation, these floodwaters also remained for weeks in some areas, much longer than typical flood events. The duration impacted recovery operations and hindered owners from returning to their properties to limit mold growth and further damages to their facility. The areas impacted by high-velocity flow were near floodways, at overtopped/breached levees, or near areas of flood flow constriction. The MAT surveyed single and multi-family residences, including some that were under repair at the time of the MAT visit and some that had been constructed subsequent to the flood event. The MAT also looked at several examples of residential elevation and acquisition projects, and two locations that had been developed and removed from the SFHA by an approved LOMR-F.

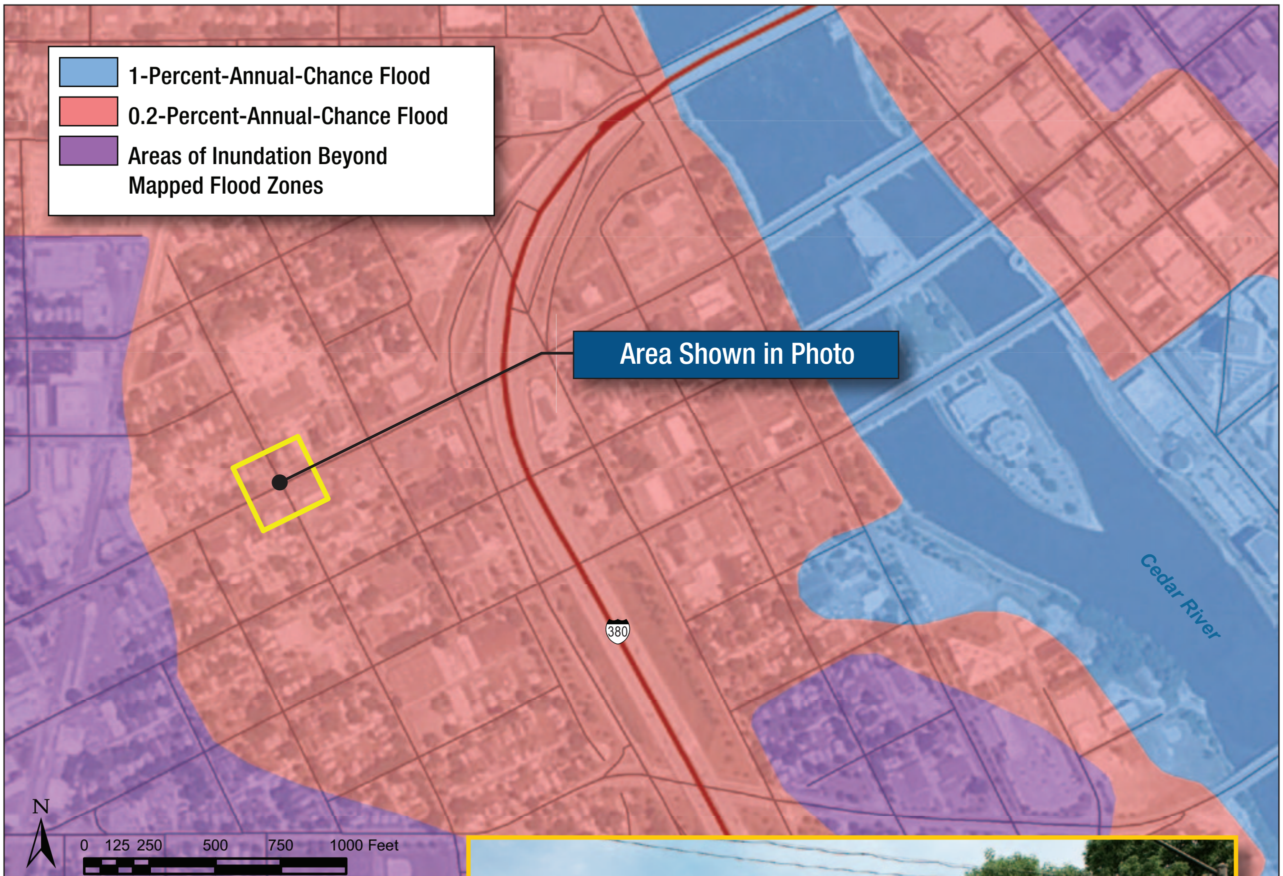


Figure 3-11.
Floodwaters in a residential area of Cedar Rapids during the flood (Cedar Rapids, Iowa).

Communities conducted inspections and tagged buildings to allow citizens back into safe homes and businesses as quickly as possible, while keeping people out of unsafe structures (see Figure 3-12). The magnitude of the event forced several jurisdictions to train and/or contract new staff to assist with damage assessments and code enforcement after the event. Several communities including Cedar Rapids and Oakville in Iowa, and Gays Mills in Wisconsin experienced flooding that required a substantial damage determination on practically every home because almost the entire SFHA was flooded. In Iowa, over 3,000 Residential Substantial Damage Estimate (RSDE) inspections were completed in the Cedar Rapids area alone, approximately half of which were deemed substantially damaged. Several communities contacted local home builders associations to help identify qualified personnel, trained the personnel, and used them to support code enforcement for repairs and reconstruction.

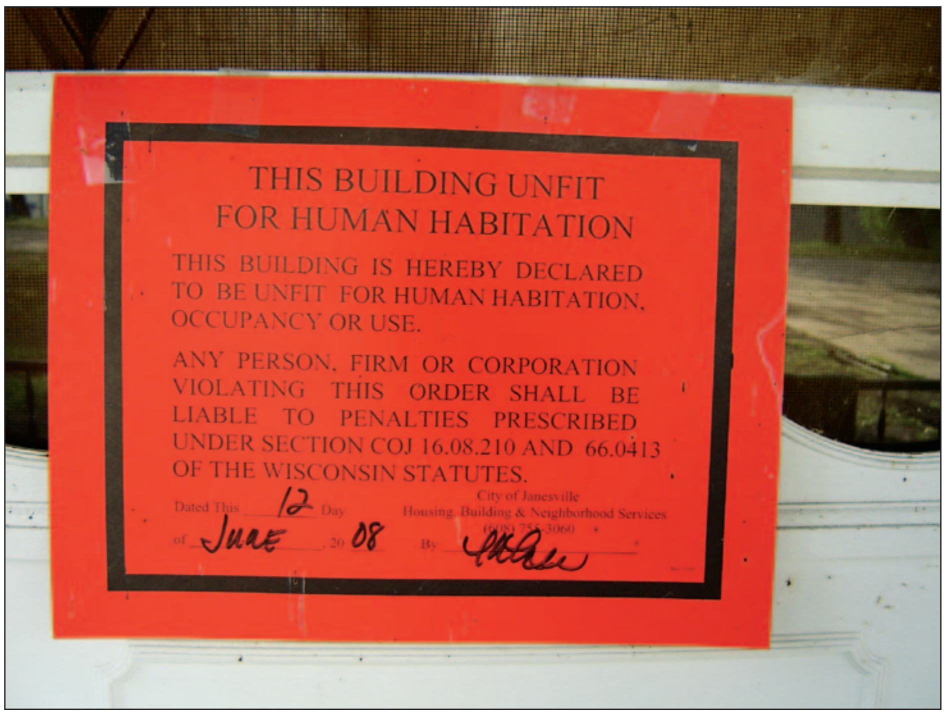


Figure 3-12. Sample placard for a building that was deemed unsafe to enter by inspectors (Janesville, Wisconsin).

3.1.1 Overview of Damages

There was significant damage to homes in the SFHA throughout the areas visited by the MAT in Iowa and Wisconsin. Figure 3-13 provides a location map for the flood damaged homes located adjacent to the Cedar River that are shown in Figures 3-14 through 3-17.

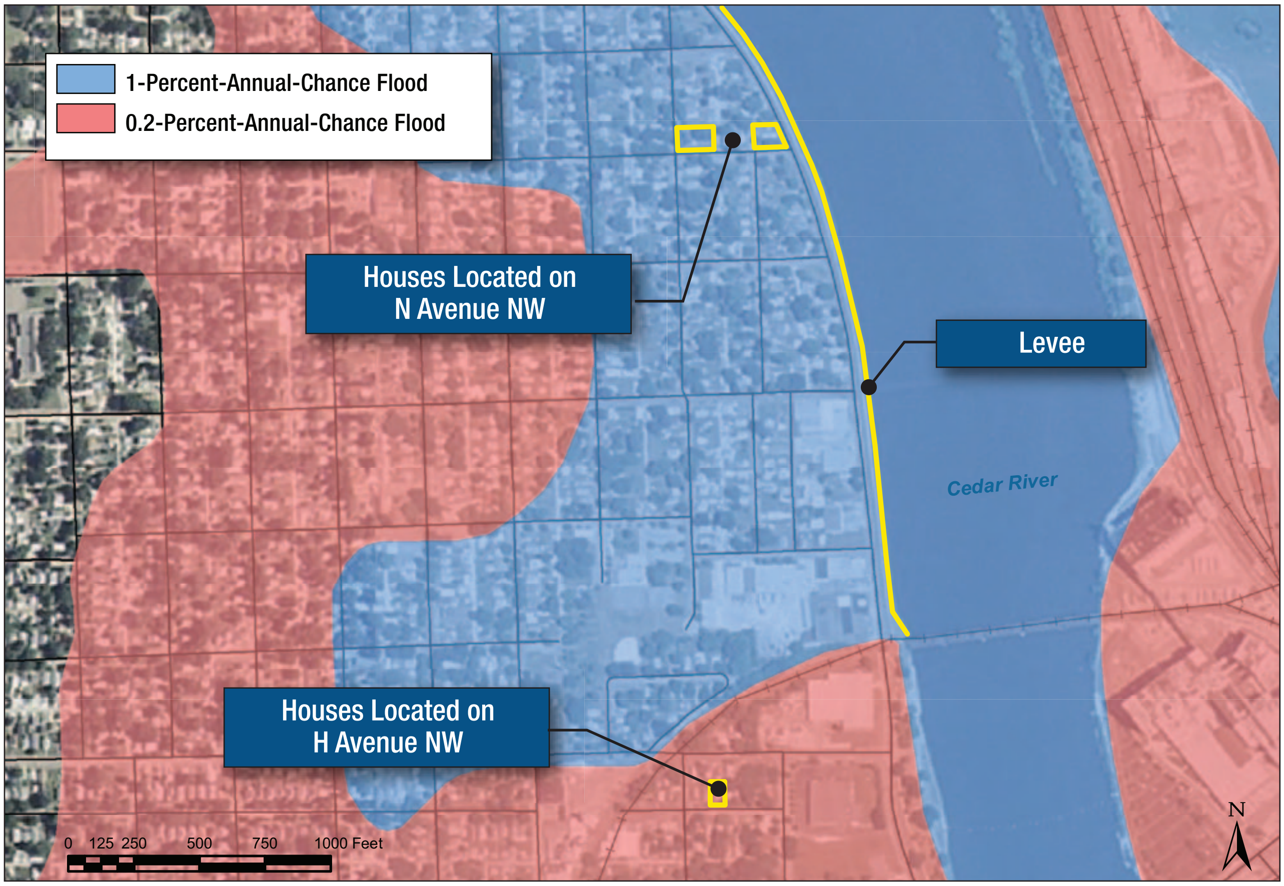


Figure 3-13. Location map for Figures 3-14 through 3-17 (Cedar Rapids, Iowa).

Figure 3-14.
Pre-FIRM house located in the SFHA at N Avenue NW. Floodwater reached the eaves of these houses located a few blocks from a levee (red line indicates flood level) (Cedar Rapids, Iowa).

Figure 3-15.
Pre-FIRM home at N Avenue NW located in the SFHA. Water marks near top of door and window frame. Marks are several feet above the levee seen in the background (Cedar Rapids, Iowa).

Figure 3-16.
Pre-FIRM house at H Avenue NW. Floodwaters reached the ceiling of the first floor in this house located outside the SFHA (Cedar Rapids, Iowa).

Figure 3-17.
This is another view of the house in Figure 3-16. The side wall and the adjacent structures are displaced in a way that suggests high-velocity water flows through this neighborhood (Cedar Rapids, Iowa).

The flooding of the living areas in residences caused damage to the architectural finishes, cabinetry, insulation, ductwork, electrical system, and appliances to the extent that they will most likely need to be removed and replaced. The MAT also observed damage to the wood framing, nails, and insulation, and the presence of mold, as a result of elevated moisture levels in post-flood walls, as evidenced in Figures 3-18 and 3-19. Such extensive damage can result from delayed recovery efforts.

Figure 3-18.
Condensation can be seen beading up on the inside face of the vapor barrier (red circle). The increased humidity has initiated the growth of black mold (blue circle), started the rusting of the nails (blue arrow), and the wood is still wet as can be seen by the dark patches on the studs (red arrow) (Cedar Rapids, Iowa).

Figure 3-19.
The kitchen countertops, cabinets, appliances, etc., had been submerged and destroyed (Cedar Rapids, Iowa).

Some buildings located in the area of inundation were displaced from their foundations because they lacked sufficient connections to secure them. Figure 3-20 shows an older masonry foundation that did not have adequate connections to anchor the structure.

Figure 3-20.
This pre-FIRM house located in the SFHA was displaced from its foundation into the roadway adjacent to it. The photo below shows the building's original location. The red line indicates the depth of flooding (Cedar Rapids, Iowa).

The most common form of structural damage to residential buildings observed by the MAT was the failure of foundation walls, especially those constructed of unreinforced masonry, as a result of lateral pressures from saturated soils and hydrostatic pressure, as illustrated in Figures 3-21 to 3-27.

Figure 3-21.
Failure of unreinforced masonry foundation walls due to hydrostatic pressure observed in various locations in Iowa.

Figure 3-22.
Collapse of a foundation wall due to hydrostatic forces (Viola, Wisconsin).

Figure 3-23.
This foundation wall collapsed due to hydrostatic pressure (Reedsburg, Wisconsin).

Figure 3-24.
This basement wall failed and almost collapsed due to lateral pressures from saturated soils (Shell Rock, Iowa).

DEFINITION

Hydrostatic force is a force exerted by water at rest, including lateral pressure on walls and uplift (buoyancy) on floors

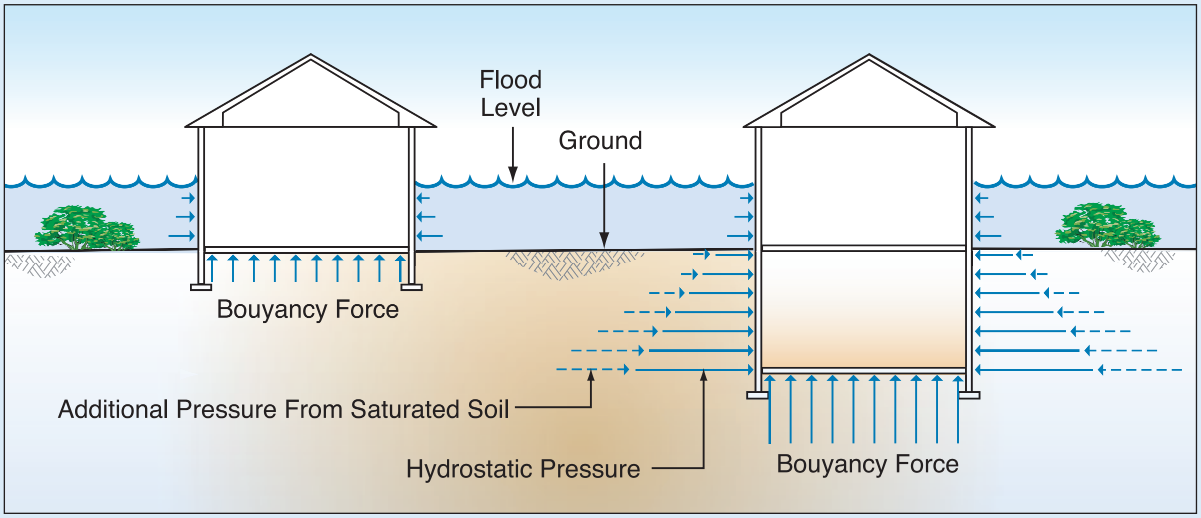


Figure 3-25.
This house had two walls that were damaged due to hydrostatic pressure (Reedsburg, Wisconsin).

Figure 3-26.
Example of a completed foundation wall repair that included vertical steel reinforcement and grout throughout the repaired wall to improve the strength and performance of the foundation (Waverly, Iowa).

Figure 3-27.
Interior view of the completed foundation wall repair in Figure 3-26; the owner stated that they placed horizontal steel reinforcement where possible along the top row of masonry blocks to create a bond beam. The yellow and blue lines are suggested reinforcing locations. This wall shows an alternative of external reinforcing of the wall using steel angles (red arrows) (Waverly, Iowa).

The IRC suggests a #5 bar every 48" for these masonry walls holding back 5 feet of fill not subject to hydrostatic pressure from groundwater. In the event that groundwater is in the soils in the unbalance backfill, the IRC requires engineering design. The reinforcing required to withstand 5 feet of water-laden soils is approximately a #5 bar every 16", or one per block, three times the number shown. Bond beams are recommended at all opening perimeters as well as at the top and bottom of the wall. Horizontal joint reinforcing should also be used every 16" vertically (blue dashes in Figure 3-27).

It is important to remember that repairing and reinforcing only the failed portions of a basement will not completely address weaknesses in the structure, and the basement will remain vulnerable to failure during future floods. In most homes with basements, all basement walls are constructed similarly and have similar strengths (see text box). When walls are similarly constructed, the relative performance of individual walls becomes a function of the loads applied to them and not of their strengths. Walls fail not because they are greatly weaker than adjacent walls but because the loads on them are greater. When a basement wall fails during a flood, the failure typically allows water to flow into the basement. Water filling a basement immediately reduces the forces on the remaining walls and essentially denies those walls the opportunity to fail. When basement walls are only partially reconstructed, the original walls that did not fail remain relatively weak and vulnerable during future floods.

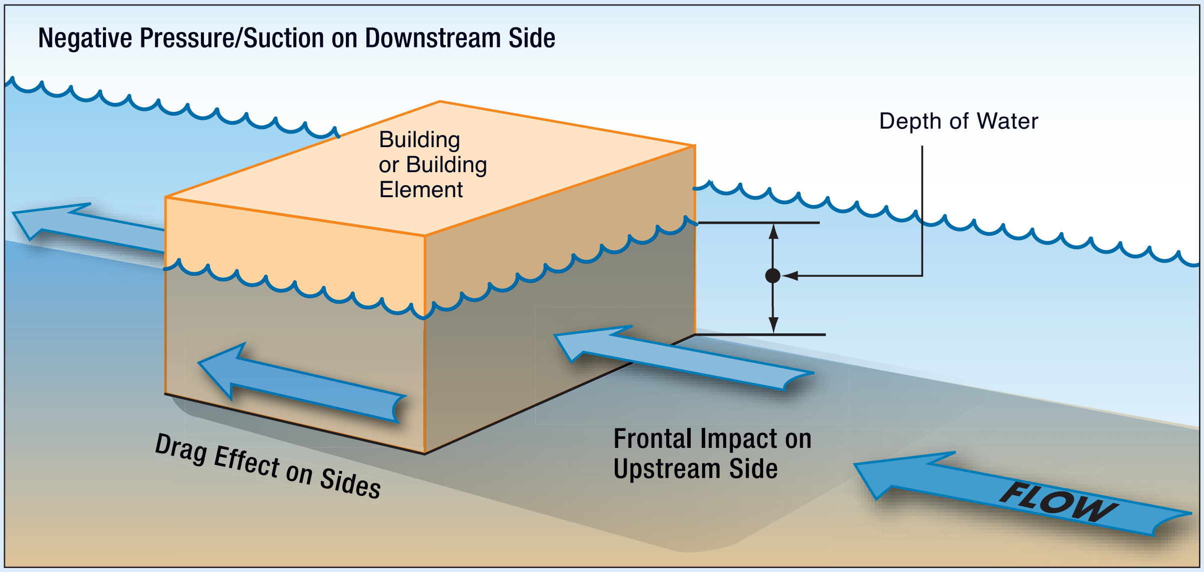
When basement walls fail, they typically fail in flexure, by trying to bend in toward the house. That is, their resistance to bending (flexure) is less than the *bending* caused by the lateral loads from floodwater and retained soils. Flexural stresses in a basement wall range from positive (compression) stresses on the outside surfaces of the walls and can become negative (tensile) stresses on the walls' inside surfaces. Since unreinforced masonry (and concrete) is inherently strong in compression but weak in tension most flexural failures are tensile failures.

Most structures visited by the MAT were impacted by water velocities that were slow enough that the buildings showed signs of inundation but not movement; however, there were occasional incidences of high-velocity flow that moved structures off their foundations. Buildings near breached or overtopped levees were most susceptible to high-velocity floodwaters that caused scour, carried large flood-borne debris, and imposed hydrodynamic forces that impacted the structural integrity of the building. In some areas, major structural damage resulted to both the foundation and the superstructure. Some structures were displaced from their foundations and driven into nearby spaces, roads, and the river. Figure 3-28 shows a house impacted by high-velocity floodwater.

Figure 3-28.
The house on the left experienced high-velocity flow that passed through the lower level of the structure. The house on the right had living space at the same elevation, and the rear of the house was displaced. The red outline is the original location of the wall; the red arrow points to the location of the wall after the flood. This area experienced flooding that exceeded the estimated 0.2-percent-annual-chance flood (Coralville, Iowa).

DEFINITION

Hydrodynamic force is imposed on an object, such as a building, by water flowing against and around it.



Several homes experienced flows with sufficient velocity that the houses were displaced from their foundations and moved several yards, as shown in Figures 3-29 through 3-35.

Figure 3-29.
This garage was swept away and over the adjacent levee. The remnants of the garage are seen in the right edge of the inset (red arrow) (Waterloo, Iowa).

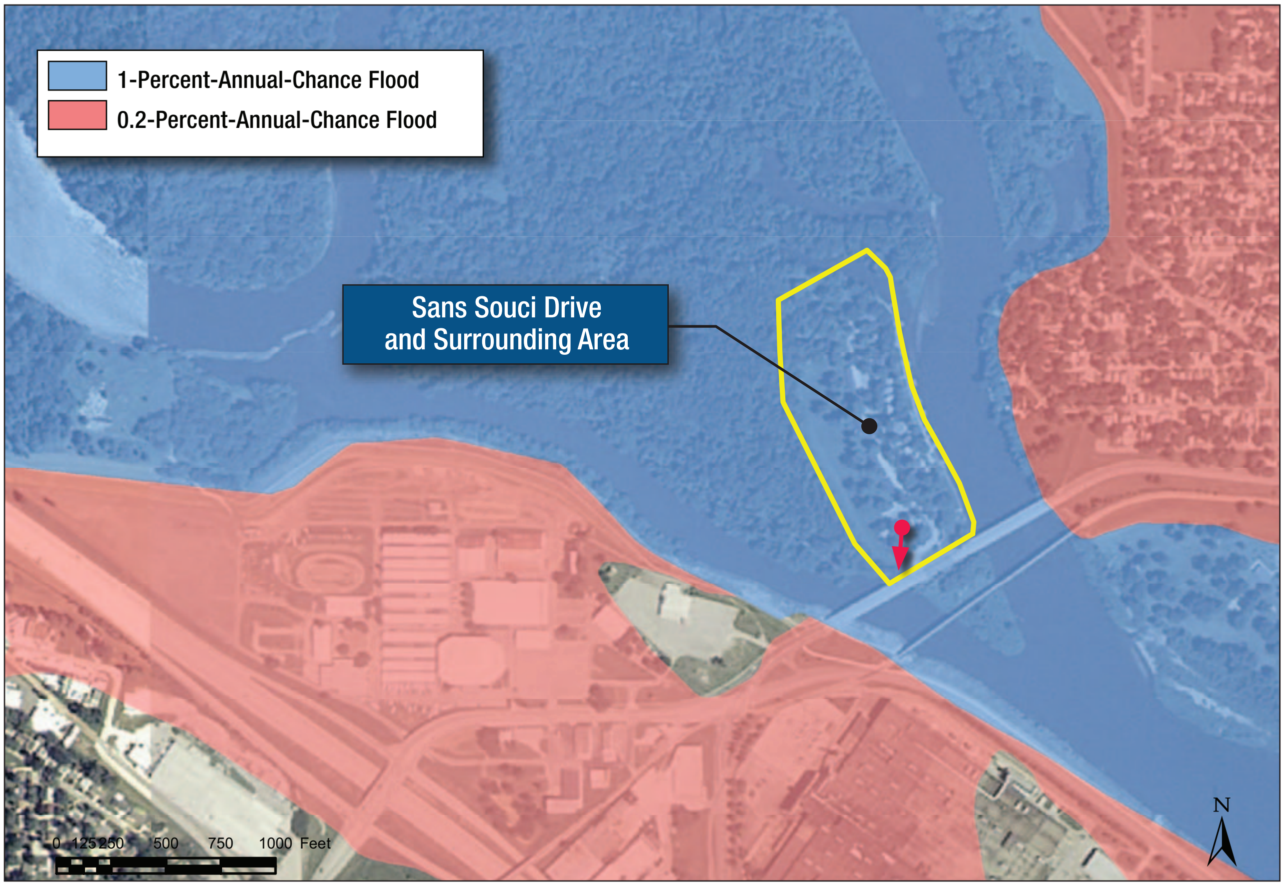


Figure 3-30.
The red arrow traces the path of the displaced structure shown in Figure 3-29. The debris field was found approximately 250 feet away from its origin (Waterloo, Iowa).

Figure 3-31.
This foundation wall was subject to scour caused by high-velocity flow after a levee was overtopped by floodwater (Oakville, Iowa).

Figure 3-32.
These failed connections were used to secure a home to a reinforced concrete foundation wall and were spaced every 6 to 7 feet (Oakville, Iowa).

Figure 3-33.
The home that was on this foundation was moved several hundred feet away by the floodwater that overtopped a levee (Oakville, Iowa).

Figure 3-34.
The home actually remained intact after being forced away from its foundation (this is the same manufactured home referenced in Figures 3-31 to 3-33) (Oakville, Iowa).

Figure 3-35. The framing for the portion of the home that remained in place was bolted down to the foundation (this is the same manufactured home referenced in Figure 3-31 through 3-34) (Oakville, Iowa).

Buildings constructed on open foundations in areas that experienced high-velocity flow remained in place and because they were generally elevated higher, suffered less damage. Figures 3-36 to 3-38 are examples of residential buildings constructed on open foundations. The buildings were located near the home that was relocated and illustrated in Figures 3-31 to 3-35.

Figure 3-36.
Residential building constructed on open foundation that suffered considerably less damage than those on closed foundations in the same area (Oakville, Iowa).

Figure 3-37.
Residential building constructed on open foundation that suffered considerably less damage than those on closed foundations in the same area. Slender columns such as those shown here offer little resistance to lateral loads that can occur from flooding and debris. Accounting for gravity and lateral loads, not just elevation, should be considered during design (Oakville, Iowa).

Figure 3-38.
Residential building constructed on open foundation that suffered considerably less damage than those on closed foundations in the same area (Oakville, Iowa).

3.1.2 Residential Basements

Basements in the Midwest have traditionally been constructed as part of residential houses. They provide protection from tornadoes, aid in designing for frost depth, and provide additional usable space at low cost when part of the initial construction. However, their below-grade location makes them a liability during floods. Throughout the areas visited by the MAT, groundwater entered basements through pre-existing cracks and openings in the floors and walls (see Figure 3-39).

Because of their low elevation, it is difficult to keep water out of basements when the water level is higher than the basement floor. In addition, keeping water out is not advised because of potential structural damage caused by floodwater-saturated soil exerting additional pressure against basement walls. As discussed in the previous section, in several instances the basement walls failed due to hydrostatic forces. However, several homeowners indicated they opened basement doors and windows so that floodwater could readily enter and equalize the hydrostatic forces on the basement walls. The intrusion of floodwater resulted in significant damage to basement contents and walls, finishes, and floor coverings. In many homes, the mechanical and electrical systems were located in the basement for convenience and space concerns, and, as a result, the systems were severely damaged. Figures 3-40 and 3-41 show a displaced water heater and other utilities that were damaged due to flooding.

DEFINITION

Basement is defined as an area of a building having its floor sub-grade (below ground level) on all sides. The lowest floor of a residential building including basement must be at or above the BFE. Basements below the BFE are allowed only in communities that have obtained a basement exception from FEMA.

Figure 3-39.
Basement windows, like the ones on these houses, were typical locations for floodwater to enter a basement (Gays Mills, Wisconsin).

Figure 3-40.
This basement sustained damage to the mechanical and plumbing systems of the home (Waverly, Iowa).

Figure 3-41.
Basement located in a circa 1880s house. This basement has a furnace and other utilities that were inundated with 6 to 8 feet of standing water (Rock Springs, Wisconsin).

After a flood, homeowners should exercise extreme caution if their basement is inundated. Homeowners should not pump water out of a basement immediately following a flood. Even after the flood crest has passed and floodwater has receded, homeowners should avoid removing water from a basement too quickly so as to prevent basement wall and floor failure due to hydrostatic forces. Although most property owners impacted by the 2008 floods knew not to pump out their basements, Figure 3-42 provides an example of a basement that was pumped out too soon.

Figure 3-42.
This foundation wall collapsed when the homeowner prematurely pumped water out of the basement (Palo, Iowa).

The NFIP floodplain management criteria at 44 CFR §60.6(c) allow exceptions to permit construction of floodproofed basements along streams in certain flood zones and when flood characteristics throughout the community meet specified criteria (see Chapter 2).

The MAT visited La Porte City, Iowa, one of the communities approved for residential basement exceptions. The certified floodproofed basements visited had drainage systems with sump pumps and reinforced concrete walls and performed as designed with no structural failures observed or reported. Figure 3-43 shows a residential property with an engineered basement in La Porte City.

> **Certified residential basements** are floodproofed with walls that are impermeable, walls and floors that are capable of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy resulting from flooding, and designed so that minimal damage will occur from floods exceeding the floodproofing design elevation (which must be at least 1 foot above the BFE). These basements must be certified by a professional engineer or architect using FEMA form 81-78.

Damage in one newly engineered basement was reported by a homeowner where floodwater exceeded the floodproofing design elevation. These damages were in a basement just outside the SFHA (see Figure 3-44).

**Figure 3-43.
Post-FIRM construction with a basement in a community approved for residential basement floodproofing. The basement performed as designed with a pump removing all flood and groundwater that entered (La Porte City, Iowa).**

Figure 3-44.
This house located just outside the SFHA suffered no damage on the first floor (unlike the adjacent property), but the basement suffered damages to architectural finishes, electrical systems, and contents (Palo, Iowa).

It is important for communities to ensure basements are removed (unless properly approved) when substantially damaged properties are being elevated or reconstructed in the SFHA. Figures 3-45 and 3-46 are examples of completed and ongoing elevation projects where basements were kept in the SFHA.

Figure 3-45.
Completed elevation project where the basement was not removed; this violation was recorded prior to the 2008 floods (Coralville, Iowa).

Figure 3-46. Ongoing elevation of property located in the floodplain where homeowner was planning to keep the basement (Vinton, Iowa).

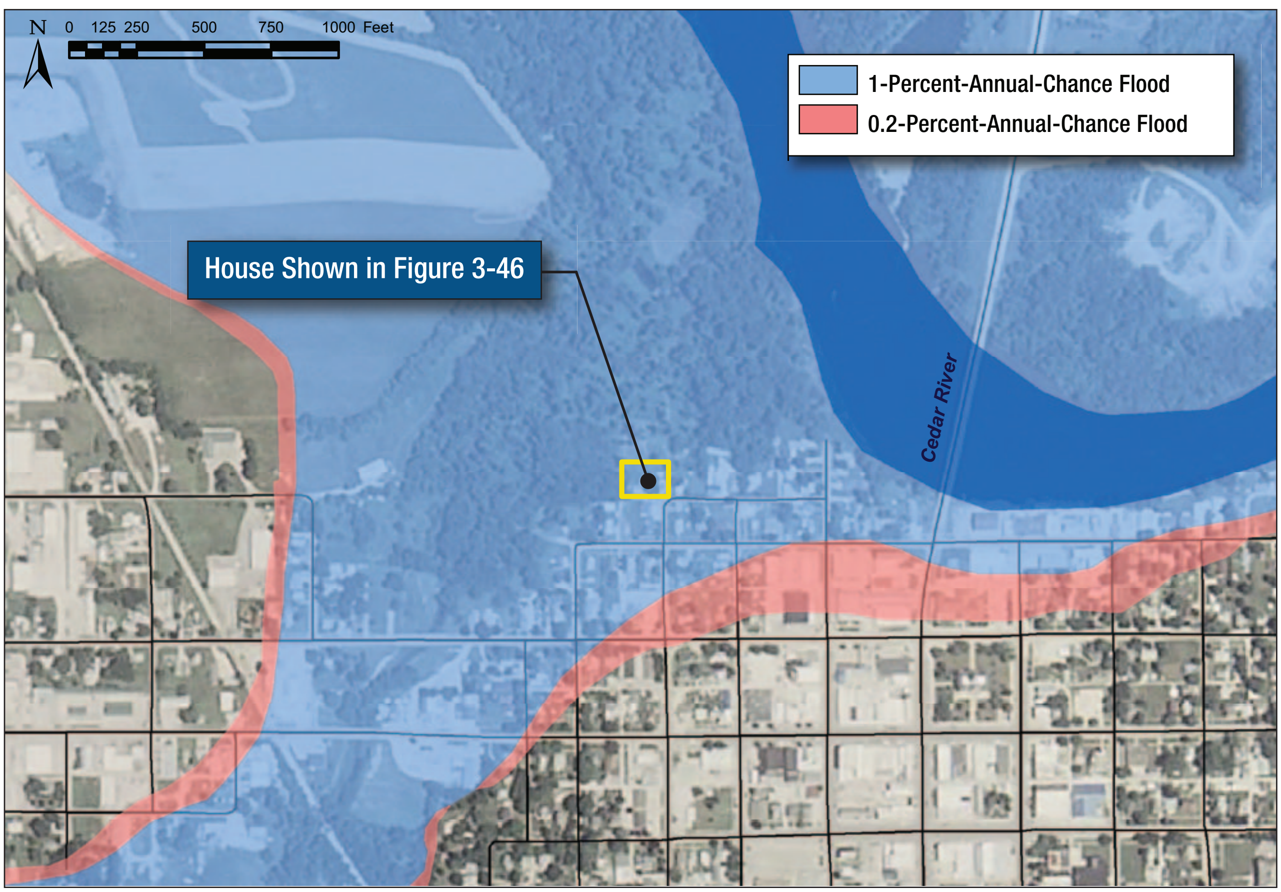


Figure 3-47. Location map for Figure 3-46 (Vinton, Iowa).

3.1.3 Residential Post-FIRM Elevated Buildings

The MAT visited numerous residential sites where owners had either already elevated their existing homes to avoid flooding or were in the process of doing so. Throughout Wisconsin, properties were elevated on fill two or more feet above the BFE (see Figure 3-48).

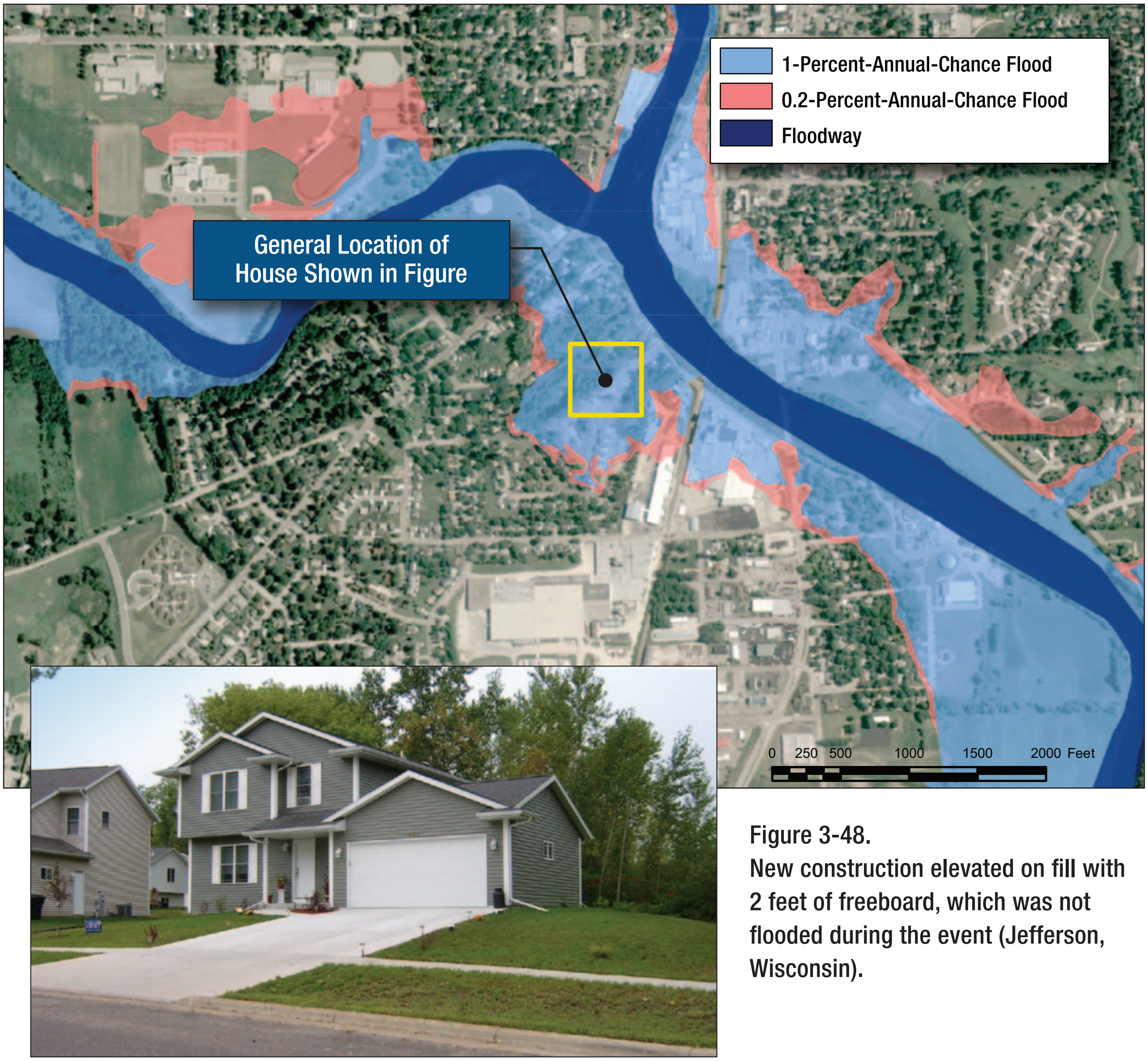


Figure 3-48.
New construction elevated on fill with 2 feet of freeboard, which was not flooded during the event (Jefferson, Wisconsin).

The Koshkonong, Wisconsin, community had several ongoing elevation projects of existing homes at the time of the MAT visit (see Figure 3-49).

Figure 3-49.
Existing house being elevated 2 feet above the BFE (Koshkonong, Wisconsin).

The MAT observed several elevated buildings in the SFHA without openings in their foundation walls that met the NFIP regulations. Several buildings did not have any openings while others either did not have enough or they were not at the proper elevation. The openings on the newly elevated house shown in Figure 3-50 are not within one foot of either interior or exterior grade as required.

Figure 3-50.
Recently completed elevation project, properly elevated above BFE; however, the foundation does not have openings at the proper height (red circles). The crawl space floor is at the same elevation as the exterior grade (New Hartford, Iowa).

Figures 3-51 through 3-57 illustrate additional observations made by the MAT related to openings that were not in compliance with NFIP regulations.

Figure 3-51.
This property, which was constructed not long before the Midwest floods, is elevated several feet above BFE and was the least damaged along a row of more than 50 riverfront properties (Iowa City, Iowa).

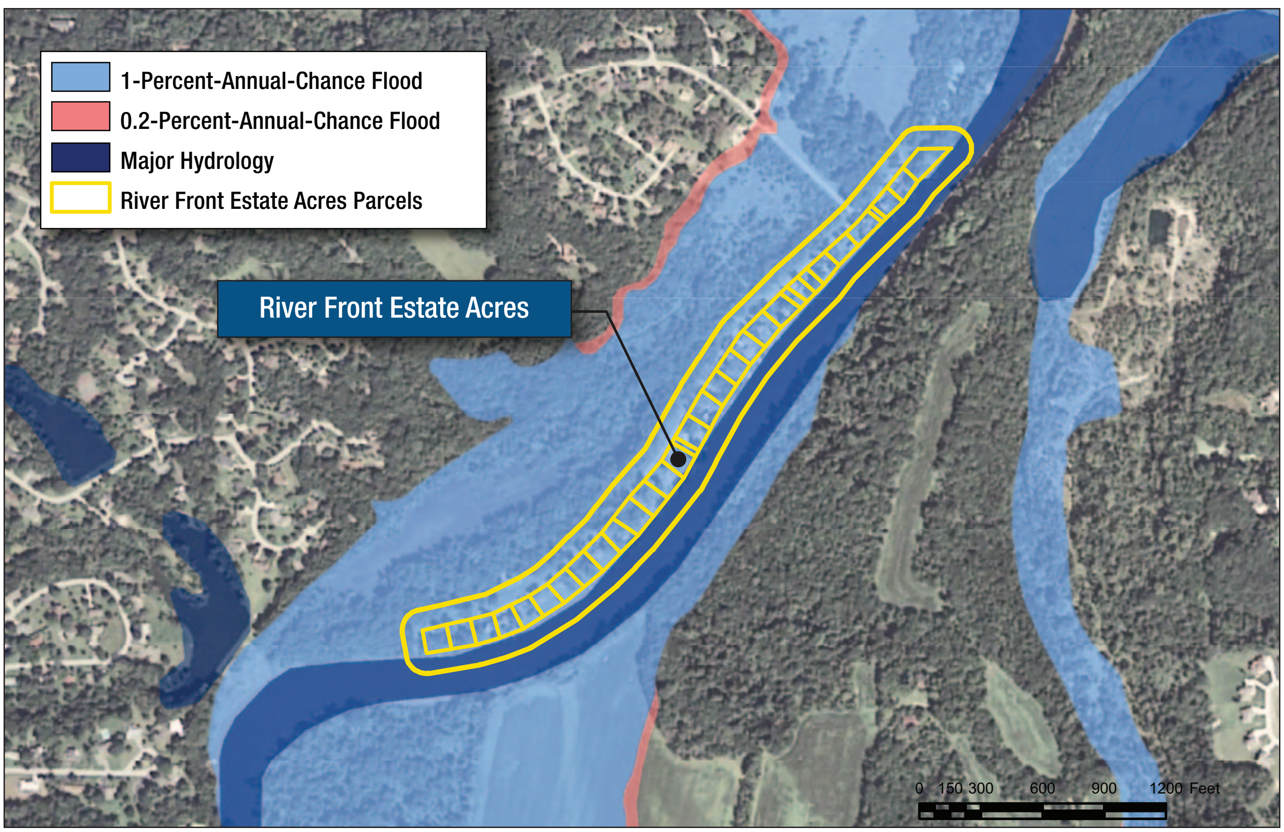


Figure 3-52.
The house in Figure 3-51 is located in River Front Estate Acres depicted above. The lots are located on the river's edge in the SFHA (Iowa City, Iowa).

Figure 3-53.
This riverfront house's two-car garage was one of only a few properties throughout the areas visited by the MAT with proper flood vent openings (Iowa City, Iowa).

Figure 3-54.
Unlike the garage, the riverfront house's flood openings were obstructed (Iowa City, Iowa).

Figure 3-55.
The homeowner had covered the openings on both the house and garage during the flood (Iowa City, Iowa).

Figure 3-56.
Foundation opening that does not conform to NFIP requirements for openings in foundation walls and walls of enclosures for structures in the floodplain (Blackhawk Island, Wisconsin).

Figure 3-57.
This house located in the SFHA had openings for ventilation of the crawl space, but were too high to be compliant flood openings (Gays Mills, Wisconsin).

Figure 3-58 shows an example of a house with openings at the proper height.

Figure 3-58.
This house located in the SFHA had openings installed within 12 inches of exterior and interior grade (La Valle, Wisconsin).

The MAT observed several ongoing elevation projects, most of which were being funded by the homeowner without federal grant or insurance money. In each case, homeowners were meeting their floodplain management ordinances for required elevation, and several were actually exceeding local requirements and elevating 2 to 3 feet higher to avoid future damages. Figures 3-59 through 3-62 illustrate observations at ongoing elevation projects.

Figure 3-59. Existing house in the process of being elevated by homeowner (Cedar Rapids, Iowa).

Figure 3-60. Most foundations were being built with anchor bolts to create a connection between the elevated house and the new foundation. For this project to be effective there must be a continuous load path and the use of frequently spaced reinforced cells in the block foundation walls. This house is located in the SFHA and is being elevated approximately 4 feet above the BFE (Iowa City, Iowa).

Figure 3-61.
This foundation has a well established layout for anchoring the sill plate. This connection is critical to the proper performance of the building in high-load events (Parkersburg, Iowa).

Figure 3-62.
Ongoing elevation of a property located in the SFHA where the foundation is prepared to establish secure connection between the foundation wall and the existing house. Upon completion, the house will have a crawlspace with openings at the proper elevation (Gays Mills, Wisconsin).

Local involvement in adoption of current building codes, strong floodplain ordinance regulation, and participation in acquisition programs appears to be an effective means of managing development in the floodplain. This is evidenced by the limited amount of new construction observed in the SFHA. Those buildings that are built in the SFHA are elevated above the BFE, i.e., with freeboard (see Figures 3-63 and 3-64).

Figure 3-63.
Structure in Reedsburg, Wisconsin, where the lowest floor is elevated 2 feet above BFE (red line shows the high water mark). The insert shows the interior of the adjacent pre-FIRM building had 3 feet of water above the first floor.

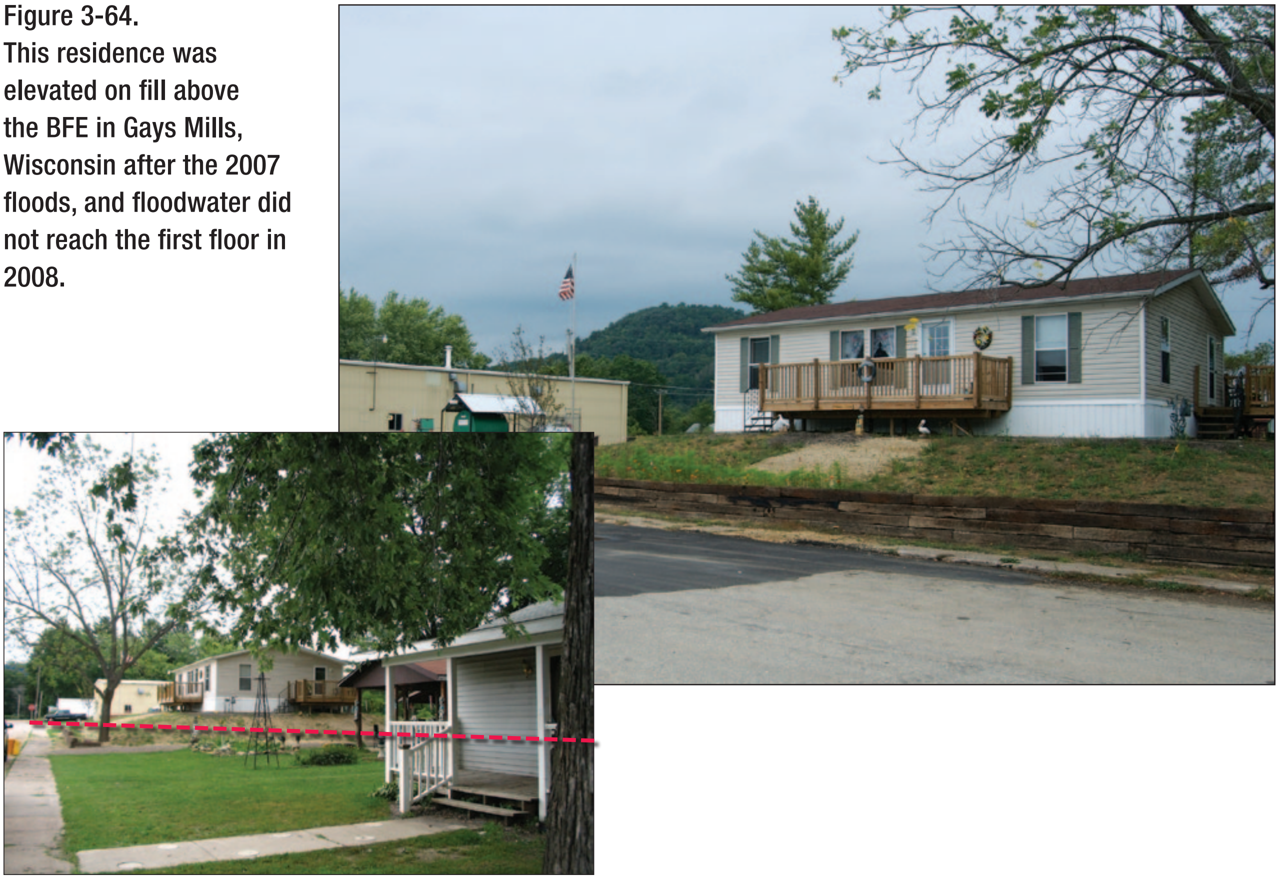


Figure 3-64.
This residence was elevated on fill above the BFE in Gays Mills, Wisconsin after the 2007 floods, and floodwater did not reach the first floor in 2008.

3.1.4 Residential Acquisitions

Since 1993, FEMA has funded more than 2,000 acquisition projects in Iowa and Wisconsin. The acquisitions were completed in conjunction with states and other federal agencies. These agencies and programs include the FEMA Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA) program, Pre-Disaster Mitigation (PDM) program, the Community Development Block Grants through the Wisconsin Department of Commerce; Stewardship Funds through the Wisconsin Department of Natural Resources; and Municipal Flood Control grants through the Iowa Department of Natural Resources. In Iowa, the USACE has also had a prominent role in acquisition projects. The acquisition properties visited by the MAT clearly show that the programs had successfully removed residences from areas that would have been flooded during the 2008 floods and, if they had not been removed, they would have sustained significant damages. The acquisition projects visited were all within the SFHA. Given that the majority of the communities visited were impacted by a greater than 1-percent-annual-chance flood, the damages avoided by these acquisitions are estimated to be in the millions of dollars. Figure 3-65 shows the location of an acquisition project completed with federal mitigation funding made available after the 1993 floods.

Figure 3-65.
Site of a 1994 clearance project where multiple residential structures were acquired under the FEMA HMGP. This area is in the SFHA. Based on observed high water marks, it is estimated the acquired buildings would have had at least 1 foot of water in them (Independence, Iowa).

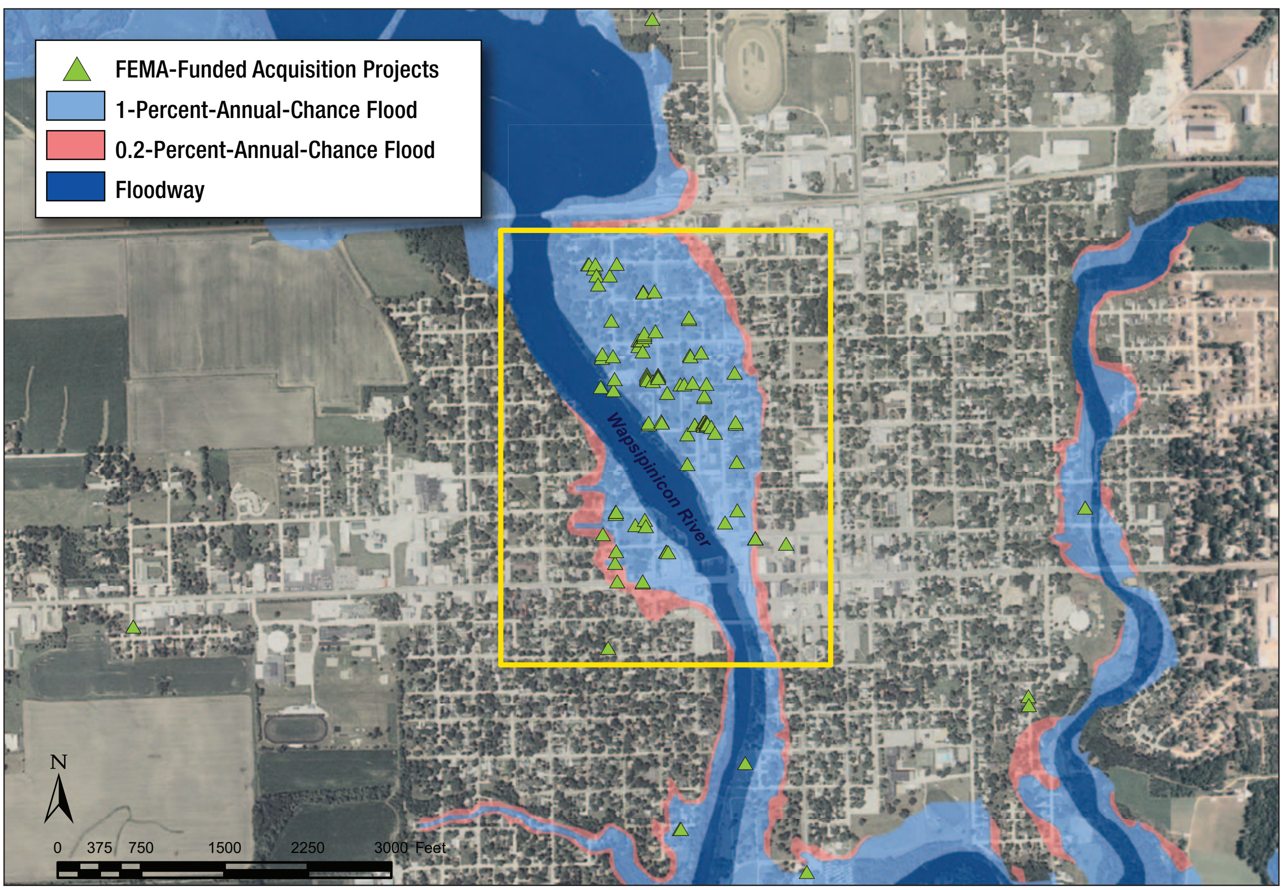


Figure 3-66. Location map for Figure 3-65 (Independence, Iowa).

When conducting wide-scale acquisition and relocation projects, it is important to consider long-term plans for the area. This helps ensure that homes subject to future flood damages do not remain and that they are not acquired and relocated or elevated in a random fashion. FEMA 317, entitled *Property Acquisition Handbook for Local Communities*, addresses such issues and lays out a framework to help communities successfully implement property acquisition projects. A patchwork approach to acquisition can lead to homes remaining in the neighborhood that are isolated between vacant lots. The effect of raising some homes within a floodprone area while others are acquired may create a strain on public services, utilities, and emergency access and response. In addition, any isolated homes may be eligible for future mitigation assistance such as elevation that may not be consistent with the need for a community to permanently vacate such areas in order to reduce the cost of providing perpetual infrastructure services and mowing and maintaining the vacant lots. Figure 3-67 shows the benefit of long-term planning versus a patchwork approach. Having a few remaining structures within such multiple vacant lots does not allow the conversion of the vacated lots into a sustainable use such as ecosystem restoration and/or open space based recreation.

Figure 3-67.
The top photos show a project where the community acquired and relocated multiple residences in the SFHA. The lower left image is one of a few sporadic completed elevations in the same area, and the lower right is an ongoing elevation project (Cedar Falls, Iowa).

A majority of the acquisition projects observed by the MAT were funded by FEMA and other federal agencies. In addition, some communities budgeted funding to finance mitigation projects internally. For example, the Milwaukee Metropolitan Sewage District Flood Management Program manages over $100 million annually for mitigation projects through funding collected from sewage disposal fees. The projects include creating increased temporary water storage, improving the sewer system to avoid backups during floods, and acquiring developed property to convert land use to open space or undeveloped property to ensure it remains open (see Figure 3-68).

Figure 3-68. Site of successful acquisition of several houses in the SFHA. The acquisitions were completed using local funds to convert the area to open space. Had the houses remained in place, they would have been impacted by 1 to 2 feet of flooding in 2008 (Milwaukee, Wisconsin).

3.1.5 Residential Properties – Other

3.1.5.1 Letter of Map Revision Based on Fill (LOMR-F)

The Idyllwild subdivision in Iowa City was built on fill approximately 10 to 15 years ago (see Figures 3-69 through 3-72). As shown in Figure 3-70, this area was originally mapped in the regulatory floodplain. However, fill was added to this subdivision site through a LOMR-F to raise the land elevation and remove it from the regulatory floodplain. A LOMR-F is FEMA's modification of the SFHA shown on the FIRM based on the placement of fill outside the existing regulatory floodway. All requests for changes to effective maps, other than those initiated by FEMA, must be made in writing through the Chief Executive Officer (CEO) of the

> FEMA recognizes that changes will be required on the flood maps and has a mechanism for addressing them. One method for addressing a change to the floodplain is via the Letter of Map Revision (LOMR) process. The presence of a LOMR simply indicates a reduced risk and removes the regulatory flood purchase requirement for mortgages in the area covered by the LOMR. It does not guarantee the area will not be flooded. The fact that it was previously mapped in the SFHA is evidence of potential flood risk.

community or an official designated by the CEO. Because a LOMR-F officially revises the effective NFIP map, it is a public record that the community must maintain. Any LOMR-F should be noted on the community's master flood map and filed by panel number in an accessible location.

Although most of the development was considered outside the floodplain based on a LOMR-F, it suffered extensive damages. (The LOMR-F is not reflected on the map shown in Figure 3-70.) The community spent over $2 million in initial clean up costs to remove damaged contents and prevent further damage (e.g., mold); repair estimates require an additional $10 million from property owners.

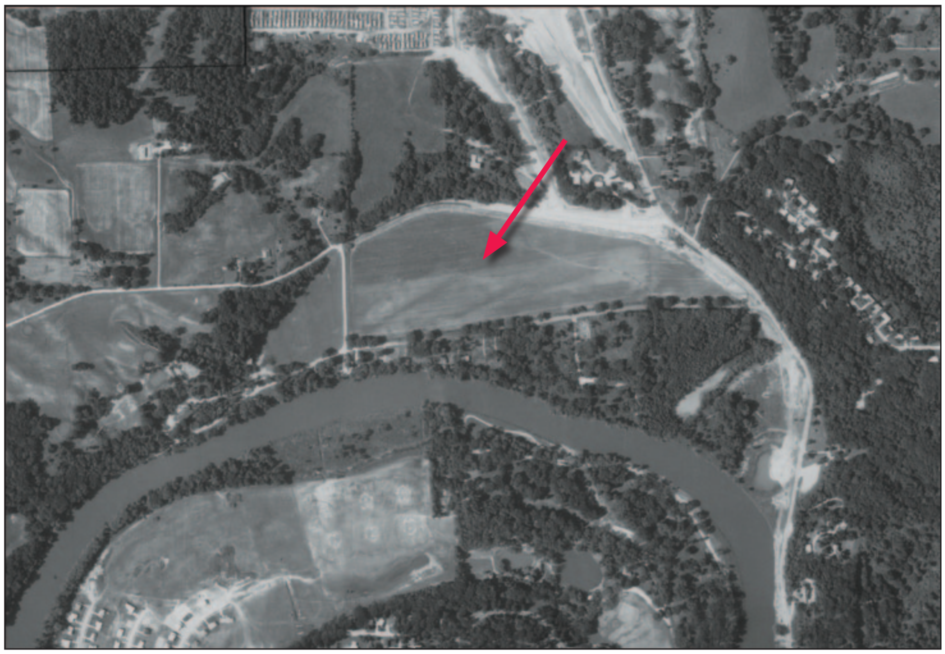


Figure 3-69. This is the historic Coralville area circa 1960 from U.S. Department of Agriculture archives. The red arrow indicates the location of the flooded subdivision (Iowa City, Iowa).

Two months after the flood, only one residence out of more than 90 residences in the subdivision was occupied. This residence had all living areas located on the second floor along with the hot water heater, air handling unit, laundry room, and kitchen, which illustrates the benefits of careful selection of these locations to ensure building performance during a design level event. The adjoining single-story unit was inundated with 3 to 5 feet of floodwater and suffered 2 to 3 times the economic losses (see Figure 3-72).

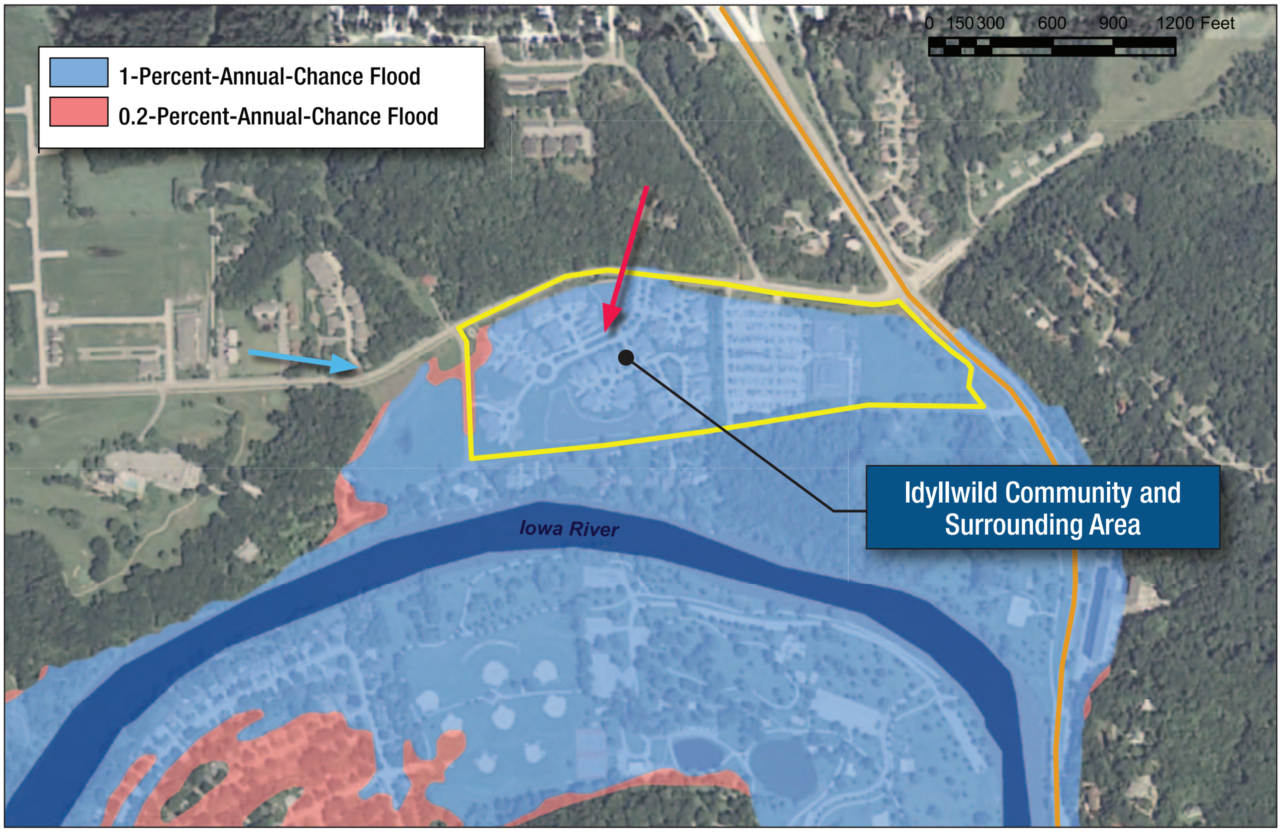


Figure 3-70.
This is the Idyllwild community (see red arrow) shown relative to the natural floodplain with the 1-percent and 0.2-percent-annual-chance floodplains highlighted without the elevation on fill being taken into consideration. The blue arrow is the position that the upper left photo in Figure 3-72 was taken from. This area experienced a <0.2-percent-annual-chance flood (Iowa City, Iowa).

Figure 3-71.
This is the Idyllwild community (see red arrow) shown during the flood event. The red arrow is the location of the house shown in Figure 3-72 (Iowa City, Iowa).

Figure 3-72.
Site of a subdivision built on fill during the early 1990s, considered outside the floodplain based on LOMR-F. The dashed line in the upper right photo indicates the floodwater level. The center right and left photos show utilities located on the second floor level of the residence in the upper right photo. The bottom photos illustrate interior damage to the adjacent properties. The upper left photo was taken from the position noted in Figure 3-70 (Iowa City, Iowa).

One challenge noted by the MAT was the difficulty in repairing the party-wall between units in the Idyllwild community. The party-wall was constructed in three layers (see Figure 3-73). The gypsum wallboard was applied to each layer successively. Then the next portion of framing and another layer of gypsum wall board were installed. The floodwaters damaged all the layers of the drywall in the party-wall. The damaged material can be broken down and easily removed. New material comes in 4-foot by 8-foot or 4-foot by 12-foot sheets. But since the spacing between studs is 16 inches, there is no practical way to replace the inner sheets.

Figure 3-73.
The majority of the units throughout the subdivision were uninhabitable two months after the event; several issues regarding re-occupancy will need to be resolved such as repair of the firewall system dividing the units (Iowa City, Iowa).

Another difficulty is that the newly removed wall board creates a single continuous open corridor between all units. With some units being ground level garden units and others being two-story units, the living space of some units is now open to the adjacent garage and automobiles. Re-occupancy of these units should be carefully monitored to ensure that life-safety and security issues are not compromised in the interest of rapid recovery.

The experience of the Idyllwild community underscores the importance of communicating risk even for areas that are considered to be outside the floodplain and the need for property owners to consider carrying flood insurance in these areas, something the homeowners association had contemplated in the late 1990s. In addition, it illustrated the advantages of designing buildings so that the more expensive components (such as the kitchen and utility room) are located on upper floors and the lower floors are restricted to open or storage space, especially in areas where there is a residual risk of flooding.

3.1.5.2 Storage Tanks

The NFIP requires that storage tanks be elevated above the BFE or be made watertight and anchored to resist floatation, collapse, or lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. The MAT observed numerous storage tanks throughout the communities visited that were not properly secured (see Figure 3-74). These unanchored tanks not only create more debris, but also generate a serious threat to public safety and the environment.

Figure 3-74.
Improperly anchored storage tanks in the SFHA (North Freedom, Wisconsin, and Iowa City, Iowa).

3.1.5.3 Boat Houses

The Ellis Boat Harbor is located in Cedar Rapids along the Cedar River with structures on the water. Prior to the 2008 floods, there were over a hundred homes in this area, but several of the houses were forced downstream during the flood, crashing into a railroad bridge downstream. The anchoring systems were insufficient to secure the structures, and almost half of the houses became floodplain debris (see Figures 3-75 to 3-78).

These anchorages were welded to the face of a light steel sheet pile section. Marine anchorages typically need to be positively tied into an anchor wall or dead-man system. These anchor points need to be designed to maintain their design capacity after years of corrosion similar to the design of a steel sheet pile bulkhead. All possible loading conditions need to be considered when designing these structural components. The height of the water aggravated the condition when relatively short ramps/ties were used. The ramps folded under the boat house generating tremendous prying forces.

Figure 3-75.
Typical boathouse in the Ellis Boat Harbor. Red arrows point to damaged anchorages (Cedar Rapids, Iowa).

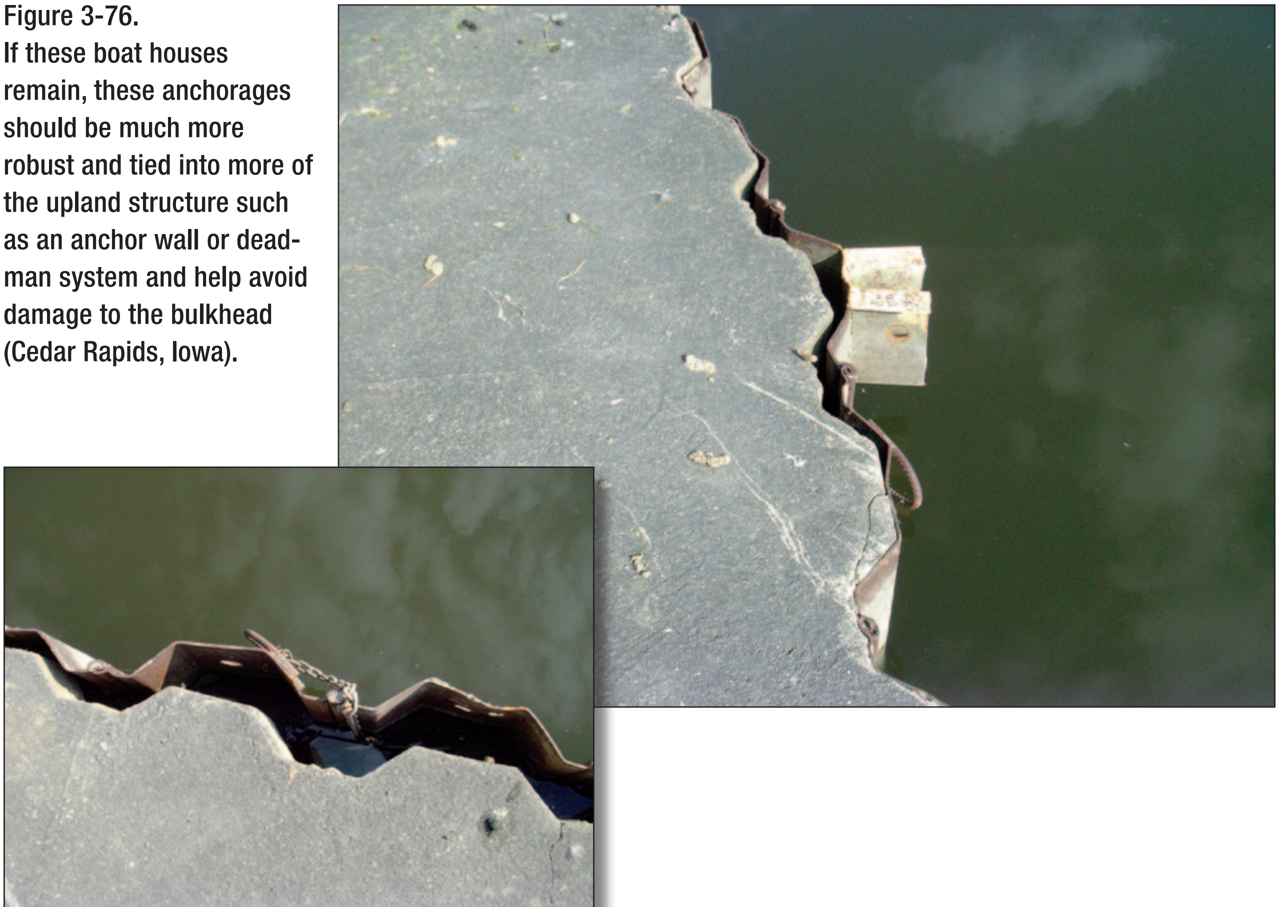


Figure 3-76.
If these boat houses remain, these anchorages should be much more robust and tied into more of the upland structure such as an anchor wall or dead-man system and help avoid damage to the bulkhead (Cedar Rapids, Iowa).

Figure 3-77.
About half of the houses were forced loose by the flooding and had to be recovered throughout the floodplain (Cedar Rapids, Iowa).

Figure 3-78.
Several houses were displaced downstream against a railroad bridge (Cedar Rapids, Iowa).

3.2 Historic Buildings

Mitigation and recovery strategies for historic buildings and structures should be designed to preserve the historic character of the properties. Assistance with this process can be found in *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Secretary of Interior Standards) from the Department of the Interior Guidelines for the treatment of historic properties, which is available at the following websites: http://www.nps.gov/history/hps/tps/tax/rhb/stand.htm and http://www.nps.gov/history/hps/tps/tax/rhb/guide.htm.

Additional resources can be found on the National Institute of Building Sciences website, most importantly, the *Whole Building Design Guide*. The information in the guide specific to historic preservation can be found at http://www.wbdg.org/design/historic_pres.php.

Many historic buildings in the Cedar Rapids Bohemian Area were inundated by waters from the 2008 Midwest floods. These buildings typically had basements. The core elements of these structures performed well due to the favorable material properties and the methods of construction. The heavy construction helped basement walls to resist the unbalanced lateral loads from saturated soils. See Section 3.1.1 for more information on behavior and performance of materials.

These buildings are typically constructed of multiple courses of unreinforced stone masonry and/or unreinforced clay masonry, and heavy timber framing and dimensional lumber sheathings. See Figures 3-79 and 3-80 for typical masonry construction and wood framing details.

Figure 3-79.
This historic building (C.S.P.S. Hall) withstood approximately 8 feet of water (red line). This property, in an A11 flood zone, has a BFE of 722 feet, and a building elevation of approximately 720 feet (Cedar Rapids, Iowa).

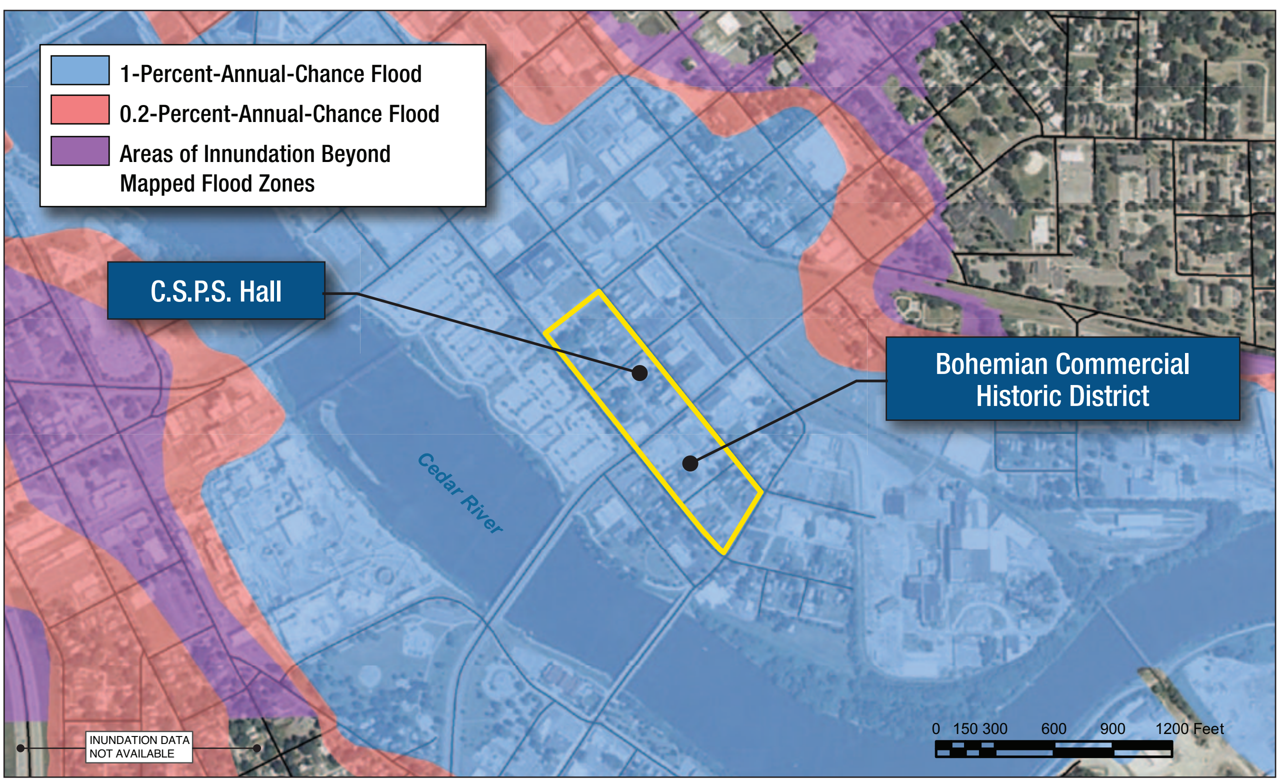


Figure 3-80. Cedar Rapids Bohemian Commercial historic district (Cedar Rapids, Iowa).

Care must be taken to use compatible materials when repairing historic structures or damage may result. Modern cement mortars have the potential to have different mechanical properties, such as elasticity or stiffness, than the original parent material and can lead to damage of the masonry elements at the base of the building.

The foundation for the C.S.P.S. building appears to be in good condition after being dried out for several months. The hand-hewn stone cap block is in perfect condition. Effort should be made to dry-out and dehumidify the basement after this inundation, to ensure the wood framing returns to acceptable moisture content (see Figure 3-81).

Figure 3-81.
Basement and foundation of historic building. The chisel marks in the hand hewn capstone (red arrow) are physical representations of the historic context of the building, the stone having been sized manually versus utilizing machinery (Cedar Rapids, Iowa).

A historic fire station experienced relatively little damage in spite of being inundated by floodwater at a similar height as floodwater that damaged adjacent buildings. This was due to the unusual interior materials used in the first floor of this building. The ground floor interior was finished in glazed brick, likely as a result of the need to clean and dry the fire equipment during all seasons, especially the winter. Thus the brick work served as a water-resistant material for routine maintenance operations, and it resisted the floodwater as well (see Figures 3-82 and 3-83).

Figure 3-82.
This historic fire station's damage was limited to some broken windows and a damaged overhead door (Cedar Rapids, Iowa).

Figure 3-83.
The interior ground floor of this historic fire station was designed with glazed brick. This effectively wet floodproofed the building (Cedar Rapids, Iowa).

The interior finishes located on the first floors of these flooded historic buildings typically did not fare well during the flooding. The flooring, trim, wall coverings, plaster, and drywall finishes were damaged by inundation. Replacement materials should be "in-kind" (of the same, or visually compatible, materials), following the guidelines and approaches recommended by the SOI Standards. These elements, which will need to be replaced, have been removed to allow the underlying structural components to dry. Care must also be given to treatment for decay and for wood-destroying organisms. A treatment and monitoring program should be implemented to verify these areas are properly de-humidified and no decay occurs. The damaged mechanical and electrical systems located on the first floor had to be replaced. Consideration should be given to locating the replacement equipment above the first floor, when possible and appropriate, to avoid future damage from flooding, as shown in Figures 3-84 and 3-85.

Figure 3-84.
This historic building had loss of the first floor furnishings, mechanical systems, electrical systems, and finishes due to 8 feet of water inundation (red line). This property, within the SFHA, has a BFE of 722 feet, and an elevation of approximately 720 feet. The upper floors survived intact (Cedar Rapids, Iowa).

Figure 3-85.
The interior of the restaurant lost all interior elements up to about 8 feet above the floor (red line) (Cedar Rapids, Iowa).

3.3 Commercial Facilities

The team surveyed commercial facilities ranging from offices and retail shops to a swine food processing plant. All of the commercial facilities discussed in this section are classified as Category II structures as defined in ASCE 7, *Minimum Design Loads for Buildings and Other Structures,* cited at the beginning of this chapter. Similar to most of the residential properties, commercial facilities were inundated with slow rising inundation. Figure 3-86 illustrates buildings within the SFHA in Gays Mills that were flooded by water that exceeded a 1-percent-annual-chance flood. On the other hand, Figure 3-87 illustrates a once similar area upstream along the Kickapoo River that was converted into open space with the buildings relocated to higher ground.

Figure 3-86. The Gays Mills downtown district had over 6 feet of water from the flood (Gays Mills, Wisconsin).

Figure 3-87. Upstream of Gays Mills along the Kickapoo River, this open space was once downtown Soldier's Grove before the community began relocating after significant flooding in 1978. In 2008, the park was inundated and repaired; however, the damages would have been much greater had the community not relocated (Soldiers Grove, Wisconsin).

Three examples highlighted in the following sections illustrate the damage to, and the functional losses of, a manufacturing plant, a commercial district, and an office building.

3.3.1 TriOak Foods Processing Plant, Oakville, Iowa

Overview: Oakville, Iowa, is home to the headquarters of TriOak Foods, a grain and pork processing company with facilities throughout the state. The Oakville complex includes several slab-on-grade, metal frame buildings that house corporate offices, a swine processing plant, and grain storage and shipping facilities. TriOak Foods, like much of Oakville, is located behind a levee; when the levee was breached, the plant flooded with over 2 feet of water. Most of Oakville remained inundated for three weeks before the floodwater receded.

Summary of Damages: Although TriOak Foods buildings incurred some minor architectural damage, storage equipment bore the brunt of the flood damage:

- Two underground, un-anchored, 10,000-gallon fuel tanks floated up from beneath a 4-inch concrete slab as shown in Figure 3-88. The Petroleum Equipment Institute publication *Recommended Practices for Installation of Underground Liquid Storage Systems* (RP100-05), which is cited in 40 CFR 280.20 (d) (ii), has recommended procedures for anchorage of these type tanks.
- Only pieces of a dry-storage wall remain upright; much of the wall was knocked over as shown in Figure 3-89.
- Metal feed silos constructed with bolted connections experienced some seepage resulting in damaged feed as shown in Figure 3-90. Welded feed silos did not have seepage issues.

Figure 3-88.
Water seeping into the ground generated enough buoyancy to force two 10,000-gallon underground fuel storage tanks through a 4-inch concrete slab at the TriOak Foods plant (Oakville, Iowa).

Figure 3-89.
A dry-storage wall was destroyed at TriOak Foods (Oakville, Iowa).

Functional Loss: Swine were evacuated during the flood. Although there was minimal damage to buildings, the plant remained closed for the duration of the flood and cleanup process. The damage to the fuel tanks could potentially lead to very expensive environmental cleanup efforts. Anchoring of any above or underground fuel tanks is recommended as well as placement and anchoring of above ground tanks in secondary retention structures.

Figure 3-90.
Bolted silos like the one at right at TriOak Foods were prone to seepage; as a result, some feed was lost. Welded silos like the one at left did not experience seepage (Oakville, Iowa).

3.3.2 Urban Commercial Buildings, Cedar Rapids, Iowa

Overview: Cedar Rapids has had several construction booms since its founding in 1841. As a result, commercial buildings in downtown Cedar Rapids represent a variety of construction types and periods. Significant periods of growth and construction occurred during the 1800s, the early and mid-1900s, and the 1980s. There are also several buildings constructed in the late 1990s.[1] See Figure 3-91 for a picture of downtown Cedar Rapids during the flood.

Summary of Damages: According to residents, the Cedar River inundated 1,300 blocks and 9.2 square miles of the city on both sides of its banks. Flooding affected the commercial, municipal, and industrial districts, among others. Throughout the downtown area, water depths of 7 to 8 feet were observed.

Most buildings experienced significant flooding in their basements and first floors, resulting in severe damage to interior architectural finishes and contents. Few structural failures were observed.

Cedar Rapids also has several parking structures that include sub-grade levels with basement access from the parking garage to buildings they connect with. Many of these parking structures and the basements of attached buildings experienced flooding.

Functional Loss: Approximately two months after the water crested, most commercial buildings had not recovered and were not functioning or occupied. Many cultural and public use buildings had

1 "Open House Presentation Boards." *Cedar Rapids Downtown Area Plan.* http://www.cedar-rapids.org/community/documents/open_house/all%20boards.pdf 15 November 2007

also suspended operations. The Paramount Theatre, the Cedar Rapids Science Museum, and the Cedar Rapids Public Library facilities were all flooded; the library may not resume function in its original location for up to three years.[2]

Figure 3-91. The Cedar Rapids downtown district had up to 8 feet of water at the height of the flood (Cedar Rapids, Iowa).

3.3.3 Great American Building, Cedar Rapids, Iowa

Overview: The Great American Building, a commercial office building, was built on the riverside in 1998 as shown in Figure 3-92. The building has a flood response plan, required by its insurance policy that includes plugging floor drains and sandbagging entrances. Although the plan was followed, rapidly rising water overwhelmed response and recovery efforts.

Summary of Damages: The slab-on-grade structure had 7.5 feet of water on the first floor, which resulted in an estimated $2 million in damages to interior finishes and utilities, including electrical equipment and wiring, fire pumps, and the emergency generator. The only damage to upper level offices was due to one office's equipment malfunctioning when power was shut off—that damage was minimal. This office building plans to restore all damaged equipment to its pre-flood location.

Functional Loss: Water entered only the first floor; however, offices on upper levels were unable to resume operations for several weeks until after the electrical components on the first floor were repaired.

2 Cedar Rapids Public Library web site. http://www.crlibrary.org/flood/index.html

Figure 3-92.
The Great American Building sits along the Cedar River. Although it had a flood response plan in place, it experienced significant flooding on its ground floor. This property, in an A11 flood zone, has a BFE of 724 feet, and an elevation of approximately 720 feet (Cedar Rapids, Iowa).

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MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

4 Critical and Essential Facilities

Chapter 4 discusses damages observed by the MAT to critical and essential facilities throughout southern and central Iowa and Wisconsin. Most flood damages were the result of riverine flooding and sewer backups. Most site visits were conducted in August and September of 2008; the University of Iowa was visited in October of 2008. In addition to notes taken in the field, the MAT made use of photographs and documentation supplied by the FEMA Joint Field Offices in Des Moines, Iowa, and Madison, Wisconsin.

Building damages assessed by the MAT were categorized according to Table 3-1. Building occupancies are classified into four categories. Chapter 4 discusses Categories III and IV, which are defined as follows:

- **Category III** (Critical Facilities), buildings and other structures that represent a substantial hazard to human life in the event of failure. This category includes water and wastewater treatment facilities, municipal buildings, educational facilities, and non-emergency healthcare facilities.
- **Category IV**, buildings and other structures designated as essential facilities. This category includes hospitals and fire, rescue, ambulance, and police stations.

Facilities reviewed during the MAT included:

- Critical Facilities (Category III)
  - Municipal Facilities
  - Detention Facilities (special evacuation issues are also discussed)
  - Water Treatment Facilities and Wastewater Treatment Facilities
  - Utility Plants
  - Educational Facilities
    - K–12 School Buildings
    - School Administration and Maintenance Buildings
    - University Buildings
- Essential Facilities (Category IV)
  - Medical
  - Police and Fire Stations

Section 4.1 discusses critical facilities including municipal facilities and detention facilities. Section 4.2 discusses essential facilities, including medical facilities and law enforcement facilities. Section 4.3 discusses water and wastewater treatment facilities, and Section 4.4 discusses educational facilities.

Section 4.5 includes a matrix of lessons learned at the facilities visited by the MAT. The matrix categorizes the lessons learned by building type and guidance in existing FEMA publications, including:

- FEMA 348, *Protecting Building Utilities from Flood Damage*, a technical handbook for elevating and otherwise protecting electrical, mechanical, gas, water, and other major building utilities
- FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds*, a technical manual that provides a comprehensive survey of the methods and processes necessary to protect critical facilities from natural hazards
- FEMA 577, *Design Guide for Improving Hospital Safety from Earthquakes, Floods, and High Winds*, a technical manual that provides a multi-hazard approach to protecting hospitals

- NFIP Technical Bulletin 2 (TB 2), *Flood Damage-Resistant Materials Requirements*, an overview and technical guide to selecting and installing flood damage-resistant structural and finish materials
- NFIP Technical Bulletin 4 (TB 4), *Elevator Installation*, regulations and guidelines for installing and protecting elevators in flood-prone areas
- NFIP Technical Bulletin 6 (TB 6), *Below-Grade Parking Requirements*, technical guidelines for designing and constructing below-grade parking garages for non-residential buildings in SFHAs
- *Sharing the Challenge: Floodplain Management Into the 21st Century* (Galloway Report), a study and review of the 1993 Midwest floods

It is anticipated that the facilities reviewed by the MAT will utilize federal funding to recover and rebuild after the 2008 floods. When federal funding is provided for the repair of existing critical facilities located within the 0.2-percent-annual-chance floodplain, the repairs are subject to the requirements of FEMA 543, ASCE 7, and ASCE 24.

Federal agencies with involvement in funding, permitting, and constructing critical facilities are also required to adhere to the requirements of Executive Order (EO) 11988. Under EO 11988 – Floodplain Management, federal agencies are to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and protect the natural and beneficial functions of floodplains.

Under EO 11988 implementing guidelines, a critical action, which includes critical facilities, is defined to include any activity for which even a slight chance of flooding is too great. The concept of critical action reflects a concern that the impacts of floods on human safety, health, and welfare for many activities could not be minimized unless a higher degree of protection than the base flood (the 1-percent-annual-chance flood) was provided. For facilities in Zone A, ASCE 24 recommends incorporating a minimum of a 1-foot freeboard for critical facilities and a 2-foot freeboard for essential facilities.

Only one of the critical facilities visited by the MAT had been constructed to a 0.2-percent-annual-chance flood event level of protection; detailed pre-event emergency planning for the remaining critical facilities is an urgent need. FEMA 543 provides further elevation guidance for critical facilities and recommends that the lowest floors of critical facilities be elevated to or above the 0.2-percent-annual-chance flood elevation. The MAT recommends locating critical and essential facilities outside the 0.2-percent-annual-chance floodplain. If that is not possible, critical and essential facilities should be elevated (or otherwise protected) to the 0.2-percent-annual-chance flood elevation or the ASCE 24 minimum elevation requirements, whichever is greater.

The locations of several Cedar Rapids, Iowa, facilities referenced in this chapter are shown in Figure 4-1.

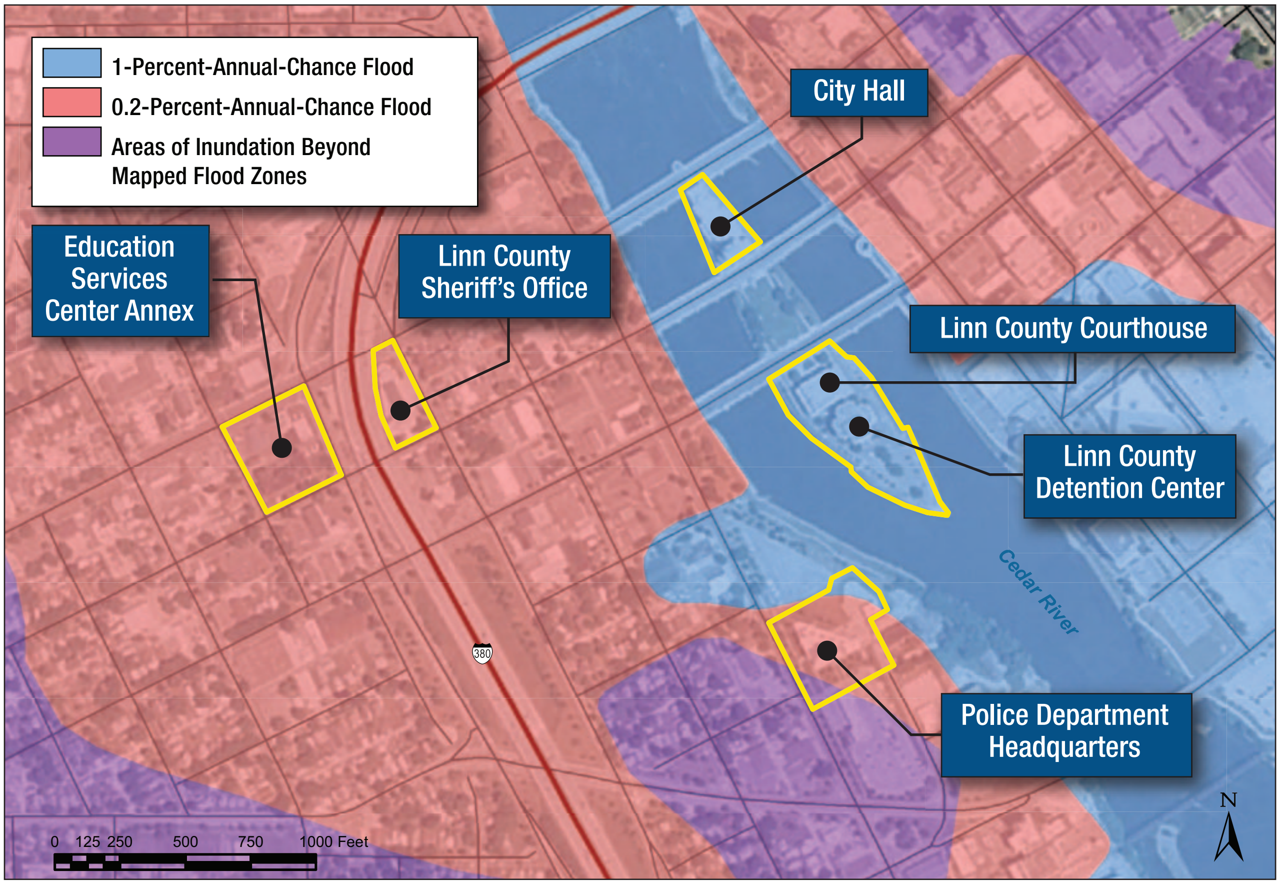

Figure 4-1.
Flood zones and inundation for Cedar Rapids City Hall, Linn County Courthouse, Linn County Detention Center, Cedar Rapids Police Department Headquarters, Linn County Sheriff's Office, and Education Services Center Annex (Cedar Rapids, Iowa)

4.1 Critical Facilities: Local Government

This section discusses building performance of public institutional facilities classified under Category III as defined by ASCE 7-05. The three buildings discussed in this section are Cedar Rapids City Hall, the Linn County Courthouse, and the Linn County Detention Center; all three facilities are in Cedar Rapids, Iowa, and are essential for continued government operations and community security. Table 4-1 summarizes elevation information for these and other facilities.

Table 4-1. Elevation Data for Cedar Rapids Critical Facilities

Facility	Floodplain	First Floor Elevation (Basement)	Lowest Adjacent Grade	Flood Elevation (Approx.)	Base Flood Elevation	0.2-Percent-Annual-Chance Flood Elevation	Recurrence Interval	Date
City Hall	SFHA	714.2	Not available	734	724.7	728.5	>500-year	Pre-FIRM
Linn County Courthouse	SFHA	Not available	726.8	734	724	728	>500-year	Pre-FIRM
Linn County Detention Center	SFHA	Not available	726.4	734	724	728	>500-year	Post-FIRM
Police Department Headquarters	0.2-Percent-Annual-Chance	724.5	724	731	723.5	729	>500-year	Post-FIRM

4.1.1 Cedar Rapids City Hall and Linn County Courthouse, Cedar Rapids, Iowa

Key Issues: Floodwaters entered the Cedar Rapids City Hall and the Linn County Courthouse, two municipal buildings located on an island in the Cedar River, through tunnels and an underground parking garage. As a result, both buildings lost critical contents and functions in their lower levels.

Overview: Cedar Rapids City Hall (Figure 4-2) and the Linn County Courthouse (Figure 4-3) were built in 1927. (The Linn County Detention Center, which is also shown in Figure 4-3, is discussed below.) The buildings are situated on Mays Island in the Cedar River and are in the SFHA (see Figure 4-1). They are both connected to an underground parking structure via underground access tunnels. Figures 4-4 and 4-5 show these areas. As water entered the adjacent parking garage and access tunnels, the buildings experienced significant flooding in their basements. In addition to completely inundated basements, both buildings had about 2 feet of water on their first floors.

Figure 4-2. Mays Island, including City Hall, flooded as the Cedar River rose (Cedar Rapids, Iowa).

Figure 4-3.
The Linn County Courthouse and Detention Center on Mays Island were inundated (Cedar Rapids, Iowa).

Figure 4-4.
The Mays Island underground parking structure connects to City Hall and the County Courthouse and was a major source of floodwater intrusion into both buildings (Cedar Rapids, Iowa).

Figure 4-5.
The tunnel and stairs into City Hall from the underground parking structure were a source of flooding in the basement (Cedar Rapids, Iowa).

Summary of Damages: Both the City Hall and Courthouse lost all interior architectural finishes in their basements as well as significant interior finishes on ground floor levels. In both cases, clean-up was complicated and prolonged by the presence of asbestos building materials, which had to be remediated prior to the rehabilitation of the buildings. Both buildings lost their electrical and mechanical distribution systems including the main electrical service equipment, communications equipment, and life safety equipment (Figure 4-6).

In addition, many public records kept in the basement of City Hall were lost. Several files were moved from the basement of the Courthouse to the first floor prior to the flood; however, the first floor was also inundated and those files were lost. Exhibits and artifacts in the Spanish-American War Museum, also on the first floor of City Hall, were damaged as well.

Functional Loss: City Hall was unusable for over eight months after the floods. After the initial cleanup was complete, ongoing environmental concerns over asbestos and mold growth hindered reconstruction and recovery. As a result, operations in meeting rooms, office space, and historic exhibits were relocated or temporarily suspended.

The Courthouse lost all basement functions, including juvenile, arraignment, small claims, and domestic courts. Because of mold intrusion and other issues, the Courthouse building was not functional for several months after the storm.

Figure 4-6.
City Hall and the Courthouse lost their electrical systems. Cleanup and replacement were prolonged because of asbestos abatement (Cedar Rapids, Iowa).

4.1.2 Linn County Detention Center, Cedar Rapids, Iowa

Key Issues: The Linn County Detention center experienced significant flooding of the basement level and 2 feet of flooding on the ground floor. Flooding in the basement was primarily due to flooding in underground access tunnels that connect it to the underground parking garage on Mays Island. Significant damages were sustained by the electrical, mechanical, and elevator equipment on the basement level and by inmate-detention system electronics and equipment on the ground floor. A last-minute evacuation of inmates occurred after the jail lost power.

Overview: The Linn County Detention Center was built in 1984 and is a cast-in-place and pre-cast concrete, six-story building located on Mays Island in the Cedar River (Figure 4-7). The building is connected to the Linn County Courthouse via an underground access tunnel (Figure 4-8). The jail has an operating capacity of 450 inmates; at the time of the flood, there were between 350 and 400 inmates in custody. The building experienced significant flooding of the basement level and 2 feet of flooding on the ground floor. As the water entered the building, an emergency evacuation was ordered.

Summary of Damages: The Detention Center lost its electrical and mechanical systems, as well as architectural floor and wall finishes, on the basement and ground levels. The elevators needed significant repairs, and mold intrusion as a result of the flooding and subsequent lack of temperature and ventilation control was an ongoing concern during recovery efforts.

Functional Loss: As river water rose over Mays Island, water began entering the jail through the access tunnel to the Courthouse. The Sheriff's Department made a decision to evacuate all inmates to other facilities, which proved to be a challenging effort under emergency conditions. Inmates boarded buses and were driven across bridges over the Cedar River. By the time of the evacuation, water levels were so high over the bridges that the buses were knocked against guardrails as they crossed the river.

Figure 4-7.
The Linn County Detention Center is on Mays Island in the Cedar River (Cedar Rapids, Iowa).

Figure 4-8.
Access tunnel to the Courthouse (Cedar Rapids, Iowa)

In less than 3 hours, Sheriff's Deputies had evacuated male and female county inmates as well as several federal inmates to nearby facilities. All inmates were moved to other facilities, and operations at the Detention Center were temporarily suspended.

The Detention Center was not operational for several months after the storm. Cleanup and mitigation efforts were phased to allow for full occupation of the facility by April of 2009. Flood mitigation measures were planned for later phases. This included:

- Moving the control room from the first floor to the fifth
- Relocating electrical switchgear and air handlers from the basement to higher levels
- Relocating the emergency generator from the basement to a higher level

4.2 Essential Facilities

This section discusses the building performance of essential facilities throughout southern and central Iowa and Wisconsin. All of the facilities discussed in this section are classified under Category IV as defined by ASCE 7.

4.2.1 Mercy Medical Center, Cedar Rapids, Iowa

Key Issues: Mercy Medical Center is near but not directly in the 0.2-percent-annual-chance floodplain (Figure 4-9). During the 2008 flood, the hospital sustained significant damage to contents and functions due to sewer backup and groundwater.

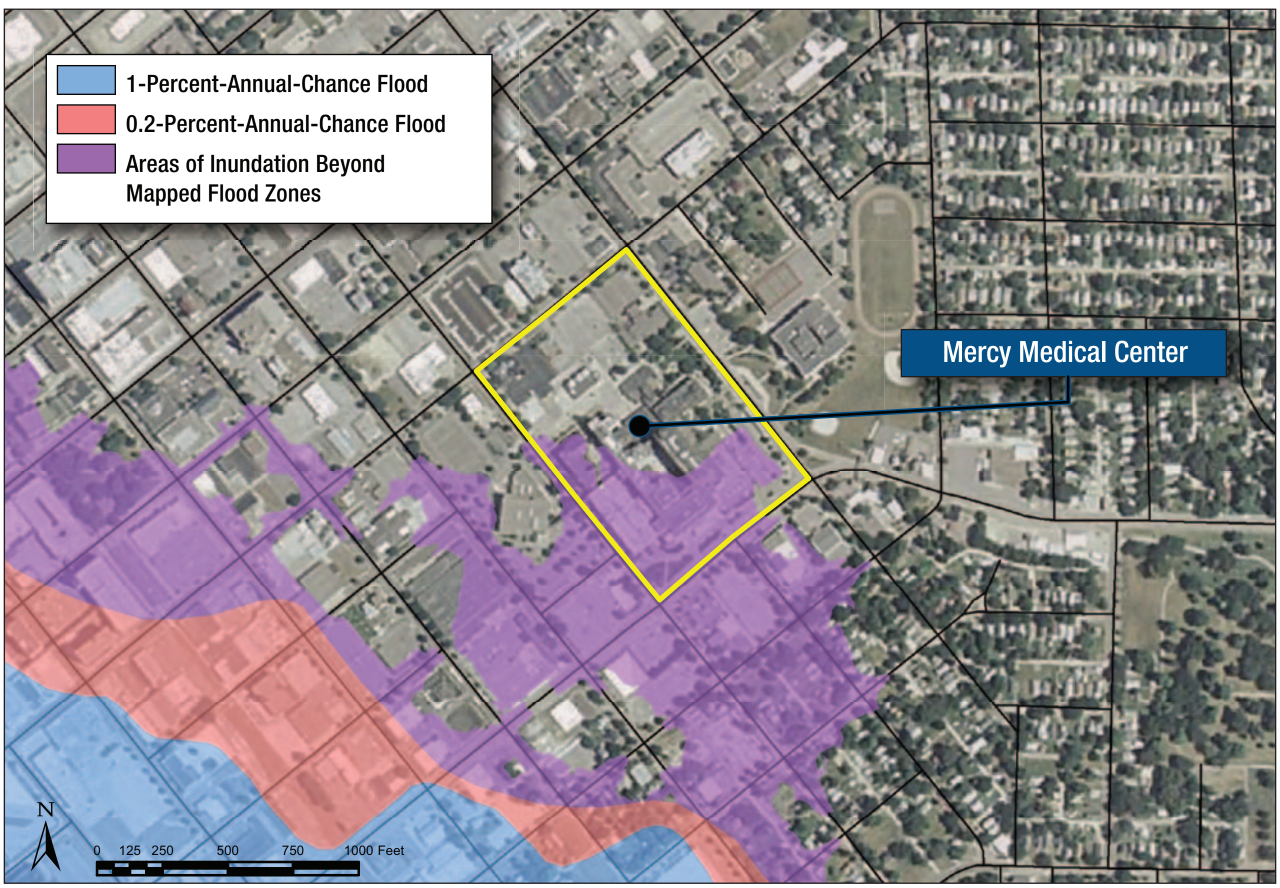

Figure 4-9. Flood zones and inundation for Mercy Medical Center (Cedar Rapids, Iowa)

Overview: Mercy Medical Center is one of two major medical facilities in Cedar Rapids. Located at the edge of the 0.2-percent-annual-chance floodplain, the hospital consists of a series of structures, several of which are connected by a continuous basement. The three main structures in the complex were built in 1923, 1947, and 1969 (Figure 4-10).

Figure 4-10.
Mercy Medical Center, which sits just outside the 0.2-percent-annual-chance floodplain, was surrounded by 3 feet of water (Cedar Rapids, Iowa).

Although flooding was higher than originally expected, higher river crest predictions were available to Mercy approximately 24 hours in advance. As a result, the staff were able to evacuate patients to other facilities. Flooding came from several sources, although the primary flooding sources were sanitary sewer backup through toilets and sinks, and groundwater seepage. There were also reports that water flowed from the flooded parking garage, across a courtyard, and into the basement.

Mercy staff and volunteers were able to keep the water largely at bay by sandbagging, pumping, and drilling holes in the basement slab to relieve hydrostatic pressure below the slab. Water levels outside the building reached depths of 3 feet, while remediation efforts limited interior water levels to only 2 or 3 inches (Figure 4-11). There was significant damage to some equipment and interior finishes, although other major equipment and contents losses were avoided.

Summary of Damages: The most significant damage was to the Nursing Building, which was built in 1947. This building lost offices, clinics, elevators, and service areas.

Flooding in the basement of the Nursing Building led to irreparable damage to medical equipment including a Magnetic Resonance Imaging (MRI) machine, two Computed Tomography (CT) computers, and pharmaceutical robotics. In addition, the communications systems, UPS systems, electrical distribution panels, mechanical controls, elevators, security systems, and radio center suffered severe damages (Figure 4-12).

Figure 4-11.
Water rose to the level of the window bar outside of Mercy. Massive volunteer efforts helped to keep water levels to a few inches inside (Cedar Rapids, Iowa).

Figure 4-12.
Electrical equipment in the basement of Mercy Medical Center, which was exposed to a few inches of water (Cedar Rapids, Iowa)

There was also significant damage to the interior finishes of the basement and ground floor levels. The emergency area, which had been remodeled one month prior to the flood, lost all of its drywall and flooring. In addition, many basement ceiling panels were saturated and fell during the flood.

Functional Loss: The hospital ceased most functions during the flood, evacuating all of its patients. In addition to the loss of medical and other equipment, and the possible total replacement of the Nursing Building, the loss of function resulted in a loss of revenue for the hospital. However, select parts of the hospital remained operational throughout the flood, including the radiation center. Mercy Medical Center was operating at 90 percent of its full function two months after the flood.

4.2.2 Law Enforcement Facilities and Fire Departments

The MAT visited law enforcement facilities in Iowa and Wisconsin. This section discusses the Linn County Sheriff's Department and Cedar Rapids Police Department Headquarters, both in Cedar Rapids, Iowa, as well as the Fire Station in La Valle, Wisconsin.

4.2.2.1 Linn County Sheriff's Department, Cedar Rapids, Iowa

Key Issues: The Linn County Sheriff's Department kept an emergency generator at ground level in an outdoor enclosure, which was flooded; the generator was completely submerged and could not be used when the facility lost power. The Sheriff's Department lost critical contents that were stored in the basement and ground floor levels.

Overview: The Linn County Sheriff's Department (Figure 4-13) was built in 1921. In 2001, a slab-on-grade garage was added onto the original structure. The building is located in the 0.2-percent-annual-chance floodplain (Figure 4-1). The basement and first floor of the original section were flooded to their full heights, and the second floor was flooded to 2 feet.

Figure 4-13. Linn County Sheriff's Department (Cedar Rapids, Iowa)

Summary of Damages: Several overhead garage doors were damaged. In addition, the emergency generator, which was kept in an outdoor enclosure, was completely submerged (Figure 4-14). The Sheriff's Department also lost significant equipment, including the electrical and mechanical distribution systems, and communications and data systems. There was also damage to interior architectural finishes.

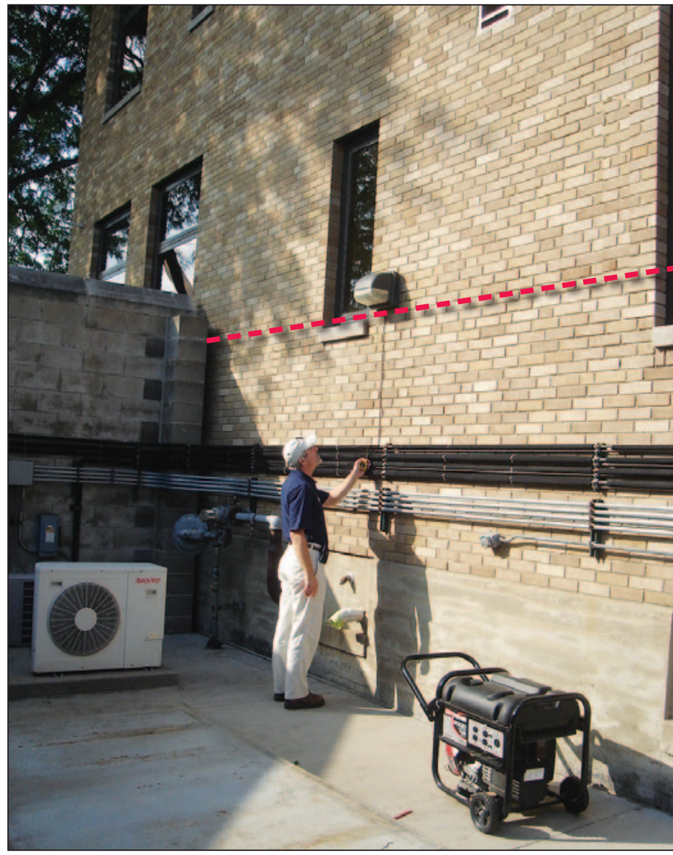

Figure 4-14.
The emergency generator was kept in an outdoor enclosure and was completely submerged. The water reached the floodlight near the second floor window (Cedar Rapids, Iowa).

Functional Loss: The Sheriff's Department building lost all functions during flooding, and operations were temporarily relocated to other facilities.

4.2.2.2 City of Cedar Rapids Police Department Headquarters, Cedar Rapids, Iowa

Key Issues: The Cedar Rapids Police Department (CRPD) Headquarters was built 1 foot above the BFE and 4.5 feet below the 0.2-percent-annual-chance flood elevation. The facility was flooded with 7 feet of water and sustained damage to critical equipment, functions, and contents, including files, evidence, and firearms.

Overview: The CRPD built its headquarters in 1997. The structure is located outside of the SFHA, but in the 0.2-percent-annual-chance floodplain (Figure 4-1). During the June 2008 floods, the walkout basement was inundated with 7 feet of river and sewer water (Figure 4-15). Floodwater entered primarily through a loading dock area. Although officers used several remediation tactics, including constructing a temporary dike, sandbagging, and pumping, their efforts did not prevent losses (Figures 4-16 and 4-17).

Figure 4-15.
The CRPD Headquarters had 7 feet of water in its ground floor. The stairs shown here lead up to the first floor (Cedar Rapids, Iowa).

Figure 4-16. Much of the water that entered the CRPD building came in through the loading dock (Cedar Rapids, Iowa).

Figure 4-17.
A temporary dike was built along the back of the CRPD building (Cedar Rapids, Iowa).

Summary of Damages: There was significant damage to the lower level of the building, including the overhead garage doors in the loading dock area, an emergency generator, electrical and mechanical distribution systems, elevators, and communications and data systems. Officers noted that several firearms that might otherwise have been salvaged were corroded beyond repair.

Functional Loss: While components such as computers, generators, and electrical equipment within the police department building were re-located after the flood, many of these components were operational within a few weeks of the event. However, all basement functions, including the crime lab, fitness and weight rooms, locker rooms, the Quartermaster (uniform distribution), and the armory were destroyed and required replacement. In addition, many files, evidence, equipment, and other contents that were stored in the basement were damaged beyond repair or restoration (Figure 4-18).

Figure 4-18.
Contents stored in the basement, including weapons and ammunition, were damaged (Cedar Rapids, Iowa).

4.2.2.3 La Valle Fire Station, La Valle, Wisconsin

Key Issues: Prior to the flood, staff at the La Valle Fire Station moved contents and equipment from the ground level of the one-story facility to a mezzanine level, and therefore, very little damage was sustained.

Overview: The La Valle Fire Station, which houses the volunteer fire department, consists of two engine bays, equipment storage, offices, and a meeting room (Figure 4-19). The building is outside of the SFHA, but is close to the Baraboo River (Figure 4-20). The building came close to flooding in August 2007; in June 2008, the building had 22 inches of water due to river water and street run-off. The building did not lose power and, thanks to volunteer efforts, much of the building's contents and equipment were moved to the mezzanine floor and avoided damage. The mechanical equipment was also on the mezzanine level.

Figure 4-19.
La Valle Fire Department (La Valle, Wisconsin)

Summary of Damages: There was some damage to interior wall finishes, and the drywall in the office and meeting areas was torn out and replaced to 4 feet above the floor. The gas meter was also damaged.

Functional Loss: The fire station did not lose power, although there was a temporary disruption of operations.

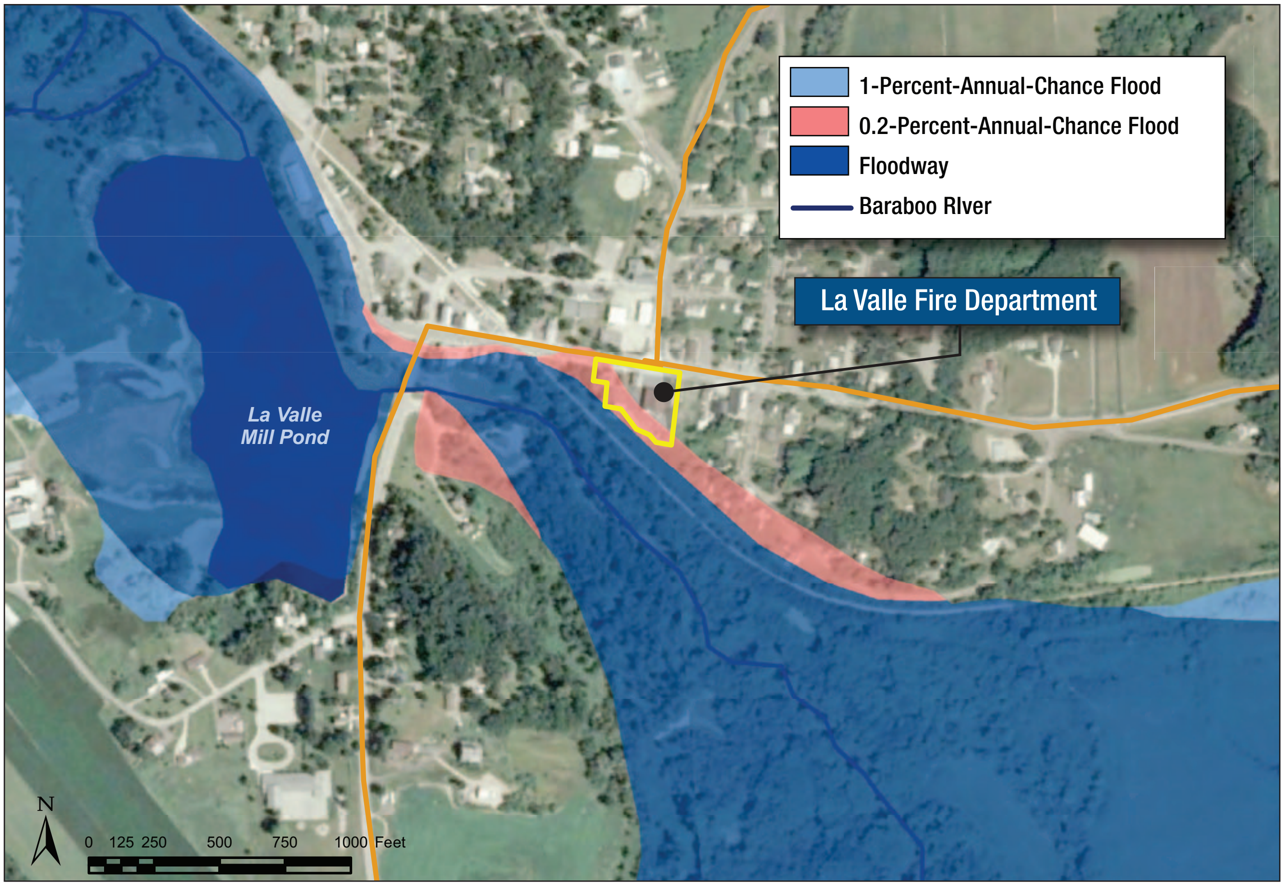

Figure 4-20. Floodway and flood zones for the La Valle Fire Department (La Valle, Wisconsin)

4.3 Utility Plants and Wastewater Treatment and Water Distribution Facilities

The MAT evaluated multiple wastewater treatment facilities and one water distribution pump station in Iowa and Wisconsin. Wastewater facilities are typically located in low-lying areas adjacent to water bodies to utilize as much gravity flow into the facility as possible and for accessible effluent discharge capabilities. This poses many risks to the community when these facilities experience flooding from surface water and excessive inflow. In addition to the possible loss of expensive equipment and facilities, the risks extend to the health and safety of downstream and upstream communities, drinking water systems, sewer backups within the system, discharge violations and associated fines, and loss of daily operational functions for the area the plant serves.

4.3.1 Wastewater Treatment Facility, Reedsburg, Wisconsin

Key Issues: The earthen berm protecting the Reedsburg Wastewater Treatment Facility (WWTF) was overtopped during the 2008 floods, causing the plant to cease operations. As a result of the shut-down, untreated sewer water was discharged into the Baraboo River. In addition, the access road to the facility was flooded and became impassable.

Overview: The Reedsburg WWTF, which was constructed in 1939, is in the SFHA (Figure 4-21). The facility is currently designed with a 2.6-million-gallons-per-day (MGD) capacity to serve approximately 10,000 people. Over the past decades, several additions and upgrades have increased its overall capacity and efficiency. The most notable renovation was the reconstruction and systems replacement completed in 2006, which upgraded most of the systems except for the modernized sludge handling equipment.

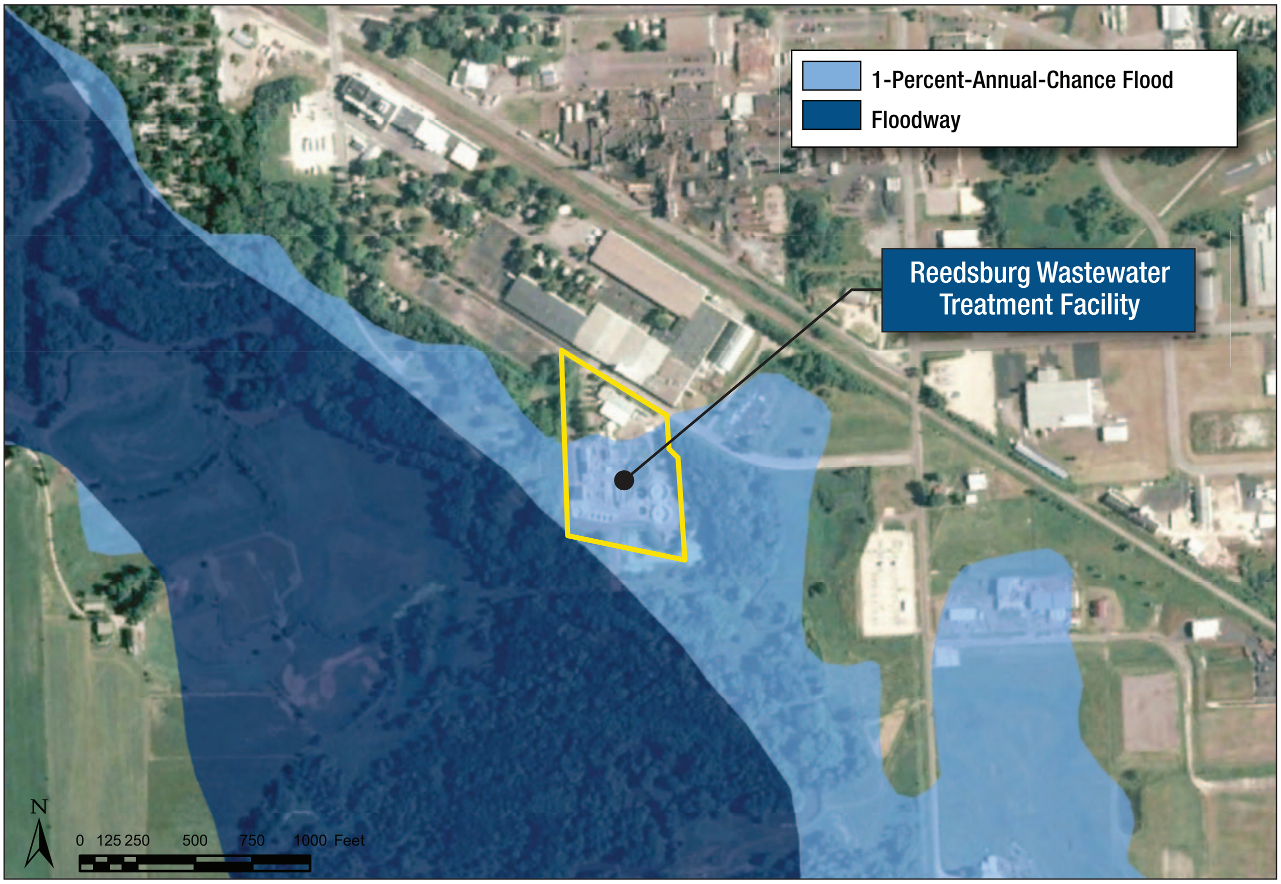

Figure 4-21. Floodway and SFHA for Reedsburg WWTF (Reedsburg, Wisconsin)

The Reedsburg WWTF layout includes one main interceptor pipe entering the plant and capturing flows from the west side of town. The system discharges by gravity through eight lift stations. The WWTF has a berm (elevation 879.0 feet) surrounding the facility and elevated to 1 foot above the BFE of 878.0 feet (Figure 4-22). The 0.2-percent-annual-chance flood elevation at the facility is approximately 881 feet. The facility's first floor elevation is at 874.6 feet with utilities and the majority of the electrical and instrumentation equipment at this level. Final clarifiers were elevated 1to 2 feet above the first floor elevation.

Figure 4-22.
Reedsburg WWTF flooded on June 9, 2008. The red line follows the berm (Reedsburg, Wisconsin).

Summary of Damages: The Reedsburg WWTF was inundated with nearly 4.5 feet of water on June 9, 2008. During the flooding, the berm held, but was overtopped by the adjacent Baraboo River. Wet wells overflowed. Effluent from the surcharged sewer system started flooding the WWTF. Groundwater "boiled up" from the paved surfaces of the parking and facility areas. The access roads to the WWTF were inundated, and the facility was accessible only by boat (see Figure 4-23).

Figure 4-23.
Reedsburg WWTF access road flooded (Reedsburg, Wisconsin).

Damages to the Reedsburg WWTF were estimated to be approximately $2 million. During the peak of the flooding, the facility ceased operations, the power was shut-off, and personnel abandoned the site for safety. The following summarizes the damages incurred by the facility:

- Electrical transformer and main breaker flooded.
- Entire lab, including all furniture and equipment were lost.
- Office drywall, casework, doors, and flooring were destroyed.
- Underground electrical wiring was damaged (some electrical equipment was cleaned and refurbished).
- Some computers were lost.
- Some vehicles were lost.
- Variable Frequency Drives (VFDs) could not be salvaged and needed to be replaced.
- Future mitigation plans include raising the berm surrounding the facility nearly 5 feet higher than its current elevation and acquiring additional emergency pumps.

Figure 4-24. Reedsburg WWTF offices and processing facilities flooded (Reedsburg, Wisconsin).

Functional Loss: Operators stayed at the facility as long as safely possible until shutting off the electrical power and abandoning the facility. All three Motor Control Centers were submerged but were salvaged after being dried out and cleaned. The facility was shut down and abandoned when water levels rose to an elevation of 883.5 feet. At that point, inflow readings had reached 11 MGD, nearly five times more than the facility's design capacity.

After the rain stopped and the river started to recede, it took two full days to remove floodwaters from the plant using six pumps ranging from 6 to 10 inches. The contaminated floodwaters were pumped directly into the Baraboo River. The facility was cleaned, temporarily repaired, and operating on permanent power by June 25. While the facility was able to function at its pre-flood capacity immediately, higher than normal levels of phosphorus—a nutrient that can lead to excessive plant growth and decay—were reported in the first two weeks of operation.

4.3.2 Sewer Pump Station, Reedsburg, Wisconsin

Key Issues: When power at the Reedsburg Sewer Pump Station was lost, the emergency generator could not be run because natural gas had been shut off by the city as part of its emergency procedures. As a result, the Sewer Pump Station failed, and the incoming raw sewage at the station could not be pumped from the drainage area. The pump station's wet well and portions of the sewer collection system backed up and became surcharged. This event resulted in sewer backups in homes, commercial buildings, and public facilities.

Overview: The Sewer Pump Station (Figure 4-25) on Grand Avenue, which is two years old, is located in the SFHA, approximately 2 feet above the BFE. The surrounding area was inundated and access to the pump station was limited, but floodwater did not enter the building (Figure 4-26). However, the natural gas supply was shut down to this part of the city, and, when the station lost power, a natural gas powered emergency generator could not be used. The failure of this lift station resulted in the inability to convey raw sewage flows from this part of Reedsburg, causing the sewer inflows to back up, affecting numerous homes, commercial facilities, and public buildings.

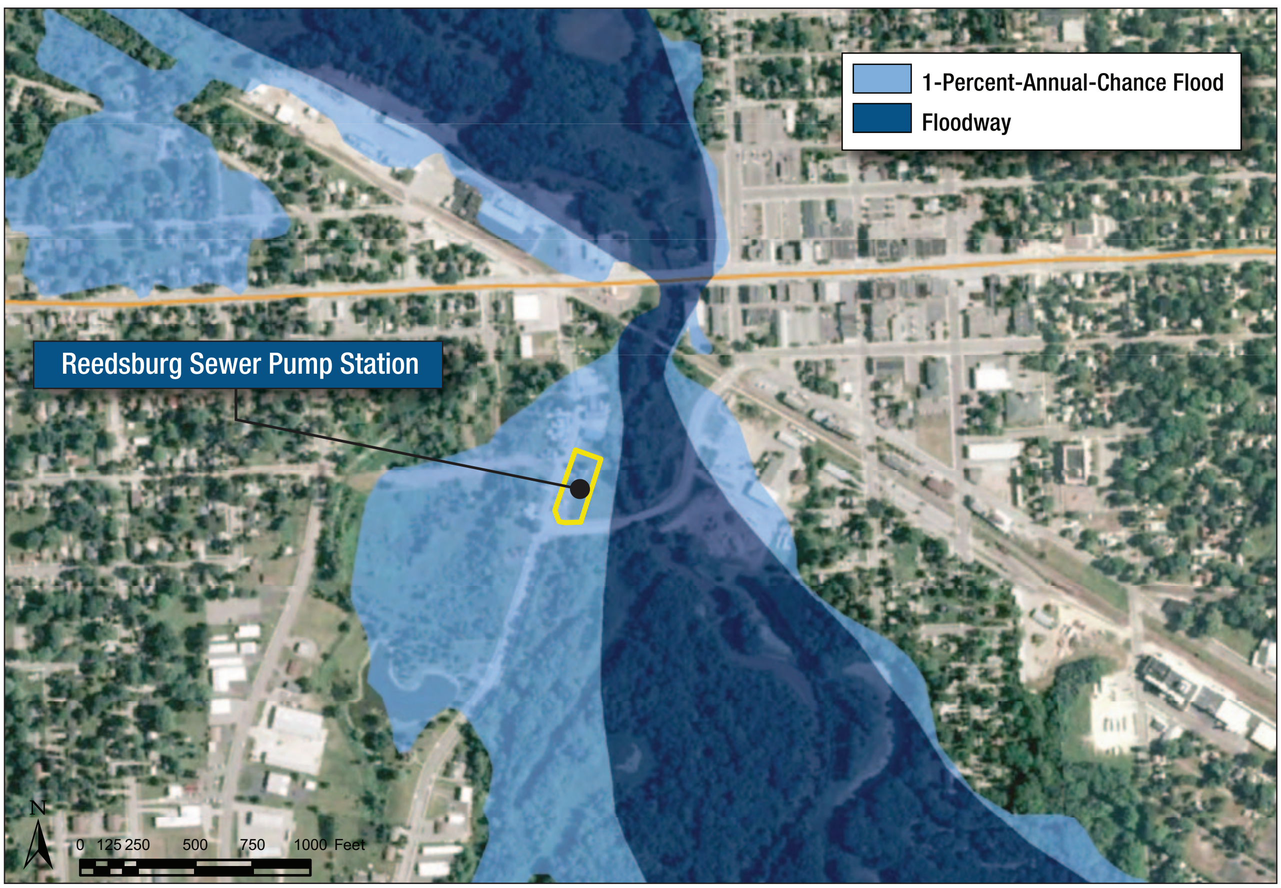

Figure 4-25. Floodway and SFHA for Reedsburg Sewer Pump Station (Reedsburg, Wisconsin)

Figure 4-26.
Reedsburg Sewer Pump Station flooded (Reedsburg, Wisconsin)

4.3.3 Wastewater Treatment Facility, Baraboo, Wisconsin

Key Issues: The Baraboo WWTF was able to maintain operations throughout the 2008 flood events thanks to elevated equipment, watertight manhole covers, and pre-flood preparations. However, the access road to the main plant was flooded and impassable. Due to the flooding on the access road, it was not possible to transport a generator to a pump station that had lost power.

Overview: The Baraboo WWTF treats wastewater from the Village of West Baraboo, Devil's Lake State Park, and the Baraboo Sanitary District, in addition to the city. The WWTF structures were built 2 feet above the BFE, which is approximately 819 feet. The 0.2-percent-annual-chance flood elevation is approximately 821 feet. In 2004, the city began a 3-year project to upgrade the facility based on projected needs over the next 20 years. Some portions of the existing facility date back to 1933. The system includes two lift stations: one that serves nine residential homes and a second that serves nearly 300 homes. The rest of the system flows to the facility by gravity. There are also three siphons carrying flow under the river to the facility.

The Baraboo WWTF had adequate warning and had made previous preparations for flooding. Manholes in Baraboo were inspected and replaced regularly to ensure they were watertight as part of a "clean sewers" program. During the 2008 floods, manholes were submerged for nearly three to four days and performed well. Operators also had an adequate supply of sand bags and adequate time to install them because the river rose slowly (Figure 4-28).

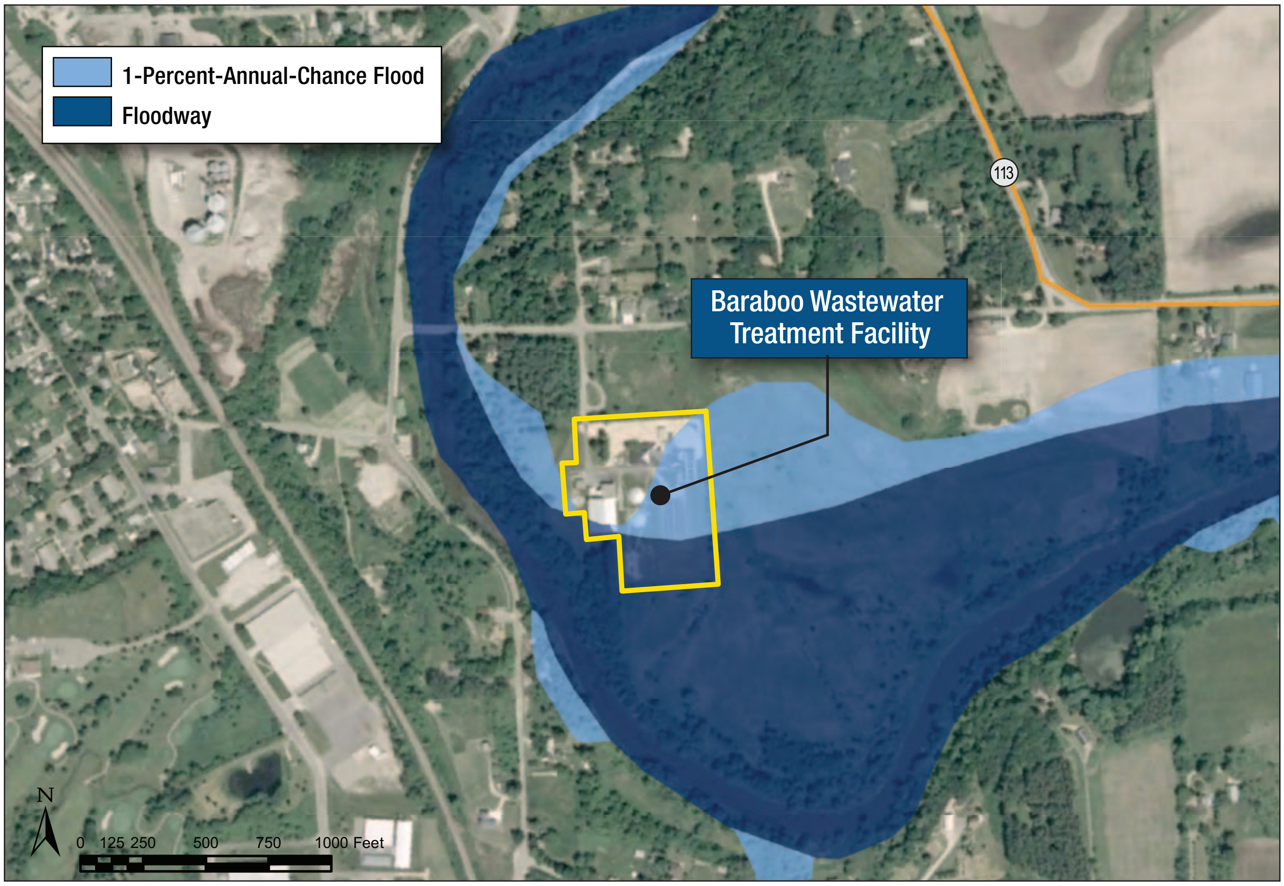

Figure 4-27. Floodway and SFHA for Baraboo WWTF (Baraboo, Wisconsin)

Figure 4-28. Sandbagging protecting the office building (Baraboo, Wisconsin)

Summary of Damages: During the June 2008 storms, the facility retained 1.5 feet of standing ground and surface water. The facility was capable of handling the excess inflows; however, operators were unable to keep river flow from entering the site. The major equipment was not damaged, except for level sensors (Figure 4-29).

Figure 4-29.
Some electrical equipment elevated on concrete pads and on wall (Baraboo, Wisconsin)

Functional Loss: The Baraboo WWTF remained operational despite inflow levels of 4 to 5 times higher than normal levels (1,500-1,800 gallons per minute). All pumps and electrical equipment for wet wells were elevated above the BFE, although mechanical equipment for the wet wells was below the BFE. One local lift station was out of service for 5 hours when its electrical equipment shorted out; operators were able to obtain a used starter from a local electrician to keep the facility operational.

Remediation efforts at the WWTF were complicated because floodwater impeded access to the facility (Figure 4-30). The facility's current plans for mitigation include raising the access road.

Figure 4-30.
Flooded access road at the Baraboo WWTF (Baraboo, Wisconsin).

4.3.4 Wastewater Treatment Facility, Jefferson, Wisconsin

Key Issues: A continuous berm around the Jefferson WWTF was not compromised despite uneven levels of protection. By controlling influent, the facility was able to continue operation throughout the floods.

Overview: The Jefferson WWTF is located in the SFHA (Figure 4-31) and has an operating capacity of 2.5 MGD. The WWTF has two main interceptors: one from the north under the river that is controlled by a sluice gate and another from the west. Flows from the west travel beneath the river through a 12-inch and 8-inch double siphon. There are five lift stations in Jefferson—four small stations and one large station that are located outside of the flood-impacted areas.

The WWTF is below the BFE and is protected by a berm. The berm is intended to be 2 feet above the BFE; however, an access road cuts through the berm, disrupting the continuity of protection.

During the flood, a citywide bulletin was issued to encourage the reduction of water use and sewage flows. Inflow to the plant was also substantially reduced when the city worked with Tyson Foods and Nestle Pet Foods to cut inflow from these facilities. Two emergency crews were set up on each side of the river since both bridges were impassable preventing access to the WWTF site from portions of the city. The WWTF operators had an effluent pump platform built to allow for an emergency diesel pump (Figure 4-32). They also had installed an emergency generator to power the entire facility, and when power was lost to the WWTF, operators were able to switch to generator power. However, the generator was installed several feet below the BFE. Although the WWTF's berm kept water out of the site and, therefore, kept the generator dry, the generator could have been lost had the berm been overtopped.

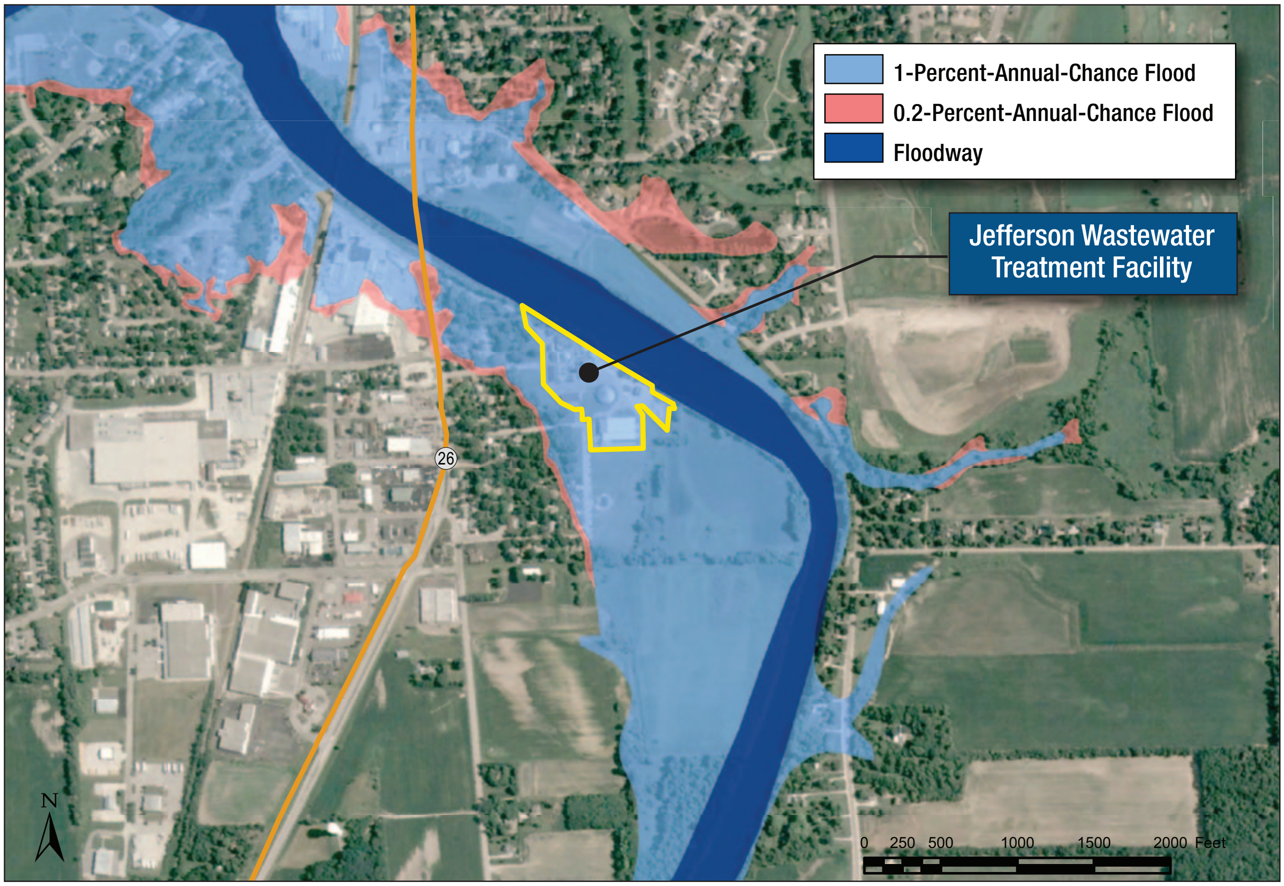

Figure 4-31. Floodway and floodplains for Jefferson WWTF (Jefferson, Wisconsin)

Figure 4-32. Discharge pump platform with space and hook ups for emergency diesel pump (Jefferson, Wisconsin)

Summary of Damages: The WWTF remained in operation during the peak wet weather event because influent flows were controlled. Approximately half of the influent flows (raw sewage) were routed around the WWTF and sent directly to the river with temporary pumping units. Because of the high peak wet weather flow rates, the biological components were washed out of the treatment system, resulting in higher ammonia levels several days after the flood. During and after the flood, nutrient effluent levels were not exceeded, and the plant operators met their discharge permit requirements, largely because the effluent was diluted with storm water.

The influent pump station temporarily lost one of its pumping units when its VFD was struck by lightning. The plant operators were able to run the pumping unit without the VFD and maintain operations. The VFD was replaced within about a month.

Functional Loss: Officials were able to curb inflows to the facility by issuing a citywide bulletin to reduce water use, close influent sluice gates, and take two major industrial users offline. One major user was able to truck their sewage for two days to keep operations going. Plant operators made the decision to have a portion of the influent bypass the facility and discharge directly into the river with temporary pumping units. The bypassed flow concentrations were diluted and, therefore, no discharge permit violations were reported.

The city's fuel station quickly flooded (Figure 4-33) and fuel supply for WWTF equipment became a primary concern to keep the facility operating. Operators were able to obtain fuel from a local gas station and have more fuel delivered to the facility on regular intervals throughout the remainder of the storm event.

Figure 4-33. The Jefferson WWTF is protected by a berm, outlined in red. The fuel station, shown by the arrow, is not protected and was flooded (Jefferson, Wisconsin).

At the peak of the flood event, the facility experienced 7.5 MGD, nearly three times the typical inflow rates, due to the high inflow into the sewer system caused by floodwater surcharging the sewer collection system through manholes, flooded homes and basements allowing inflows into the sewer system, and groundwater infiltration due to the saturated conditions. The river stage rose above the outlet discharge pump, and the operators quickly installed stop planks to keep flow out. An emergency diesel pump and both discharge effluent pumps were run continuously.

The Jefferson WWTF plans to create an emergency action plan and contact list to expedite repairs, such as finding additional portable pumps, contractors, and suppliers. Future plans under consideration may include re-designing the pumping units and the discharge piping elevation to the river to ensure that during high river water levels, the plant effluent can be adequately discharged into the river.

4.3.5 Utility Plant, Cedar Falls, Iowa

Key Issues: Two floodwalls protect the Cedar Falls Utility Plant, and large openings in the floodwalls are sealed with a combination of floodgates and water-filled bladders prior to a flood event, such that the floodwalls are continuous and protect to the 0.2-percent-annual-chance level. The redundant systems could have protected the facility well; however, actual flood levels were approximately 2 feet higher than expected, and the floodwall assemblies were overtopped.

Overview: The Cedar Falls Utility Plant has a complex of several plants on varied terrains and staff has taken measures to mitigate both flood and wind hazards. The complex is in the SFHA (Figure 4-34) and equipment is elevated to maintain operability during floods.

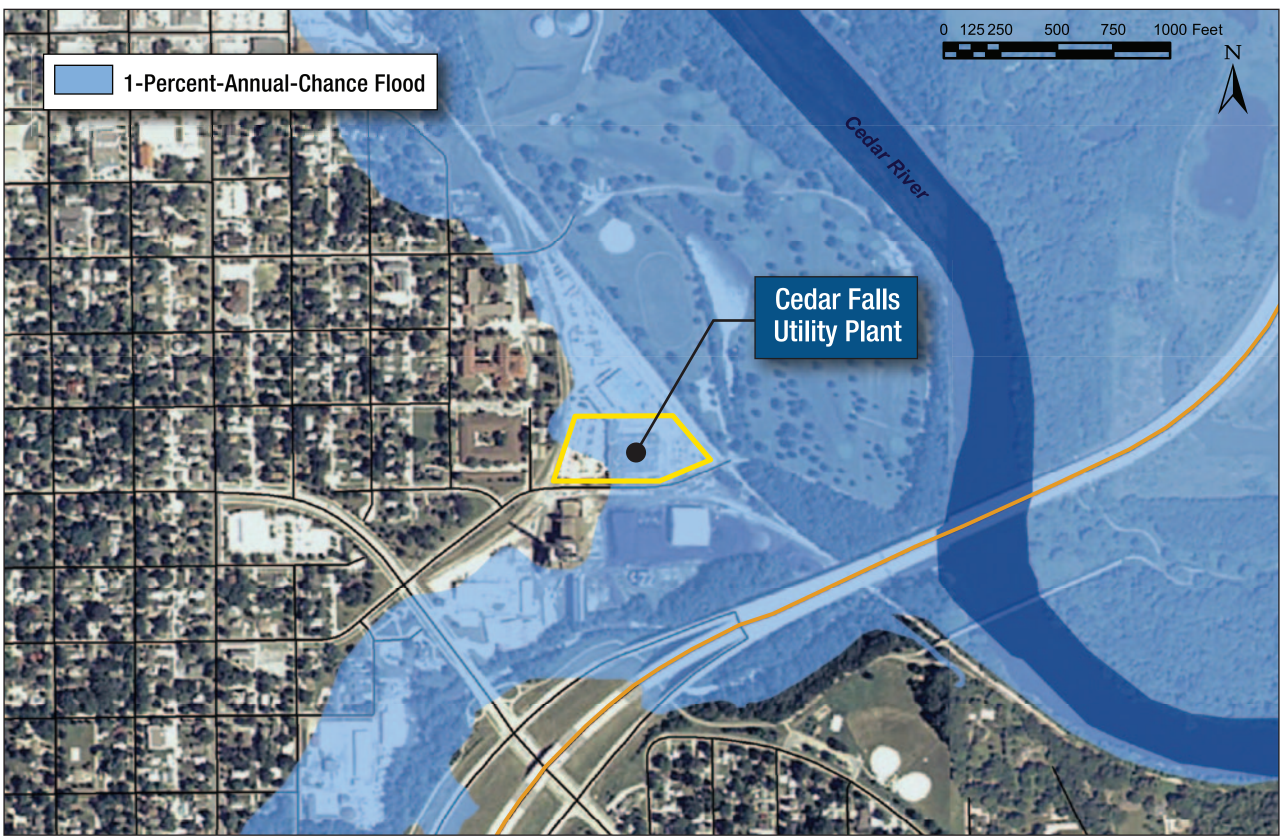

Figure 4-34. SFHA for Cedar Falls Utility Plant (Cedar Falls, Iowa)

The coal fired electric generation station was inundated during the flood. The station has two floodwalls in place: one around the entire site, and the other around the power plant building. The perimeter floodwall is not continuous; during normal operations, breaks in the floodwall allow for access to the plant and staging areas for trucks. When a flood threat is perceived, the plant staff deploys bladders to fill the gaps and build the wall to a continuous height. The bladders are an engineered system that can be stored on site (Figure 4-35) and positioned and filled with water in one to two days. Bladders are easy to fill and repair. In conjunction with the floodwall, they could have been an effective means of protecting the plant; however, the floodwater crest was higher than expected and overtopped the floodwall assembly.

Figure 4-35. Inflatable bladders are stored on site and deployed when a flood threat is perceived. The Cedar Falls Utility Plant maintained hourly monitoring of the latest flood levels to determine deployment of barrier systems (Cedar Falls, Iowa).

In the days leading up to the 2008 floods, plant staff had been tracking reports and anticipated river crests. Water-filled bladder systems were prepared and assembled to protect against the anticipated flood levels. However, just before the floods began, river crest predictions rose by 3 feet. Though they had the capability to raise the protection level, plant staff did not have enough time to fill additional bladders and construct the additional bracing necessary to hold them in place. Actual flood levels were 1 to 2 feet above the floodwalls, and, as a result, the facility was inundated (Figure 4-36).

Future mitigation plans for the Cedar Falls utility plant call for protection to the 0.2-percent-annual-chance flood elevation plus 3 feet.

Summary of Damages: Damage to the utility plant was approximately $5 million, and additional damage to the utility complex was approximately $2.5 million. Most of the equipment inside the plant, including feed pumps and coal mills, was damaged. Plant staff estimated that total repairs would cost approximately $15 million.

Figure 4-36.
The water level at the Cedar Falls power plant was approximately 2 feet higher than the anticipated flood levels and overtopped the floodwalls (Cedar Falls, Iowa).

Functional Loss: Staff estimated that the plant would be down for five months, amounting to approximately $26,000 per day in lost function. However, lost service to customers was minimal due to the existence of other plants on higher terrain that the Cedar Falls Utility Plant owns and operates.

4.4 Educational Facilities

The MAT visited numerous educational facilities in both Iowa and Wisconsin, including elementary schools, school administration facilities, and university campuses. Local officials should consult FEMA 424, *Design Guide for Improving School Safety,* for guidance and recommendations on protecting educational facilities against floods and other hazards.

4.4.1 Education Services Center and Annex, Cedar Rapids Community School District, Cedar Rapids, Iowa

Key Issues: The basement of the Education Services Center (ESC) Annex, where school system files and an emergency generator were stored, was flooded. As a result, the facility could not set up emergency power, and the school record-keeping systems were destroyed.

Overview: The Cedar Rapids Community School District includes 31 schools, of which only two were damaged in the floods:

- Harrison Elementary School, which reopened for the 2008 fall sessions, experienced both riverine and sewer backup flooding, but major sandbagging and pumping efforts helped to reduce damages.
- Taylor Elementary School experienced mostly riverine flooding. The slab-on-grade school did not reopen for the beginning of the 2008–2009 academic year.

Four administrative buildings were also damaged in the floods. Two of them, the ESC and Annex buildings, are both masonry buildings located in the 0.2-percent-annual-chance floodplain (see Figure 4-1). Both buildings had 8 to 9 feet of flooding on the ground floor. The ESC basement was filled with water for nearly seven days (Figure 4-37). The ESC Annex building is slab-on-grade.

Figure 4-37.
The ESC had about 8 feet of water on its ground floor, in addition to a flooded basement (Cedar Rapids, Iowa).

Summary of Damages: The ESC basement housed the building's emergency generator, which was completely submerged. The generator ran on natural gas, which was shut off by the local utility provider during the flood; therefore, even if the generator had been moved from the basement, it would not have been operational. Other losses included the electrical and mechanical systems, as well as interior architectural finishes. Plaster walls and ceilings and wood flooring on the ground floor were damaged. Clean-up and repairs were complicated by the presence of asbestos building materials.

The ESC annex wall system consists of clay tile and was saturated (Figure 4-38). School officials were reluctant to reopen the building because of concern about mold growth inside the clay walls. The building's electrical and mechanical systems also sustained significant damages.

Functional Loss: After the flood, both buildings were closed for ongoing repairs and asbestos abatement. Operations were moved to modular buildings. While many files and other important contents were lost, computers were removed from the ESC by boat during the flood, which allowed the school system to save much of its data and resume operations quickly.

Figure 4-38.
Clay tile wall system of the ESC Annex (Cedar Rapids, Iowa)

4.4.2 South School, Reedsburg, Wisconsin

Key Issues: South School in Reedsburg, Wisconsin, sustained flooding due to sewer backup through drains in the basement. Damaged equipment and finishes were refurbished, not completely replaced.

Overview: South School, which was built in 1937, is in a residential area of Reedsburg. The school is not in the SFHA (Figure 4-39). Flooding inside the building was the result of storm sewer backup, which allowed water to enter through floor drains (Figure 4-40). The school had about 2 feet of standing water in the basement, which houses the kitchen, a cafeteria/multi-purpose room, and storage areas. In addition, the sub-basement was totally flooded.

Summary of Damages: The flooding resulted in the loss of two boilers and kitchen equipment, including a freezer, cooler, and stove. There was also damage to the interior wall and floor finishes in the cafeteria (Figure 4-41). The school district refurbished an air compressor and the main electrical panel, which were also damaged.

Functional Loss: The basement and sub-basement were cleaned and repaired during the summer break. Boiler replacement continued into the beginning of the 2008–2009 school year.

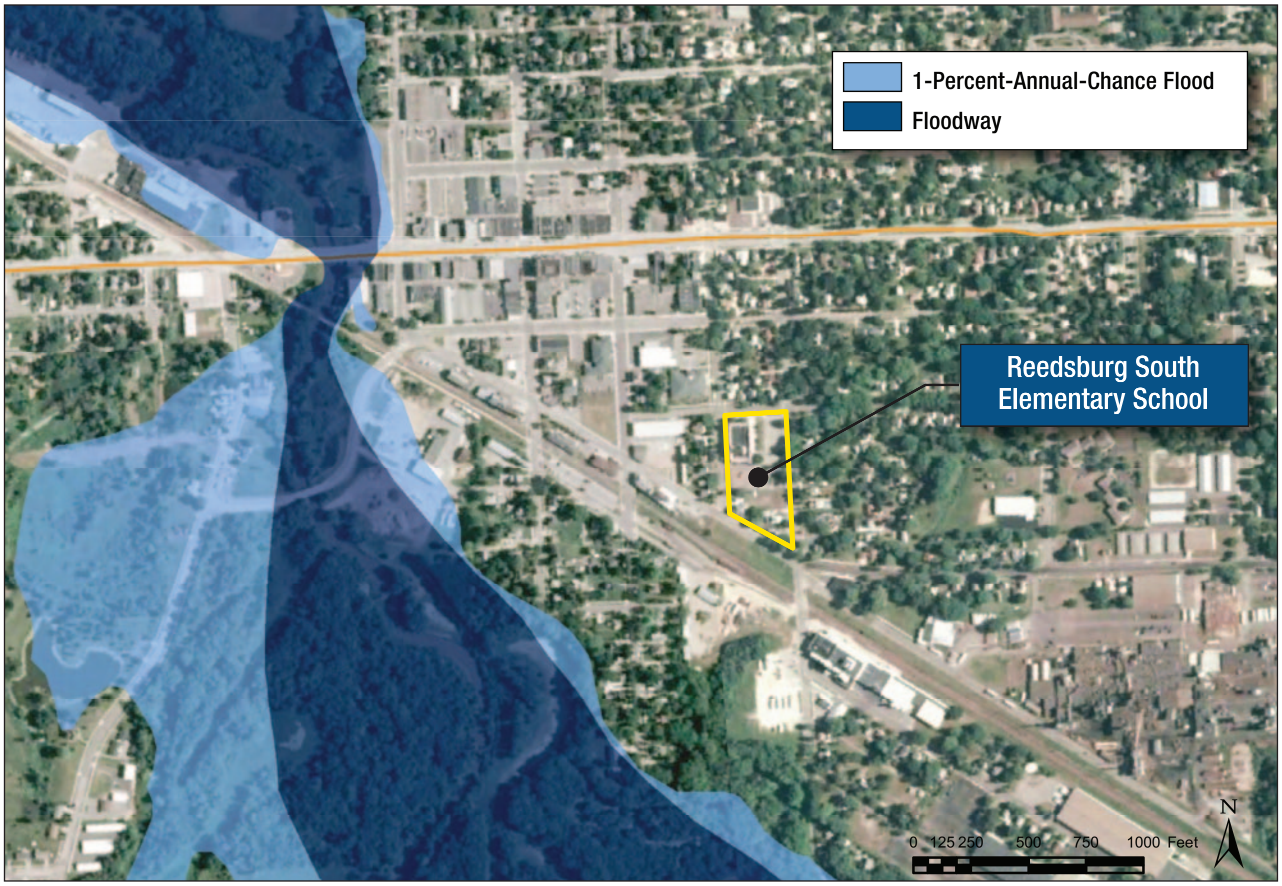

Figure 4-39. Floodway and SFHA for South Elementary School (Reedsburg, Wisconsin)

Figure 4-40.
Flooding in South School was due to backup through floor drains such as the one shown in this photo (Reedsburg, Wisconsin).

Figure 4-41.
Damaged paneling in the Pine Room, South School's cafeteria and multi-purpose room, was refurbished to maintain the room's character (Reedsburg, Wisconsin).

4.4.3 Academic Buildings, University of Wisconsin at Oshkosh, Oshkosh, Wisconsin

Key Issues: Backup in storm sewers caused surface water to enter steam tunnels and, through the steam tunnels, several academic buildings at the University of Wisconsin (UW) at Oshkosh. Backflow valves installed at the site successfully prevented some flooding from sanitary sewers. Following the flood, repairs were made to damaged buildings using flood damage-resistant materials and construction practices.

Overview: UW Oshkosh was founded in 1871 and is the third largest university in Wisconsin. The school's total enrollment is approximately 12,700 students.[1]

The school is located near the Fox River (Figure 4-42), although river water was not the cause of flooding on campus. Flooding in university facilities was the result of backup in city-owned storm sewers (Figure 4-43), which allowed water to infiltrate buildings such as the Nursing & Education Building, the Clow Social Science Center, Swart Hall, and Oviatt House through utility tunnels. In most cases, standing water inside buildings was limited to a few inches. Massive flooding at the River Center, discussed in Section 4.4.4, led to a campus-wide power loss.

1 Chancellor's Welcome, UW Oshkosh website. http://www.uwosh.edu/chancellor/welcome.php

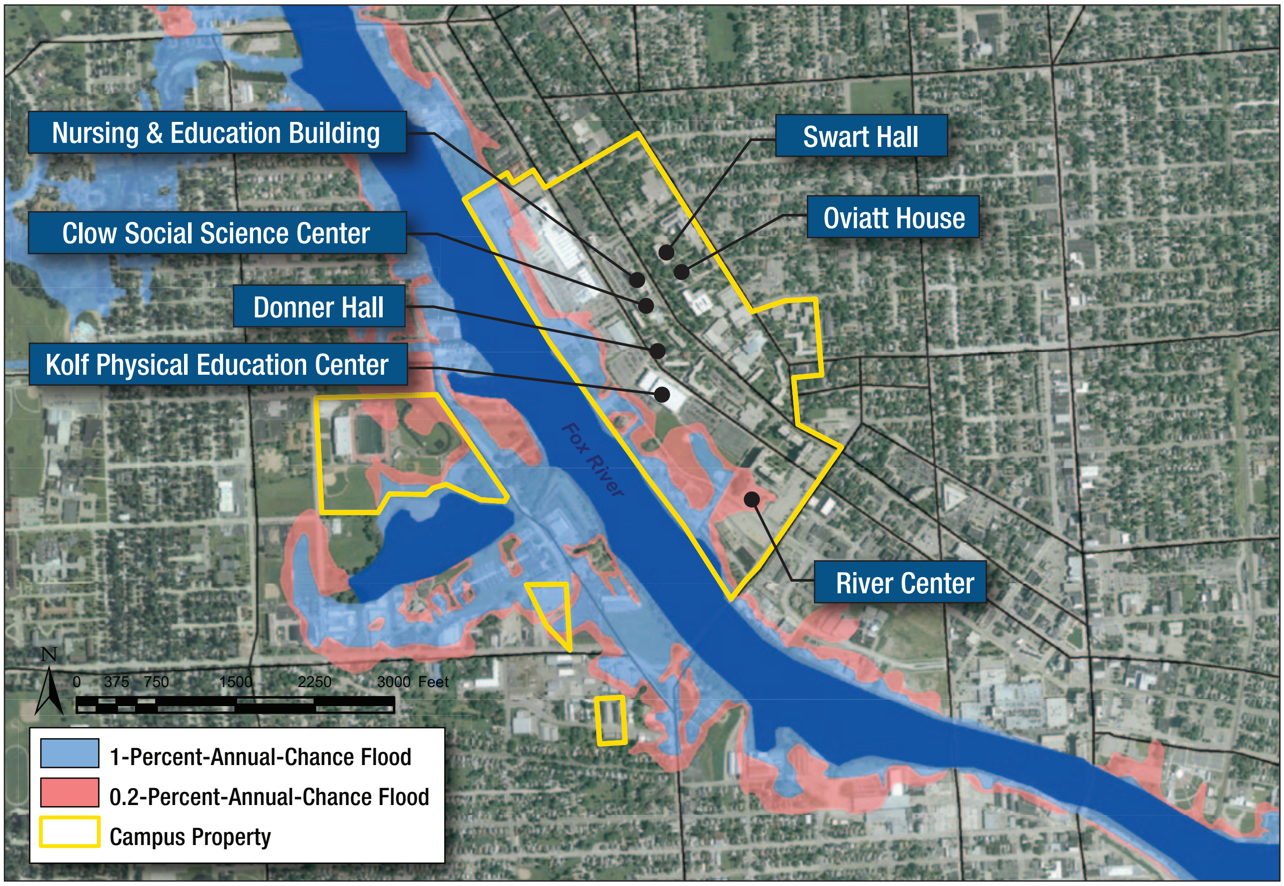

Figure 4-42.
Flood zones for the University of Wisconsin at Oshkosh and buildings visited by the MAT (Oshkosh, Wisconsin)

Figure 4-43.
City-owned storm drains contributed to flooding at UW Oshkosh, but this vulnerability was not considered prior to the 2008 floods (Oshkosh, Wisconsin).

UW Oshkosh had previously experienced flooding, and, as a result, had implemented mitigation measures such as installing check valves on sewer lines (at Donner Hall and others) and raising curbs and entrances (at the Kolf Physical Education and Sports Center) (Figure 4-44). These measures helped to avoid damages at certain buildings, and, as of September 2008, the school plans to continue mitigation efforts. After the flood, the staff refurbished damaged academic buildings with flood damage-resistant materials (Figure 4-45). The Institute for Business and Home Safety (IBHS) publication *Water Damage Prevention for Commercial Buildings* includes more information about the effects of grounds maintenance and landscaping on flood vulnerability.

Figure 4-44.
The curb and sidewalk along the entrance to the Kolf Center had been raised as part of a previous mitigation project to prevent water that collected in the parking lot from entering the building and, thus, to provide positive drainage per local building codes (Oshkosh, Wisconsin).

Figure 4-45.
Carpeting was replaced with flood damage-resistant vinyl flooring throughout the damaged academic buildings (Oshkosh, Wisconsin).

Summary of Damages: Temporary changes in grading for construction allowed surface water to collect behind Oviatt House. The flooding in the academic buildings resulted from surface storm water entering the steam tunnels behind Oviatt House (Figures 4-46 and 4-47). The tunnels, which connect to several buildings including those mentioned above, allowed floodwater to enter academic and mechanical areas in several basements. In one case, staff attempted to contain water in a mechanical room by placing a wooden plank in the doorway. As water flowed in through the tunnel, it was stopped from entering into the hallway and academic area.

Figure 4-46.
Water entered steam conduits through above-ground openings like these. Construction near these openings contributed to the volume of water entering the conduits (Oshkosh, Wisconsin).

Damages incurred in the academic buildings included loss of carpeting, electrical floor outlets, drywall, and wall finishes. Following the floods, damaged basement finishes were replaced with flood damage-resistant materials:

- Carpeting and damaged tile were replaced with vinyl sheet flooring.
- Drywall was removed to 4 feet above the ground and replaced with mold-resistant cement board.
- Rather than installing floor-to-ceiling drywall, staff installed a strip of pressure treated lumber at floor level, left an air gap above it, and then installed cement board in order to prevent wicking in future flood events (similar to the technique shown in Figure 4-48).

Functional Loss: Because the flooding occurred in June, the school was able to clean affected buildings and make all necessary repairs before classes started in the fall.

Figure 4-47.
Water entered academic buildings through steam conduits, like the one in the background (Oshkosh, Wisconsin).

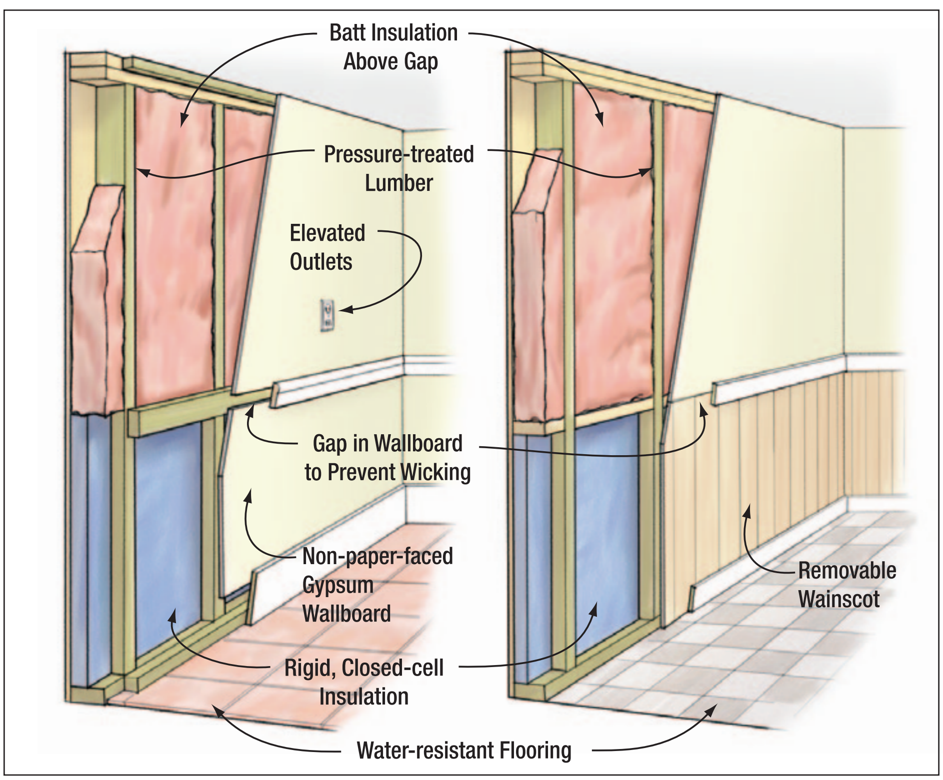

Figure 4-48.
Air gap in drywall to prevent wicking

4.4.4 River Center, University of Wisconsin at Oshkosh, Oshkosh, Wisconsin

Key Issues: Massive flooding at the UW at Oshkosh River Center caused the loss of a transformer, which led to a campus-wide power outage.

Overview: The River Center is a two-story structure that served as a cafeteria prior to the flood (see Figure 4-42). Storm sewer backup allowed water to flow from street level down a steep driveway into the River Center's loading dock, and led to 8 feet of standing water in the basement (Figure 4-49). Loss of a transformer at the River Center triggered a campus-wide power loss. Though campus power was restored within hours, the River Center was not restored before the 2008–2009 academic year; it was without power for at least two months after the flood.

Figure 4-49.
The steep driveway leads from street level to the loading dock at River Center's basement (Oshkosh, Wisconsin).

As of September 2008, UW Oshkosh staff was considering several mitigation options.

Summary of Damages: The River Center basement housed the Department of Residence Life, including its offices, storage space, and maintenance shop. Office finishes, contents in storage, communications systems, and maintenance equipment were all severely damaged. In addition, electrical and mechanical equipment, elevator equipment, the fire alarm system, and the emergency generator were lost in the flood. Hydrostatic pressure from the floodwater caused damage to windows as well (Figure 4-50).

Figure 4-50. Water pressure in the basement courtyard caused glass windows to shatter (Oshkosh, Wisconsin).

Functional Loss: UW Oshkosh operated six pumps for three days to empty the basement. As of September 2008, the building was not operational and the Department of Residence Life had relocated to another facility.

4.4.5 University of Iowa, Iowa City, Iowa

Key Issues: Several buildings built above the BFE at the University of Iowa sustained major damages from stillwater flooding and from water intrusion through the utility tunnel system. Loss of access to the campus and, in particular, to medical facilities, hindered operations and presented a life safety hazard. Flooding also led to loss of power generation and central mechanical systems throughout campus, causing significant loss of functions and equipment. In spite of volunteer efforts in the days leading up to the event, the University sustained damage to several buildings including mechanical and electrical equipment, research equipment, and building contents.

Overview: The University of Iowa in Iowa City is a 1,900 acre campus of 119 buildings that straddles the Iowa River (Figure 4-51). The University has an enrollment of approximately 30,000 students in programs ranging from liberal arts to medicine.[2] Approximately 29 buildings and facilities sustained damages in the flood. Two months after the flood, 17 buildings and facilities remained closed, including:

- Art Building
- Art Building West
- Danforth Chapel

2 http://www.registrar.uiowa.edu/registrar/catalog/WhatIowaIsAllAbout/index.html

- Hancher Auditorium
- Hawkeye Court Apartments
- Iowa Advanced Technology Labs (IATL)
- Iowa Memorial Union (IMU)
- Museum of Art
- Power Plant
- Theatre Building
- Voxman/Clapp Music Building
- Cretzmeyer Track
- Lagoon Shelter House
- Softball Equipment Storage Building
- Softball Stadium
- Track Equipment Building
- IMU Footbridge

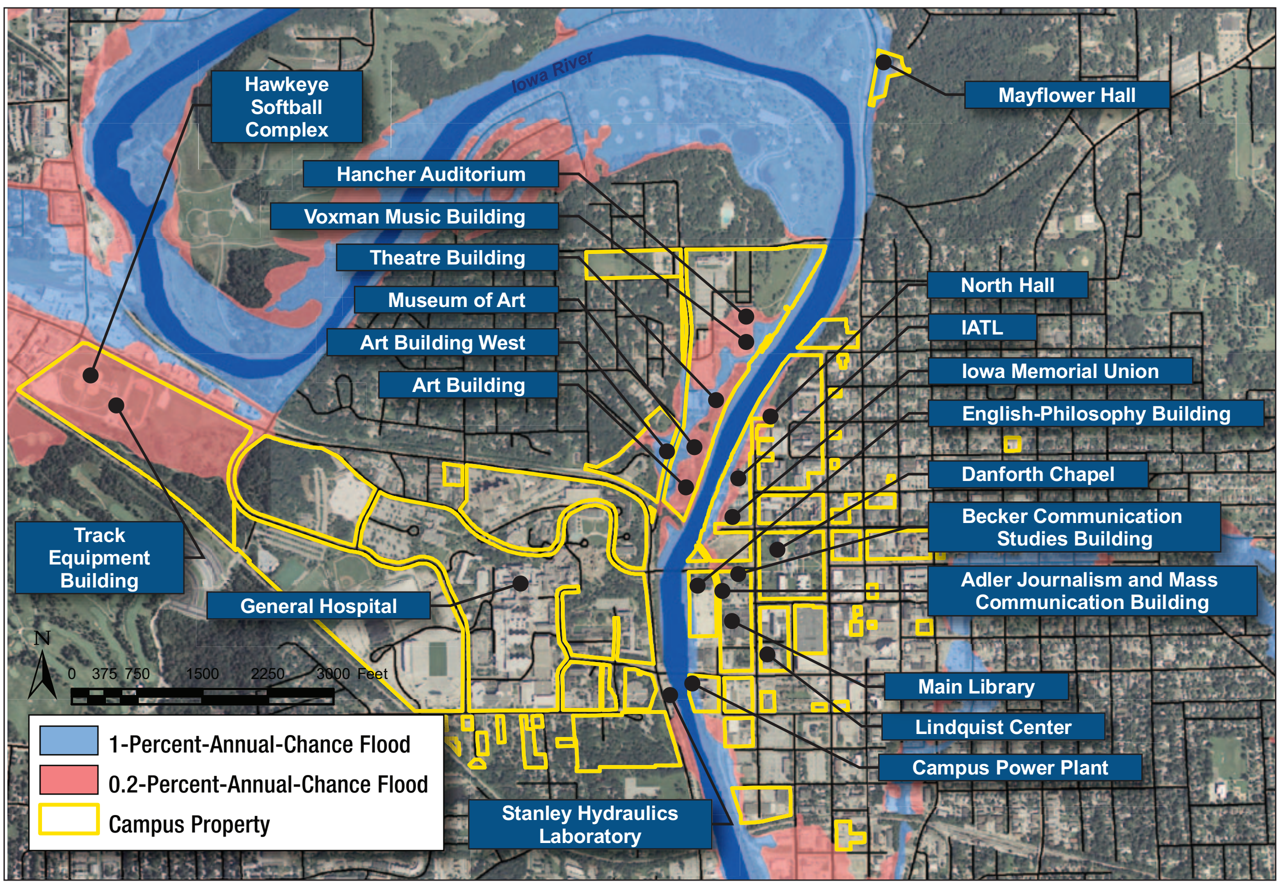

Figure 4-51. Flood zones and inundated buildings for the University of Iowa (Iowa City, Iowa)

Table 4-2 summarizes building elevation, flood depth, and floodplain information for select University of Iowa structures.

Table 4-2. Elevation Data for Facilities at the University of Iowa

Facility	Floodplain	First Floor Elevation (Basement)	Flood Elevation (Approx.)	Base Flood Elevation	0.2-Percent-Annual-Chance Flood Elevation	Recurrence Interval	Date
Mayflower Hall	SFHA	636.2	655.4	650	654.3	>500 year	Pre-FIRM
Art Building West	SFHA	635.2	653.4	648.4	652.5	>500 year	Post-FIRM
Museum of Art	SFHA	641.7	653.3	648.4	652.5	>500 year	Pre-FIRM
Voxman Music Building	0.2-Percent-Annual-Chance	644.1	653.6	649	653	>500 year	Pre-FIRM

On Friday June 13, 2008, the Iowa River levees for the Arts Campus and the IMU and IATL areas were breached (Figure 4-52). Flooding occurred at buildings on both sides of the river. A massive effort involving up to 2,000 volunteers who sandbagged buildings and removed building contents took place in the days before the flood. These emergency efforts saved valuable books from the library and the art collection from the Museum. The University estimates that approximately $750 million in contents were removed prior to the flooding.

Figure 4-52. Flooding of IATL and IMU (Source: University of Iowa Office of University Relations)

Although most of the buildings were directly flooded by river water, Adler Journalism Building, Becker Hall, and the Power Plant were significantly damaged by water entering from the utility tunnels. Access to Iowa City, the campus, and the University Hospital was severely limited. Medical personnel had to be flown in by helicopter to meet manpower needs. Power was lost throughout the campus. Temporary power generation plants were brought onto campus and restored power within three days of the flooding. The hospital, which had limited power from an operational sub-station on the west side of the river, had a temporary boiler system installed to provide the hot water necessary to continue emergency services.

Summary of Damages: The preliminary damages were estimated to be approximately $230 million. As of October 2008, the University, insurance companies, and FEMA were verifying those estimates. Approximate estimates of damages to some of the significant facilities' property and contents are shown in Table 4-3.

Table 4-3. Approximate Estimates of Damages to Facilities at the University of Iowa

Building	Initial Estimated Amount
IATL Flood Damages	$42,000,000
Power Plant Flood Damages	$25,100,000
IMU Flood Damages	$23,000,000
Flood Damaged Utility Tunnel System	$22,000,000
Voxman/Clapp Music Building Flood Damages	$14,000,000
Hancher Auditorium Flood Damages	$13,000,000
Art Building West Flood Damages	$13,000,000
Art Building Flood Damages	$8,000,000
Mayflower Residence Hall Flood Damages	$8,000,000
Museum of Art Flood Damages	$6,000,000
English-Philosophy Building Flood Damages	$5,500,000
Theater Building Flood Damages	$4,500,000
Adler Journalism and Mass Communication Building Flood Damages	$3,500,000
Becker Communication Studies Building Flood Damage	$3,500,000
Flood Damaged Footbridges	$1,500,000
Madison Street Services Building Flood Damages	$1,250,000
Main Library Flood Damages	$1,100,000
North Hall Flood Damages	$1,100,000
Hawkeye Court Apartments, 3 Bldgs, Units 301-376 Flood Damages	$1,100,000
Stanley Hydraulics Laboratory Flood Damages	$850,000
Lindquist Center Flood Damages	$550,000

The buildings incurred damages to the building structure and architecture, but the majority of the damage was to equipment. Several buildings lost mechanical and electrical equipment in the basement levels.

The MAT focused on five buildings located in the 1- or 0.2-percent-annual-chance floodplain and were most impacted by the floods:

- Voxman Music Building, a building with instructional and performance spaces
- Art Building West, an academic building
- Museum of Art
- Mayflower Hall, a residential building
- Campus power plant

Voxman Building: Water came through glass window walls, doors, entryways, and ventilation intakes. The interior finishes were removed to a height of 4 feet and replaced on the first floor. Most of the mechanical and electrical equipment and some of the damaged ductwork in the basement was replaced (Figure 4-53).

Figure 4-53.
Interior damage at Voxman Building (Iowa City, Iowa)

Art Building West: Although the first floor was designed to be 1 foot above the BFE, Art Building West has a below-grade basement that is well below the BFE. The building had 3 to 4 feet of standing water on the first floor in addition to complete flooding of the basement. The basement housed all the electrical and mechanical systems as well as two elevators, which were completely under water and required extensive repairs or replacement. The first floor sustained damage to drywall partitions, electrical wiring and devices, mechanical ductwork, and floor finishes. The glass panels of the exterior wall on the north side filled with water and had to be cleaned (Figure 4-54). Mold intrusion was a concern, and appropriate mitigation was underway in October 2008.

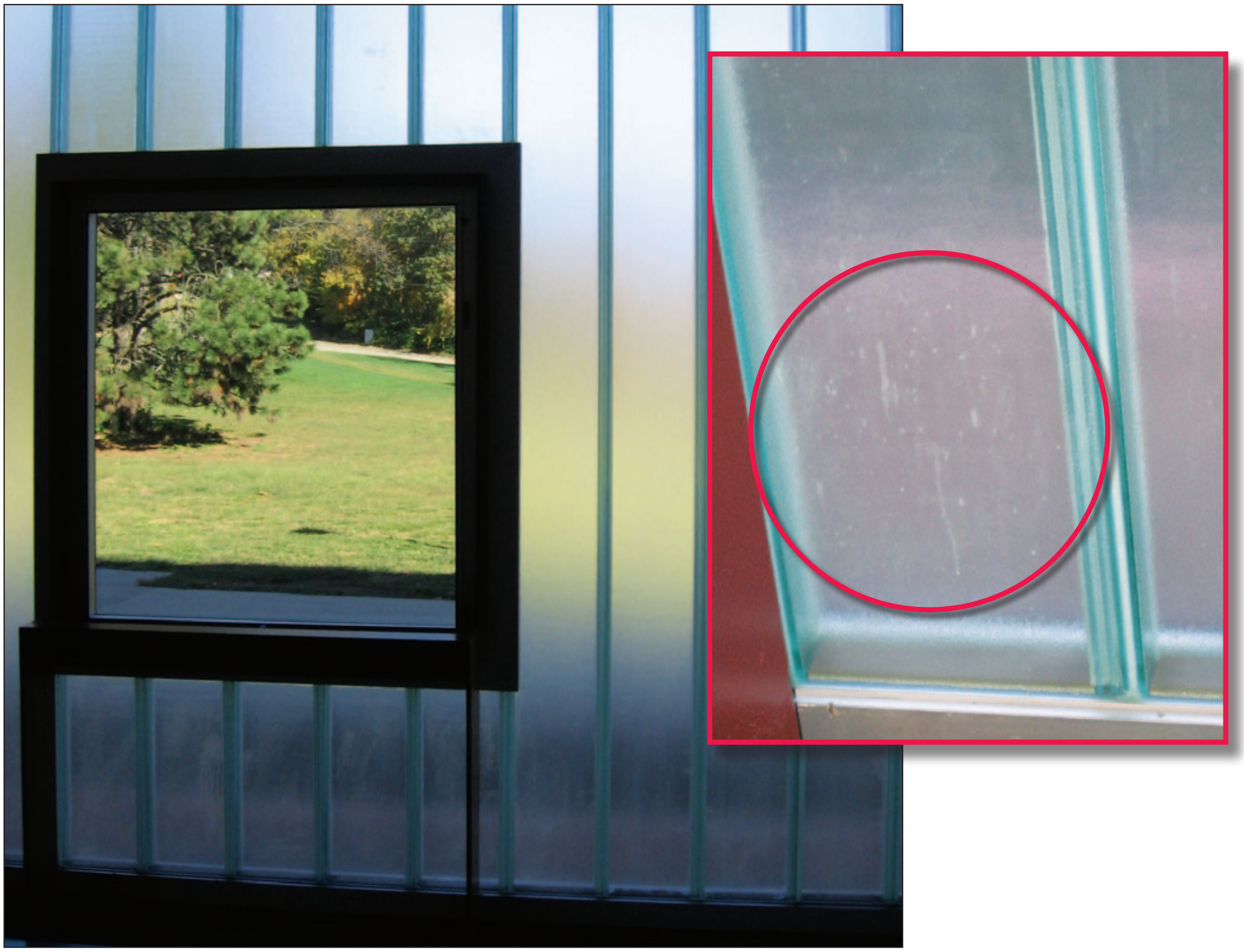

Figure 4-54.
Double glass panels trapped river water between panes in structural glass walls at the Art Building West (Iowa City, Iowa).

Museum of Art: This building had 2 to 6 inches of water on the first floor and several feet of water in the basement. The basement housed all the electrical and mechanical systems, which were completely under water and required extensive repairs or replacement. The first floor sustained damage to drywall partitions, electrical wiring and devices, mechanical ductwork, and floor finishes (Figure 4-55). The art collection was removed prior to flooding and will not be returned; as of October 2008, the University was evaluating the structure for other possible uses.

Mayflower Residence Hall: Built in 1968 and acquired by the University in 1983, this building is a medium rise, eight-story dormitory. It is located upstream of the main campus and in the SFHA. The building, which sits on top of a two-story, below-grade parking structure, had 2 inches of water on the first floor. The parking structure, which housed electrical and mechanical systems, was completely flooded (Figure 4-56). Although the parking structure had not been used for parking in several years, the electrical and mechanical equipment were severely damaged. The first floor sustained damage to wooden doors and frames, drywall partitions, appliances, casework, electrical wiring and devices, mechanical ductwork, and floor finishes in the housing areas. The Food Services area sustained major damage to interior architectural finishes and food service equipment. The building was repaired and reoccupied in time for the 2008–2009 academic year.

Figure 4-55. Drywall damage on first floor of Art Museum (Iowa City, Iowa)

Figure 4-56. Entrance to the parking garage beneath the Mayflower Residence Hall (Iowa City, Iowa)

Power Plant: A portion of the Power Plant is located in the 0.2-percent-annual-chance floodplain along the Iowa River. This building had major flooding in the basement, which housed the power, processing, pumping, and controls of the steam generation equipment for the entire campus. The controls were completely submerged, and, as a result, they needed extensive repairs. In October 2008, the building was under evaluation for structural damage; the basement floor was estimated to have incurred damage of over $25 million, primarily to the main steam generation equipment (Figure 4-57).

Figure 4-57. Power plant site repairs (Iowa City, Iowa)

Utility Tunnels: Water entered campus utility tunnels through access hatches and tunnel vents, and through tunnel openings in the Power Plant. The utility tunnels, which run from the Power Plant carrying steam and water piping and communication lines throughout the campus, were flooded in the following locations:

- On the west side of the river, flooding occurred in:
  - The Art tunnel from the Voxman/Clapp Music Building to the Art Building.
  - Dam tunnel across the river and into the Grand Avenue tunnel.
  - International Center tunnel from Art Building to the International Center.
- On the east side of the river, flooding occurred in:
  - The IMU tunnel from north of the IATL to the Power Plant.
  - The Old Capitol tunnel from the Power Plant to the Seamans Center.

The tunnels incurred damages to steam pipe insulation, valves, pipe penetrations, ductwork, and building entrances (Figures 4-58 and 4-59).

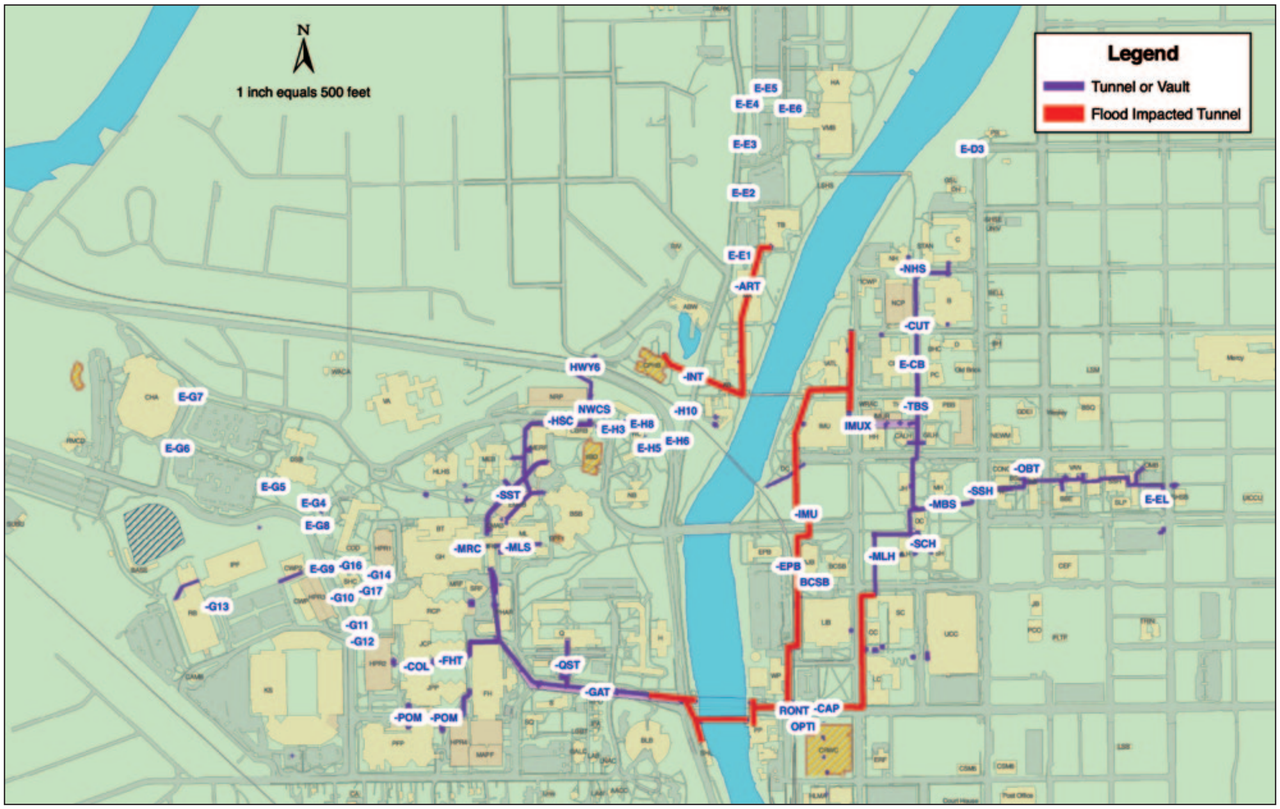

Figure 4-58. Schematic layout of campus tunnels indicating flooded areas
SOURCE: UNIVERSITY OF IOWA FACILITIES MANAGEMENT DEPARTMENT

Functional Loss: As of October 2008, the University was operational with limitations due to closed buildings, such as the Art Museum, Art Building West, Voxman Music Building, and the IATL building. The Iowa Memorial Union Bookstore was relocated to the University Capitol Centre during repairs. The Museum of Art's collection was removed and stored in Chicago. The athletic programs were relocated to available space. Major issues facing the University include expediting repairs, replacing damaged facilities, and mitigating future flooding disasters while maintaining the character of the Iowa River and the University of Iowa campus.

Figure 4-59.
Repair to tunnel entrance to Alder Journalism and Mass Communications Building (Iowa City, Iowa)

4.5 Lessons Learned

Table 4.5 lists the critical and essential facilities reviewed in Chapter 4 and presents lessons learned from the 2008 floods. Each lesson is an observation or recommendation based on observed damages and conversations with facility staff and includes a reference to one or more federal documents that can provide additional guidance. This table is recommended as a reference guideline for users prior to and during site selection, preliminary design, and building rehabilitation of an existing facility. The table is meant to illustrate the issues encountered by the MAT in flood damaged areas of Iowa and Wisconsin, to recommend strategies for mitigating those problems, and to indicate federal publications for further reference. The conclusions and recommendations presented here are discussed in detail in Chapters 6 and 7 of this report.

Table 4-4. Lessons Learned for Critical and Essential Facilities

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
General																
Critical facilities should be protected to the 0.2-percent-annual-chance flood or the ASCE 24 recommended level, whichever is greater. *Reference: FEMA 543*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
New critical facilities should be sited outside of the 0.2-percent-annual-chance floodplain. *Reference: FEMA 543*															●	
Planning and Preparedness																
Critical actions (contents and functions including public records, operations centers, and emergency equipment) should be located above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348, E.O. 11988, FEMA 543*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Critical medical or research functions and equipment and valuable property such as art and music equipment in individual buildings should be located above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348, FEMA 543*	●	●	●		●	●	●						●	●	●	●
Emergency plans must consider the availability of power supply for emergency equipment. Flooding caused loss of off-site natural gas supplies for generators. Anchored, on-site fuel tanks for emergency generators should be considered. *Reference: FEMA 543, FEMA 577*		●						●	●	●	●	●	●	●	●	

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Planning and Preparedness (cont.)																
Detailed emergency plans and checklists are needed for prisons' response to natural disasters, including detailed plans and preparedness for offsite evacuation of prisoners. *Reference: Critical Analysis of Emergency Preparedness, U.S. Department of Justice, National Institute of Corrections*		●														
Building Systems																
Building utilities including electrical, mechanical, and gas should be elevated to or above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Installation of elevator equipment should comply with guidance in NFIP TB 4. *Reference: NFIP TB 4*	●	●			●	●	●						●		●	
Risk and Remediation																
Flood recurrence intervals are difficult to predict given limited history for hydrological data and long-term weather patterns. *Reference: Galloway Report*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Facilities protected by levees or floodwalls should include redundant flood protection measures, including elevating critical equipment and functions. *Reference: FEMA 543*								●			●	●				

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Risk and Remediation (cont.)																
Manufactured products such as water-filled bladders, sand-filled containers, frame-supported fabrics, and others that serve as temporary barriers to hold back floodwater can be used as standalone mitigation measures or to reinforce existing, more permanent mitigation measures. Facility owners considering purchasing such manufactured products to reduce future flood damage should consider whether these products have been subjected to the testing and standards within the National Program to Test and Certify Flood Proofing and Flood Fighting Products. *Reference: National Program to Test and Certify Flood Proofing and Flood Fighting Products*							●	●		●	●	●	●			
Utility Tunnels																
Conduct a vulnerability assessment of utility tunnels to determine potential points of entry. Utility tunnels should be protected against flooding: ■ Tunnel hatches and vents should be raised to elevations that prevent floodwater entry ■ Tunnel access points to buildings should be dry floodproofed *Reference: NA*					●		●						●			

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Access																
Floodprone access routes should be elevated to no more than 1 to 2 feet below the 0.2-percent-annual-chance flood elevation, particularly for WWTFs, which tend to be in low-lying areas. *Reference: FEMA 543*		●	●				●	●	●	●	●		●			
Access ramps and underground tunnels to and from underground parking garages can provide points of entry for water and should be watertight or otherwise floodproofed. *Reference: FEMA 543 & NFIP TB 6*	●	●				●							●			
All points of entry, including stairwells, loading ramps, and courtyards, must be considered in mitigating floods. *Reference: FEMA 543*	●	●		●	●	●	●	●					●			
Sewers and Wastewater Management																
Replacing manhole covers to ensure they are watertight can protect sewers from floodwater infiltration. *Reference: FEMA 348*								●	●	●	●					
Reducing direct inflows to wastewater treatment facilities can help to avoid overwhelming equipment and should be considered as part of emergency preparedness plans. *Reference: NA*								●		●	●					
Backflow prevention valves can help to avoid sewer system backup in a facility's toilets, drains, etc. *Reference: FEMA 348*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Flood Damage-Resistant Materials																
For facilities that cannot be elevated, staff should install flood damage-resistant materials below the 0.2-percent-annual-chance flood elevation. Using flood damage-resistant materials and construction practices can reduce losses and facilitate cleanup. *Reference: NFIP TB 2*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Glazing located below the design flood elevation should be designed to resist flood-related loads. *Reference: NFIP TB 2*	●			●		●	●									





Stacy Robinson

5 Mitigation Program Assessment

Since the 1993 floods in the Midwest, existing and new mitigation programs have evolved to encourage and fund mitigation efforts, particularly in incorporating mitigation into the planning process at the state and community level. When Iowa and Wisconsin experienced large-scale flooding in 1993 and subsequently worked to recover as well as mitigate future losses in some locations, federal support for mitigation began to gain momentum in these areas.

As a result, several mitigation grant programs have been created that increase the amount of funding available for hazard mitigation. In light of this evolution, it is worth exploring how Iowa and Wisconsin have used these programs and how the current programs are assisting recovery efforts.

FEMA offers several programs that provide technical assistance and grant funding to sponsor mitigation efforts across the United States. Numerous mitigation grants are awarded each year to states and communities to undertake mitigation projects to prevent future loss of life and property resulting from hazard impacts. This chapter will assess the following programs and how they relate to the impacted areas in Iowa and Wisconsin:

- Mitigation Planning
- Hazard Mitigation Assistance Programs
- Public Assistance
- Flood Insurance

5.1 Mitigation Planning

In an effort to reduce the nation's mounting natural disaster losses, Congress passed the Disaster Mitigation Act of 2000 (DMA 2000) in order to amend the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act). Section 322 of DMA 2000 emphasizes the need for state and local government entities to closely coordinate on mitigation planning activities, and it makes the development of a hazard mitigation plan a specific eligibility requirement for any local government applying for federal mitigation grant funding, thus pre-positioning communities to receive available mitigation funds before and after the next disaster strikes. The rules governing how state, local, and Indian Tribal governments meet these requirements are outlined in the Mitigation Planning Regulations (interim Final Rule), as published in the CFR.

FEMA published multi-hazard mitigation planning guidance for state, local, and Indian Tribal governments to use in meeting the requirements of the Mitigation Planning regulations under the Stafford Act and 44 CFR § 201. Also, FEMA provides several publications with information and tools to assist mitigation planning efforts:

- *Getting Started: Building Support for Mitigation Planning* (FEMA 386-1)
- *Understanding Your Risks: Identifying Hazards and Estimating Losses* (FEMA 386-2)
- *Developing the Mitigation Plan: Identifying Mitigation Actions and Implementing Strategies* (FEMA 386-3)
- *Bringing the Plan to Life: Implementing the Hazard Mitigation Plan* (FEMA 386-4)
- *Using Benefit-Cost Review in Mitigation Planning* (FEMA 386-5)
- *Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning* (FEMA 386-6)
- *Integrating Manmade Hazards into Mitigation Planning* (FEMA 386-7)
- *Multi-Jurisdictional Mitigation Planning* (FEMA 386-8)
- *Using the Hazard Mitigation Plan to Prepare Successful Mitigation Projects* (FEMA 386-9)

A hazard mitigation plan should establish a comprehensive approach to hazard mitigation, including the broad community vision and guiding principles for reducing risk. By investing in mitigation before a hazard event occurs, a community can prevent or lessen future damages, and, thus, significantly reduce the need for emergency response, and repair and recovery operations and funding. Mitigation practices help communities to become more resilient—able to recover more quickly and with fewer long term impacts. Residents, businesses, and industries re-establish themselves in the wake of a disaster, getting the community economy back on track sooner and with less interruption.

Mitigation planning offers many benefits, including:

- Saving lives and property
- Saving money (including insurance payouts; federal, state, local, and private dollars; etc.)
- Demonstrating a firm commitment to improving community health and safety
- Expediting recovery following disasters, as well as the receipt of pre-disaster and post-disaster grant funding
- Reducing future vulnerability through wise development and post-disaster recovery and reconstruction

The benefits of mitigation planning go beyond solely reducing hazard vulnerability. Measures such as the acquisition or regulation of land in known hazard areas can help achieve multiple community goals, such as preserving open space, maintaining environmental health, and enhancing recreational opportunities. Thus, the local mitigation planning process should be integrated with other concurrent local planning efforts, and any proposed mitigation strategies must take into account other existing community goals or initiatives that will either complement or hinder their future implementation.

However, some communities may not approach the mitigation planning process properly, neglecting to incorporate good planning practices and meaningful strategies into their plan as they try to meet the requirements of DMA 2000. Though the planning process is federally mandated, communities should not complete it as an exercise in achieving FEMA approval. Rather, communities should embrace the process with the goal of developing wisely and protecting citizens and property through mitigation. FEMA provides numerous resources and technical assistance to communities to support local mitigation planning efforts.

Those communities that embrace the planning process and identify specific areas of concern and actions to pursue are often better prepared to submit grant applications for mitigation funds. Ultimately, a good mitigation plan should provide a "road map" that can be followed over time to strategically pursue holistic mitigation efforts. Ideally, a mitigation plan should include specific projects to target mitigation efforts and assign local department or staff personnel to bring the project to fruition. Mitigation actions target residential and commercial structures as well as critical facilities, and include education and outreach components as well.

Both Iowa and Wisconsin have FEMA-approved Enhanced State Mitigation Plans, and four Tribal groups in Wisconsin each have a FEMA-approved Tribal State Plan. In Iowa, as of February 3, 2009, 209 jurisdictions are covered by Hazard Mitigation Plans and 519 jurisdictions have plans in progress. In Wisconsin, as of March 2009, there are 58 approved plans covering 532 jurisdictions, and 14 multi-jurisdictional plans are currently in progress. Since 2006, Iowa has received funding through the Pre-Disaster Mitigation (PDM) program for the creation or update of 87 mitigation plans. Wisconsin has received funding for 21 mitigation plans through the PDM program, as well as one plan through the Flood Mitigation Assistance (FMA) program. Most of the locations visited by the MAT were covered under a FEMA-approved Hazard Mitigation Plan at the time of the flood. However, the jurisdictions of Des Moines, Iowa City, Coralville, Columbus Junction, Oakville, and Palo in Iowa and Richland Center in Wisconsin are not covered by a mitigation plan. According to Iowa Homeland Security, the jurisdictions of Des Moines, Iowa City, and Coralville are in the process of developing a mitigation plan as of February 2009.

5.2 Hazard Mitigation Assistance (HMA) Programs

FEMA manages several HMA programs specifically targeting mitigation, including the Hazard Mitigation Grant Program (HMGP), and the FMA, PDM, Repetitive Flood Claims (RFC), and Severe Repetitive Loss (SRL) programs. The HMGP and PDM programs are authorized by the Stafford Act and offer funding for mitigation planning and project activities that address multiple natural hazard events. The FMA, RFC, and SRL programs are authorized by the National Flood Insurance Act as amended in 2004 and focus funding efforts on reducing claims against the NFIP. Funding under HMA programs is subject to availability of annual appropriations and under HMGP to the amount of FEMA disaster recovery assistance under a presidential major disaster declaration. Table 5-1 briefly describes each program and purpose.

Table 5-1. FEMA Hazard Mitigation Assistance Programs

Mitigation Grant Program	Authorization	Year Authorized	Purpose
Hazard Mitigation Grant Program (HMGP)	Robert T. Stafford Disaster Relief and Emergency Assistance Act	1988	Activated after a presidential disaster declaration; provides funds on a sliding scale formula based on a percentage of the total federal assistance for a disaster for long-term mitigation measures to reduce vulnerability to natural hazards
Flood Mitigation Assistance (FMA)	National Flood Insurance Reform Act	1994	Reduce or eliminate claims against the NFIP
Pre-Disaster Mitigation (PDM)	Disaster Mitigation Act	2000	National competitive program focuses on mitigation project and planning activities that address multiple natural hazards
Repetitive Flood Claims (RFC)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	2004	Reduce flood claims against the NFIP through flood mitigation; properties must be currently NFIP insured and have had at least one NFIP claim
Severe Repetitive Loss (SRL)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	2004	Reduce or eliminate the long-term risk of flood damage to SRL residential structures currently insured under the NFIP

Through Fiscal Year (FY) 2008, FEMA has conducted these programs separately, with separate application cycles and guidance. Beginning in FY2009, FEMA's Mitigation Directorate has unified the multi-hazard PDM program with the FMA, RFC, and SRL programs into a new HMA program application cycle. Aligning these programs into one application cycle will streamline the application review and program delivery resources; encourage sound, cost-effective mitigation projects; and enhance the quality and efficiency of grant awards on an allocation and competitive basis to state, territory, Tribal, and local entities to expand national outreach for all types of mitigation. The HMGP has been added to the HMA program for FY2010.

FEMA's HMA grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages (see Table 5-2).

Table 5-2. Eligible Flood Mitigation Activities by Program

Eligible Activities	HMGP	PDM	FMA	RFC	SRL
Mitigation Projects					
Property Acquisition and Structure Demolition for purposes of open space	✓	✓	✓	✓	✓
Property Acquisition and Structure Relocation	✓	✓	✓	✓	✓
Structure Elevation	✓	✓	✓	✓	✓
Dry Floodproofing of Historic Residential Structures	✓	✓	✓	✓	✓
Dry Floodproofing of Non-residential Structures	✓	✓	✓	✓	
Minor Localized Flood Reduction Projects	✓	✓	✓	✓	✓
Mitigation Reconstruction					✓
Hazard Mitigation Planning	✓	✓	✓		

5.2.1 Hazard Mitigation Grant Program (HMGP)

After a major disaster declaration, the HMGP provides grants to state and local governments to implement hazard mitigation measures that will make a long-term impact and reduce the loss of life and property due to natural disasters.

As of July 31, 2008, there have been 90 flood-related approved HMGP projects (totaling 1,422 properties) in Iowa and 47 flood-related approved HMGP projects (totaling 483 properties) in Wisconsin, as shown in Figure 5-1. The vast majority of these projects, funded in Iowa from 1993 to 2005 and in Wisconsin from 1994 to 2008, have focused on acquisition activities to remove structures prone to riverine flooding. FEMA requires that any property voluntarily acquired by local governments through FEMA mitigation grant programs be deed-restricted to be used only for open space, recreation, or wetlands in perpetuity. Figure 5-2 is an example of a residential lot converted to open space utilizing HMGP funding.

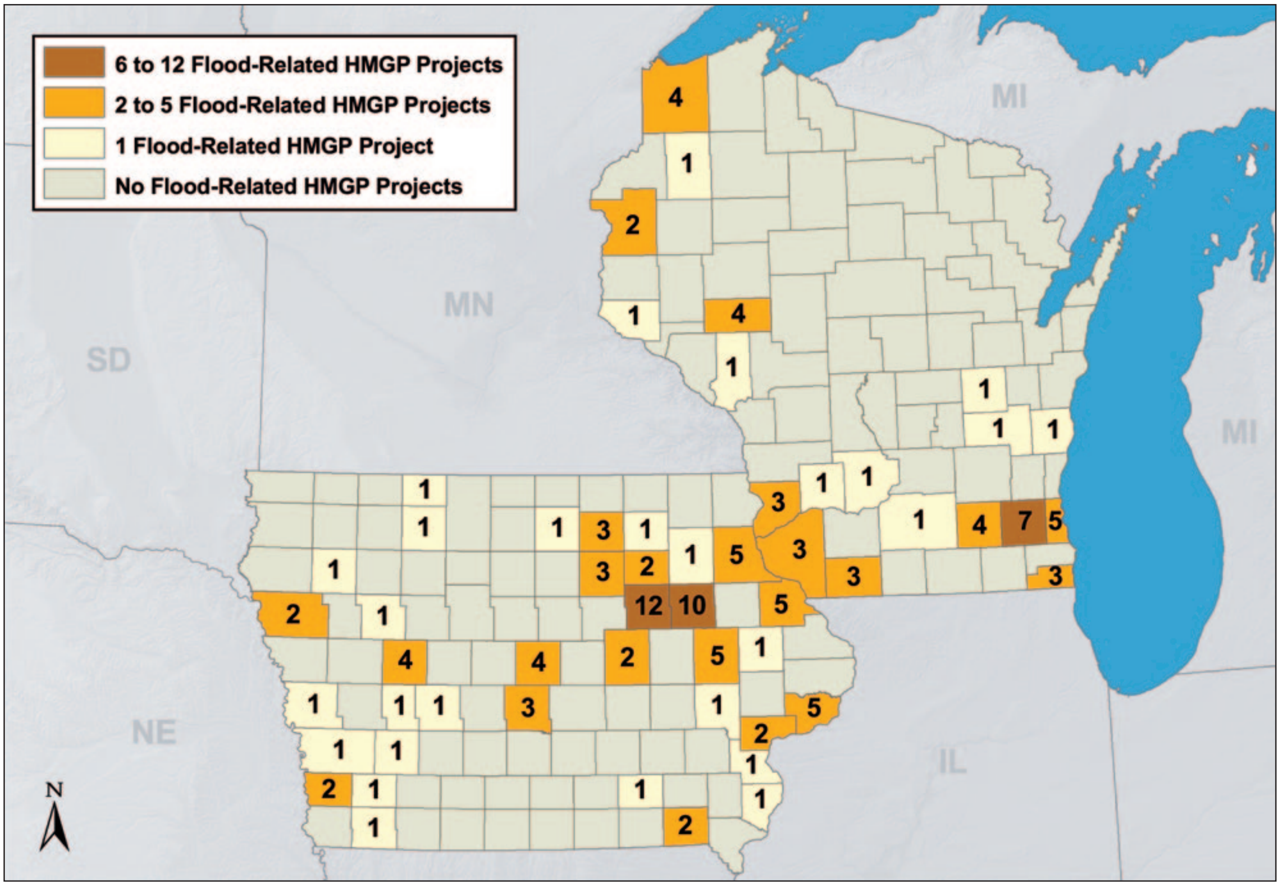

Figure 5-1.
Location of HMGP projects in Iowa and Wisconsin (Based on FEMA mitigation grant programs data through July 31, 2008)

Figure 5-2.
Acquisition for the purposes of open space removes buildings from the floodplain to prevent future damages. Residents relocate outside of the floodplain and green open space is provided in a community (Marion, Iowa).

Acquisition guidelines are provided in 44 CFR § 80, Property Acquisition and Relocation for Open Space, and describe the requirements of land use following acquisition. Acquiring floodprone properties with FEMA funds requires that deed restrictions be recorded to ensure that the property be dedicated as open space in perpetuity to restore and/or conserve the natural floodplain functions and that no new development can ever occur on the property (limited uses are allowed but must be coordinated with FEMA). This mitigation option permanently removes people and structures from harm's way, and reduces future emotional despair and financial costs associated with a community's disaster response, recovery, and repair. Iowa and Wisconsin have supported and successfully completed numerous acquisition projects, and they were among the first to acquire floodprone properties through the HMGP program following the 1993 floods. Figure 5-3 displays the location of FEMA-funded acquisitions in Cedar Falls, Iowa, along with substantial damage inspection results using FEMA's RSDE software for numerous properties in the same area. If the substantially damaged properties had been acquired, their damages could have been avoided.

HMGP funding is available to eligible communities in both Iowa and Wisconsin as a result of this disaster. Both states support using acquisition projects as a priority for HMGP funding for the 2008 flood disaster. As of January 2009, the State of Iowa had received notices from 35 communities interested in pursuing acquisition of 2,562 properties totaling over $251 million. The City of Cedar Rapids alone submitted a notice of interest to acquire 1,126 properties through HMGP, making up 44 percent of the total properties interested in acquisition across the state. Wisconsin also places a priority on acquisition, especially focusing on substantially damaged structures and repetitive loss properties that are primary residences or residential rental properties.

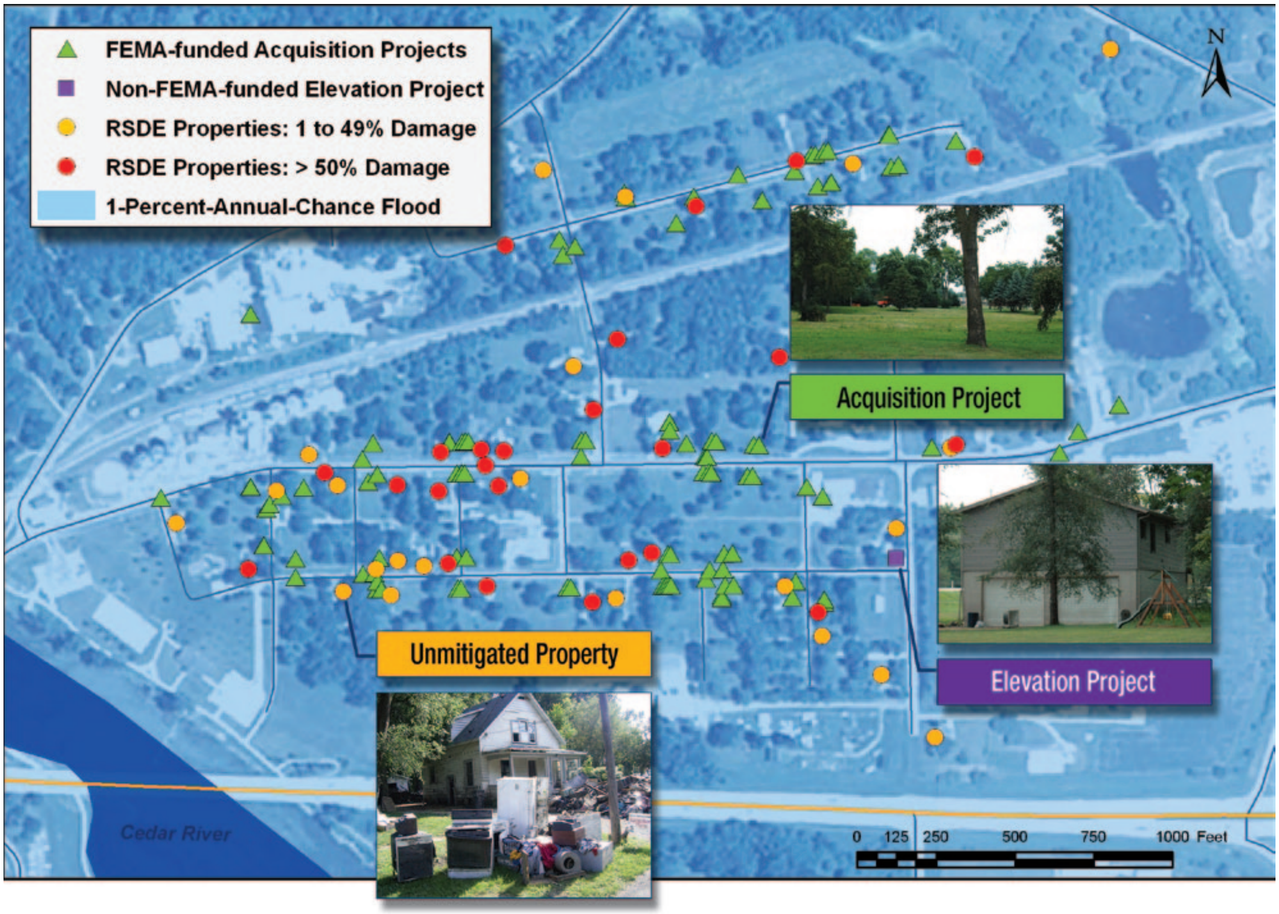

Figure 5-3.
Location of FEMA acquisition projects funded primarily through the HMGP, along with substantial damage inspection information for residences in the same area (Cedar Falls, Iowa) (Based on FEMA mitigation grant programs data through July 31, 2008)

5.2.2 Flood Mitigation Assistance (FMA)

The FMA grant program was created as part of the National Flood Insurance Reform Act of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. An allocation is provided to each state based on the total number of NFIP insurance policies and the total number of repetitive loss properties within the state. States can submit additional projects that exceed their annual allocation for national consideration.

As of July 31, 2008, there had been 11 approved FMA projects in Iowa including acquisition and stormwater management and 8 approved projects in Wisconsin acquiring 9 properties. The majority of these projects, funded in Iowa from 2001 to 2006 and in Wisconsin from 1997 to 2007, focused on acquisition of structures prone to riverine flooding.

5.2.3 Pre-Disaster Mitigation (PDM)

The PDM grant program, authorized under DMA 2000, awards funds prior to the occurrence of a disaster event. This competitive grant process encourages planning and mitigation measures before disaster strikes so that overall risks to people and property are reduced while also reducing the need for funding following a disaster declaration. Congress allocates funding for this program each year, offering millions of dollars for award.

As of July 31, 2008, there had been one approved flood-related PDM project mitigating three properties in Iowa and five approved flood-related projects in Wisconsin mitigating several properties through acquisition and stormwater management. The majority of these projects, funded in Iowa in 2005 and in Wisconsin from 2003 to 2007, focused on acquisition of structures prone to riverine flooding.

5.2.4 Repetitive Flood Claims (RFC)

The RFC grant program was authorized in 2004 by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act (P.L. 108–264), which amended the National Flood Insurance Act (NFIA) of 1968 (42 U.S.C. 4001, et al). Up to $10 million in RFC funds is available each year to encourage states and communities to reduce flood damages to insured properties that have had one or more claims to the NFIP. Unlike other FEMA mitigation programs, RFC funds do not require a local match and can be funded with up to a 100 percent federal share.

As of July 31, 2008, Iowa had submitted one RFC application for acquisition in FY2006 (and an application for corresponding management costs), and Wisconsin had not submitted any applications for RFC program funds.

5.2.5 Severe Repetitive Loss (SRL)

The SRL grant program was authorized in 2004 by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act, which amended the NFIA of 1968. SRL program funds are provided to reduce or eliminate the long-term risk of flood damage to SRL structures insured under the NFIP.

The definition of SRL as applied to this program was established in Section 1361A of the NFIA, as amended in 2004, 42 U.S.C. 4102a, and reads as follows:

> An SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:
>
> *(a) That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or*
>
> *(b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.*
>
> *For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.*

FEMA maintains a list of properties that may qualify as SRL properties based on NFIP claim data and validates properties before deeming them as SRL. State allocations are provided on an annual basis and are based on the number of validated SRL properties per state. Competitive funds are often available from remaining unallocated funds.

It should be noted that the designation of an SRL property applies only to structures with a history of flood insurance and does not consider those uninsured structures that have been impacted by multiple events over time that potentially resulted in losses.

As outlined in the FY2010 SRL guidance, "Property owners who decline formal offers of mitigation assistance, in the form of a Mitigation Offer Letter, will be subject to increases to their insurance premium rates." Facing the potential of large increases in flood insurance premiums, property owners should seriously consider any offers for mitigation assistance under the SRL program.

For the FY2009 SRL program, both Iowa and Wisconsin are considered "non-target states," meaning that they each have fewer than 51 structures designated as SRL properties. As of November 30, 2008, Iowa had 20 validated SRL properties and Wisconsin had 3 validated SRL properties that qualified for SRL funding, as shown in Figure 5-4. As of November 30, 2008, neither Iowa nor Wisconsin had submitted any applications for SRL program funds.

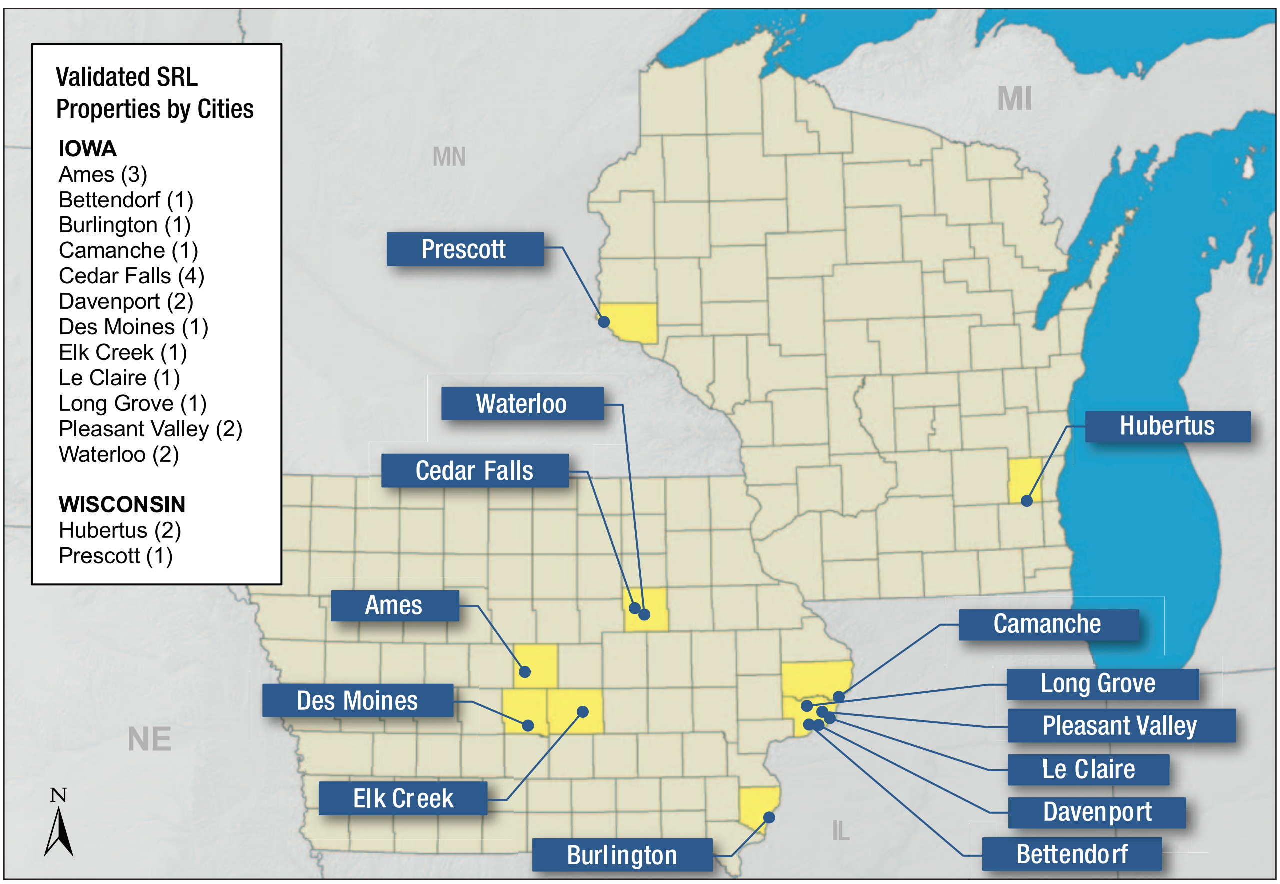

Figure 5-4. SRL property locations in Iowa and Wisconsin

5.3 Public Assistance

FEMA's Public Assistance (PA) disaster recovery program, in partnership with Mitigation, ensures federal grants and technical assistance are effectively provided to local, state, and Tribal communities by planning and implementing immediate rebuilding actions that are conducive to long-term community sustainability and disaster resilience.

FEMA's PA program was authorized under Section 406 of the Stafford Act. It provides assistance to state, Tribal, and local governments, and certain types of Private Nonprofit (PNP) organizations following a presidentially declared disaster to aid with response and recovery through debris removal and emergency protective measures, and repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain PNP organizations. Section 406 provides discretionary authority to fund mitigation measures in conjunction with the repair of damaged facilities. The mitigation measures, which may amount to up to 15 percent of the total eligible cost of the eligible repair work on a particular project, must be cost-effective, related to eligible disaster-related damages, and directly reduce the potential of future, similar disaster damages to the eligible facility. Costs approved for project-specific mitigation measures under PA may not be applied to improved projects that will involve the replacement of a disaster-damaged facility, whether on the same site or an alternate site.

Under the federal disaster declarations for this event, 84 counties in Iowa and 29 counties in Wisconsin are eligible for PA program funding. In Iowa, the State/FEMA Public Assistance program obligated over $651 million to the state for reimbursements for more than 1,100 applications representing over 9,000 PA projects for government-related, eligible expenses in the area of emergency response measures, debris removal, and repair or restoration of disaster-damaged public infrastructure by April 2009.[1] The University of Iowa is working with PA to request over $231 million for building and contents damage, protective measures and debris removal as a result of the floods.[2] In Wisconsin as of March 2009, FEMA PA grants totaling more than $70 million had been obligated for projects from public entities for government-related, eligible expenses in the areas of emergency response measures, debris removal, and repair or restoration of disaster-damaged public infrastructure.[3]

5.4 Flood Insurance

Flood insurance is sold separately from homeowners insurance and protects against losses to buildings and their contents, not the land surrounding them. The coverage is available for residential and commercial buildings in communities that participate in the NFIP and applies whether the flooding results from heavy or prolonged rains, coastal storm surge, snow melt, blocked storm drainage systems, levee dam failure, or other causes. To be considered a flood, the water must cover at least two acres or affect at least two properties. Flood insurance is sold and serviced by private

1 Rebuild Iowa Office. "Facts and Figures." April 15, 2009. http://www.rio.iowa.gov/resources/facts.html

2 University of Iowa. "University of Iowa Flood Action Plans, January 2009." http://www.uiowa.edu/floodrecovery/recovery-reports/action-plan-jan-09.pdf

3 Gray, Roxanne. Wisconsin State Hazard Mitigation Officer.

insurers, and backed by the federal government. Flood insurance covers both homes and businesses. For residential properties, the maximum building coverage is $250,000 and the maximum contents coverage is $100,000. Commercial properties can be insured to a maximum of $500,000 in building coverage and $500,000 for contents. A 30-day waiting period is required for new flood insurance policies, which prevents property owners from obtaining insurance while a flood is in progress. However, two exceptions to this waiting period include:

- If the initial purchase of flood insurance is in connection with the making, increasing, extending, or renewing of a loan, there is no waiting period. Coverage becomes effective at the time of the loan, provided application and payment of premium is made at or prior to loan closing.
- If the initial purchase of flood insurance is made during the 13-month period following the effective date of a revised flood map for a community, there is a 1-day waiting period. This applies only where the FIRM is revised to show the building to be in a SFHA when it had not previously been in a SFHA.

Flood insurance is available for properties located both within and outside of floodplains, and the type of policy and cost vary depending on the subject property's flood risk. Factors such as date of construction, type of building, and methods of construction are considered in the rating. For properties located in high-risk areas, mortgage lenders require the property owner to purchase and maintain a Standard Policy for loan approval and throughout the life of the loan. Outside of high-risk areas, flood insurance is available through a Preferred Risk Policy, which offers lower premiums due to the decreased risk. Although these low-to-moderate risk areas are statistically less likely to experience flooding, it does happen. In fact, nearly 25 percent of all claims made to the NFIP are for properties from low-to-moderate risk areas.

The NFIP's CRS is a voluntary incentive program that recognizes community floodplain management activities that exceed the NFIP requirements. For CRS-participating communities, incentives are provided for the community to take actions that not only improve citizen health and safety, but that can also result in out-of-pocket savings for property owners through reduced insurance rates.

After a building is determined by the appropriate authority (i.e., local building department or floodplain administrator) to be substantially damaged or a repetitive loss property, Increased Cost of Compliance funds may be claimed through the NFIP to pay for additional mitigation and risk reduction measures to be implemented during recovery or reconstruction as required to bring the building to local code requirements, including (but not limited to) elevation or relocation of the structure. Wisconsin floodplain management regulations require that damages calculated to structures are cumulative over the life of the structure, so a home can be considered substantially damaged at a much lower threshold. To assist flood insurance policyholders in covering the costs of meeting these requirements, the NFIP includes up to $30,000 of Increased Cost of Compliance coverage for all new and renewed Standard Flood Insurance Policies. An Increased Cost of Compliance claim is handled separately from the standard policy and can only be filed if the community determines that the policyholder's home or business has been substantially damaged or repetitively damaged by a flood. Once a community has made this determination, policyholders should contact their insurance company or agent who wrote their flood policy to file an Increased Cost of Compliance claim, and their insurer will assign a claims representative to assist with the processing of the Increased Cost of Compliance claim. The NFIP provides a brochure entitled "National Flood Insurance Program Increased Cost of Compliance Coverage How You Can Benefit" to educate property owners on this program.

A local floodplain administrator must understand and execute his post-flood responsibilities, particularly substantial damage assessments. In addition, the community can add a repetitive loss provision to their floodplain management ordinance, if not already included. FEMA has prepared "The NFIP Increased Cost of Compliance Coverage: Guidance for State and Local Officials" (FEMA 301) to assist local officials with the Increased Cost of Compliance process.

Many policyholders and insurance agents in the impacted area lack knowledge regarding additional funds available through the NFIP's Increased Cost of Compliance program. Several property owners in Iowa indicated to the MAT that they contacted their flood insurance agent after the flooding to inquire about Increased Cost of Compliance availability and were met with confusion and lack of awareness of the program by the agents. Other policyholders were not aware that these funds were available through their existing policy. Policyholders and insurance agents, as well as floodplain managers, should educate themselves regarding the Increased Cost of Compliance program before flooding occurs.

NFIP data indicates that a large number of properties impacted by the June 2008 floods were underinsured or had no insurance coverage, including those both inside and outside of the SFHA. According to the City of Cedar Rapids, only 36 percent of flood-impacted homes in the Cedar Rapids SFHA had flood insurance at the time of the flood. Many residents appeared to misunderstand the flood risk of their property, despite their locations in the floodplain or behind levees. Some residents understood that their property was located in the floodplain but did not believe that their property could be affected, while others were unaware of their property's location in relation to the floodplain, including the 0.2-percent-annual-chance (or 500-year) floodplain as indicated on the FIRM. Several residents reported that they did not experience any flooding in 1993, which led them to mistakenly assume that they would not experience flooding in the 2008 flood event. Misperception of personal risk is a common reason why property owners choose not to purchase flood insurance.[4]

4 Rosenbaum, Walter A. and Boulware, Gary. "The Developmental and Environmental Impact of the National Flood Insurance Program: IA Summary Research Report." October 2006.





MIDWEST FLOODS of 2008 IN IOWA & WISCONSIN

6 Conclusions

The conclusions presented in Chapter 6 are based on MAT field observations in the areas studied; evaluations of relevant codes, standards, and regulations; and meetings with state and local officials, contractors, and other interested parties. These conclusions are intended to assist the States of Iowa and Wisconsin as well as communities, businesses, and individuals in the reconstruction process; and to help reduce damage and other impacts from future floods. The report and its recommendations are also valuable to FEMA in considering changes or additional guidance that can make mitigation programs more effective.

The conclusions in this chapter are presented in four sections: Section 6.1 Building Performance, Section 6.2 Risk and Communication, Section 6.3 Hazard Mitigation Assistance Programs, and Section 6.4 Floodplain Management. These conclusions relate directly to recommendations presented in Chapter 7.

6.1 Building Performance

6.1.1 Basements

The MAT observed several basement wall failures in older construction that lacked reinforced foundation walls to resist lateral loads caused by hydrostatic forces and saturated soils. These failures were primarily observed in pre-FIRM basement construction within the SFHA and older unreinforced foundation walls outside the SFHA. Ongoing renovations observed by the MAT indicated that foundation walls were being reinforced during repair. Due to the magnitude of flooding, several basements outside the 1-percent-annual-chance floodplain were inundated; however, no observations of failure due to hydrostatic pressure were observed in areas that had newer construction practices with reinforced basement foundation walls. Finally, in the one community visited by the MAT with a basement exception under the 44 CFR §60.6(c) NFIP floodplain management criteria, the certified basements performed as designed.

6.1.2 Foundations

The foundation failures studied by the MAT were primarily due to hydrostatic forces, but, in some cases, hydrodynamic forces were the cause. Hydrodynamic force failures occurred due to high-velocity floodwater acting directly upon the foundation. These failures were seen primarily in two places:

- Near stream channels where floodwater was exiting the channel and entering the floodplain at high velocity, such as at the outer side of stream bends
- Near failed levees that allowed concentrated floodwater to enter the floodplain at high velocity

Figure 6-1 illustrates a pre-FIRM foundation that was exposed to hydrodynamic forces as wind-driven waves flowed from Lake Koshkonong to the Rock River. Figure 6-2 illustrates a residential building that was situated behind a levee and removed from its foundation by high-velocity floodwater when the protective structure was overtopped.

Figure 6-1.
The foundation of this residential building was exposed to floodwater flowing from Lake Koshkonong to the Rock River (Newville, Wisconsin).

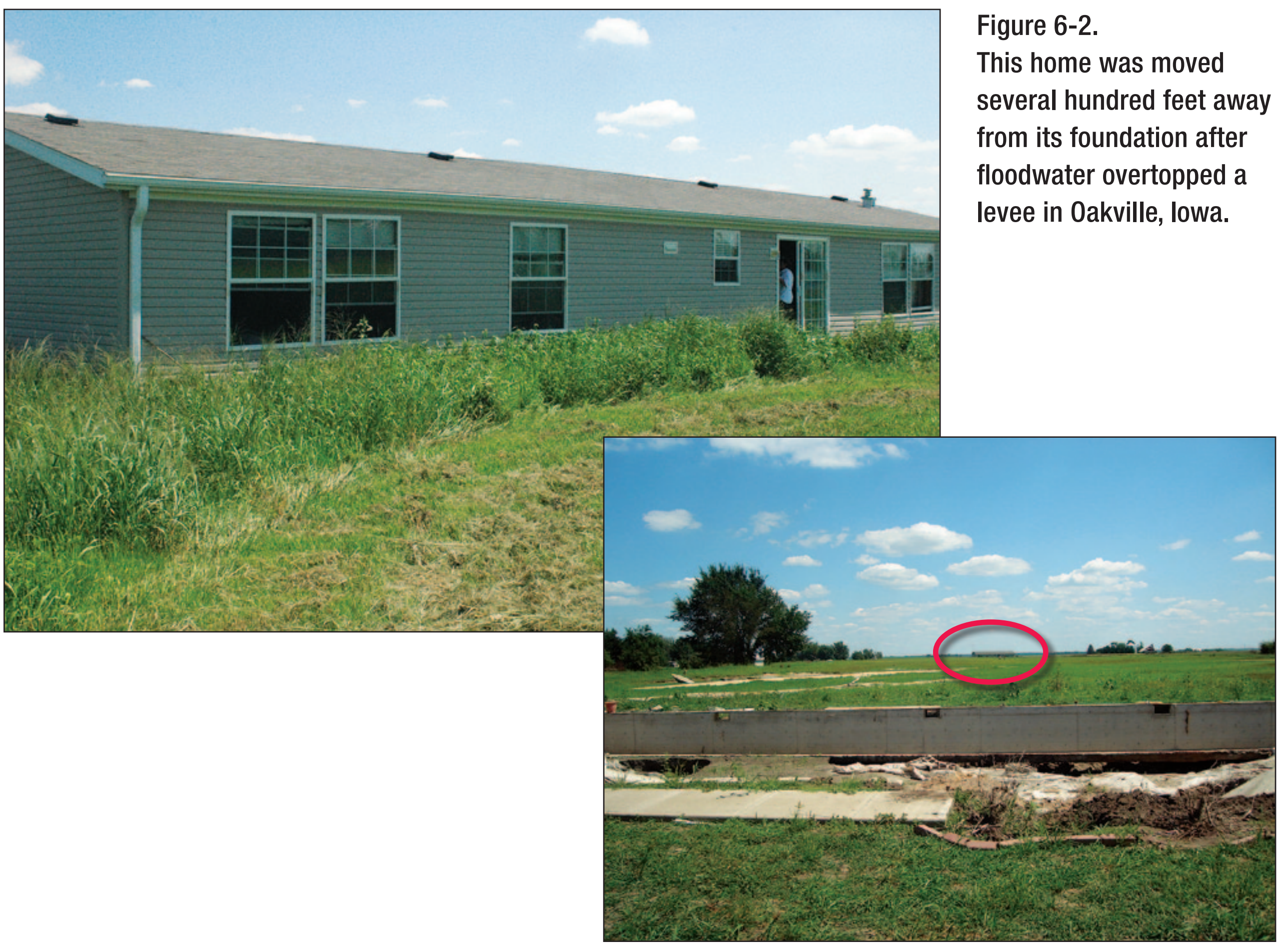

Figure 6-2.
This home was moved several hundred feet away from its foundation after floodwater overtopped a levee in Oakville, Iowa.

6.1.3 Openings

Throughout the field visits, the MAT observed a lack of openings in foundation walls, openings that were too high above grade, and openings that were obstructed. Because foundation walls can sustain damage or collapse due to hydrostatic loads, NFIP regulations require that enclosure walls contain openings that allow for the automatic entry and exit of floodwater. These openings are intended to allow floodwater to reach equal levels on each side of the wall, thereby lessening the probability of damage caused by a difference in hydrostatic loads on opposite sides of the wall. In some cases, openings that were designed in compliance with the NFIP and FEMA TB 1, *Openings in Foundation Walls and Walls of Enclosures*, became non-compliant during construction due to the addition of insulation, as shown in Figure 6-3.

Figure 6-3.
Example of a riverfront property with foundation vent openings; the openings in the garage were clear but those around the house were blocked by insulation, eliminating the effectiveness of the openings (Iowa City, Iowa).

6.1.4 Damage Inspections

Following the floods, local building departments had difficulty keeping up with the high volume of required post-disaster damage assessments, including substantial damage inspections. Several communities put a temporary hold on issuing building permits until their workloads became more manageable. To help manage their workload, communities trained personnel identified through local home builders associations to provide support with plan reviews and code enforcement. They also utilized emergency contracts to help complete residential substantial damage inspections.

6.1.5 Elevation

Although little new construction was observed in the floodplain, most of the buildings that were elevated above the BFE performed well and had limited damages. However, some that were elevated to the minimum requirements of the NFIP (i.e., at BFE) were still not high enough to avoid damage. Others were damaged because they were constructed pre-FIRM and had what, if constructed today, would be considered NFIP compliance issues, such as basements, utilities, or other functions located below the BFE. As expected, newer buildings performed best when elevated higher on proper foundations. Figure 6-4 is an example of a property constructed on fill so that the first floor elevation was 2 feet above the BFE.

Figure 6-4.
This property was elevated 2 feet above the BFE and sustained minimal damages, whereas the adjacent pre-FIRM properties built at grade had over 4 feet of flooding (Milton, Wisconsin).

6.1.6 Backflow Prevention

During the Midwest floods, backflow from sanitary sewers caused flooding in buildings, some of which could have been prevented with a backflow device. A backflow prevention device is a valve that is located in the sewer line that exits a building. This line is subject to possible flooding due to elevations of the finished floor of the building in relation to the sanitary sewer system elevations. The purpose of this valve is to prevent sewage and floodwater that enters the sanitary system from flowing back into the building through the sewer piping. Sewer flow into buildings occurs when wastewater flows increase and create sufficient pressure to cause sewage to flow backward into buildings via the laterals. Facilities within the building, such as toilets, floor drains, sinks, etc., overflow with untreated sewage.

The elevation of the flooding in the building is directly related to the surface elevation of the wastewater and head in the sanitary sewer system. Sewage backflow can occur in buildings that may not be flooded by overland surface floodwater but are affected by the sanitary sewer system that has collected storm flows to the point that the pressure in the system pushes the flows back into the buildings. With backflow prevention devices, the pressure closes the devices and prevents sewage from entering the buildings, as observed in academic buildings at the University of Wisconsin at Oshkosh. In other areas visited by the MAT, flooding caused sewage from sanitary sewer lines to back up through drain pipes. These backups not only caused damage that is difficult to repair, but also created health hazards.

6.1.7 Critical Facilities

The Midwest floods illustrated the importance of properly locating critical facilities to reduce their flood risk. EO 11988 requires and FEMA 543 recommends that critical facilities either be located outside the 0.2-percent-annual-chance floodplain or, if that is not possible, protected to the 0.2 percent-annual-chance flood level. Several critical facilities that were located within the 0.2-percent-annual-chance floodplain and, in some cases, within the 1-percent-annual-chance floodplain sustained considerable damage requiring several hundred million dollars in repairs and numerous months of closure. In addition, the damages impacted vital resources during response and recovery operations. The three facilities on Mays Island in Cedar Rapids are examples of facilities whose operations had to be relocated for several months due to flood damages. The floods also showed that critical facilities that are near, but not within, a 0.2-percent-annual-chance floodplain still face a residual flood risk, and their staff should plan accordingly. Mercy Medical Center, which is located adjacent to but not directly in the 0.2-percent-annual-chance floodplain, illustrates this residual risk to facilities. Damage to the hospital included flooding of an MRI machine, pharmaceutical robotics, communications equipment, and electrical distribution panels.

Critical facilities that relocated contents or functions to higher levels during the 2008 floods successfully avoided damages to valuable property, as was the case at the University of Iowa library. Thorough planning and integrated design are essential to ensuring a critical facility remains functional during and after a disaster. Having detailed plans in place to vacate a correctional facility, hospital, or other critical facility is essential to properly evacuating to an offsite location. In addition, planning for necessary logistics such as food, water, and fuel are essential to keeping critical facilities functioning during a major disaster when resources can be limited.

To prepare for the floods, several critical facilities visited by the MAT monitored forecasts several times daily and prepared levels of protection based upon projected crests. Some were caught by surprise when the river crests exceeded forecasts. In Cedar Rapids, forecasts versus actual crests differed by more than 7 feet, and the County Sheriff’s Department had to evacuate inmates at the correctional facility on Mays Island during emergency conditions. Other jurisdictions staged pumps throughout low-lying communities to help limit sewer backups before they reached residences. In addition to protecting facilities with sandbags, staging equipment, and other measures, one wastewater treatment facility manager coordinated with the facility’s major users to reduce demand on the facility, which helped avoid discharge violations, associated fines, and loss of function for the plant.

6.2 Risk and Communication

Based upon numerous observations recorded by the MAT, the Midwest floods demonstrate that a significant number of property owners in the affected area did not fully understand and appreciate their level of flood risk. This has been attributed to a variety of reasons, including:

- **Emphasis on the SFHA.** Many property owners seemed to be misinformed or did not fully understand that they may be at risk of flooding even if they are not located within the SFHA. The areas of inundation associated with the 2008 Midwest floods illustrate that with certain conditions, such as above average soil saturation levels and large quantities of rain over a short period of time, floods can exceed the area delineated as the SFHA.
- **Levees and Flood Control Measures.** Flood control measures, such as levees, dams, or floodwalls, protect areas that are naturally vulnerable to flooding. Many property owners did not understand the limit of protection provided by the flood control structure. Portions of communities visited by the MAT, such as Baraboo, Cedar Rapids, Coralville, and Oakville, were guarded by flood control structures, but the 2008 floods exceeded their design capacity and buildings thought to be protected were exposed to several feet of flooding.

In addition to realizing their flood risk, everyone must comprehend how flood risk is calculated to fully understand and appreciate their level of flood risk. There are two components to flood risk: the probability of flooding and the consequences associated with that level of flooding. For example, the 2008 floods illustrated that structural flood protection measures can actually increase flood risk over time. Although properly constructed levees, floodwalls, and other structural flood protection measures decrease the probability of flooding for the area they are protecting, they indirectly support development in potentially at-risk areas, thus increasing the consequences if or when the structural flood protection measure is overtopped or fails. This is especially true when a structural flood protection measure becomes accredited for the NFIP, thus eliminating the requirement for flood insurance and floodplain regulations in the protected area. Any new development is then constructed as if a floodplain did not exist.

Besides not understanding their flood risk, some property owners stated that they did not have adequate real-time information regarding the magnitude and size of the event. Local officials said there was confusion between correlating stage and estimated crest information with elevations in a FEMA FIS so the public can estimate how deep the water may get at their location. The flood stages were typically associated with a category of damage (minor, moderate, major, or record flooding), but there was not enough information to convert the stages to a known vertical datum and develop depth grids or inundation maps that could be used by the public and/or emergency management officials as recommended by FEMA 64, *Federal Guidelines for Dam Safety*. Based on field interviews and a rainfall-river forecast summit convened by the USACE, NWS, and USGS, the need for better coordination, communication, and collaboration was identified as a lesson learned from the 2008 floods.

6.3 Hazard Mitigation Assistance Programs

6.3.1 Acquisitions for the Purpose of Open Space

Based on FEMA mitigation grant programs data through July 31, 2008, more than 2,000, or approximately 97 percent, of the properties mitigated in Iowa and Wisconsin under FEMA's mitigation grant programs involved acquiring and demolishing or relocating a structure out of the floodplain. The MAT visited several of these locations, most of which were inundated with several feet of floodwater. One example was the Monkey Run neighborhood of Columbus Junction, Iowa. Most of the homes in this neighborhood had been severely damaged by the 1993 floods, and nearly all structures had been bought and removed through FEMA mitigation grant programs. By 2008, most of these properties had been converted into green space such as soccer and baseball fields. Despite flood depths of over 4 feet above the BFE, only 6 houses in the general vicinity of the acquisitions sustained damage in the June 2008 floods. Acquisitions, which are the most effective mitigation measure because they eliminate risk completely, have been a top mitigation priority for both states since 1993.

Following the Midwest floods, homeowner attitudes toward acquisition varied. Some property owners who were substantially damaged expected to be bought out, whether they were in the floodplain or not. Others wanted to repair and remain where they were even if it meant rebuilding to a higher elevation and potentially facing the same level of risk in the future. Figures 6-5 and 6-6 illustrate the effectiveness of acquisitions.

Figure 6-5.
This is the site of a FEMA-funded acquisition project near Lake Koshkonong, Wisconsin; the adjacent building had approximately 3 feet of water throughout the living area.

Figure 6-6.
This park/open area was once the site of Soldier's Grove, Wisconsin, but in the early 1970s the community began to relocate after repetitive flooding; although the park was damaged, the acquisition/relocation program was successful in avoiding damage to residential and commercial properties that had been relocated.

According to the State Hazard Mitigation Officers, Iowa and Wisconsin set acquisition projects as their top priority. Both states planned to invoke FEMA guidance that provides a categorical determination of cost-effectiveness for the purchase of substantially damaged properties located in a FEMA-delineated floodway or floodplain under the HMGP.

6.4 Floodplain Management

6.4.1 Sources of Debris

The MAT observed activities/development in the floodplain that led to sources of debris as the floodwaters rose. Unanchored propane tanks, a traditional source of debris and hazard especially throughout the Midwest, were observed in various locations of the MAT investigations. These floating tanks become a hazard as they often leak and can explode with a spark or other source of ignition. Houseboats from Ellis Harbor in Cedar Rapids were a source of debris unique to this disaster. Both of these debris sources illustrate the need for floodplain managers and local zoning officials to be aware of daily activities in the floodplain and the potential sources of debris and high hazards they create.

6.4.2 Executive Order 11988

Executive Order 11988 – Floodplain Management, which was issued in 1977, requires federal agencies to apply a decision-making process to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to avoid the direct or indirect support of floodplain development whenever there is a practicable alternative.

If there is no practicable alternative, the federal agency must minimize any adverse impacts to life, property, and the natural and beneficial functions of floodplains. EO 11988 establishes the BFE as the minimum standard for all federal agencies. In addition, the eight-step decision-making process for complying with EO 11988 must be applied whenever there is a federal action in or affecting the floodplain. The 0.2-percent-annual-chance floodplain applies to action involving critical facilities, such as hospitals, emergency operation centers, and facilities that store hazardous materials. There continues to be a lack of adherence to the EO through federal funding and support of floodplain development.

6.4.3 Floodplain Management, Flood Insurance, and Mapping

FIRMs show the level of flood risk in certain areas and assign a flood zone designation to each area for flood insurance premium purposes. Properties that are in the SFHA are deemed high risk and are required to have flood insurance when property owners obtain a loan from a federally regulated lending institution or when they receive federal financial assistance for acquisition or construction purposes. For properties deemed to have moderate to low risk of flooding because they are outside the SFHA, the purchase of flood insurance is voluntary.

Due to the magnitude of the Midwest flooding, the inundation extended beyond the limits of the SFHA in most communities visited by the MAT. Many property owners located outside of the SFHA that were, nevertheless, impacted by the Midwest floods had been told or wrongly concluded that they could not carry flood insurance. In addition, many property owners believed that the government would provide them with economic assistance despite their lack of insurance. Finally, several were unaware of provisions like the Increased Cost of Compliance coverage available to them under their policy.

Interviews with several property owners and public officials revealed the need for maps to delineate the level and extent of inundation that would result if levees, floodwalls, and dams fail. Such information will not only help communicate the residual risk to buildings behind these flood-protection structures, but will also help local governments and facility managers plan when failure is imminent.

Finally, as revealed by MAT interviews with homeowners within three CRS-participating communities, there was a general lack of knowledge about the CRS program. Floodplain managers interviewed were aware of the program; however, most homeowners had not heard of it. Most homeowners, both inside and outside communities participating in the CRS, were also unaware of the savings a community can receive for participating in the program.

MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

7 Recommendations

The recommendations in Chapter 7 are based on the observations and conclusions of the MAT, as discussed in the previous chapters of this report. They are intended to assist the States of Iowa and Wisconsin as well as communities, businesses, and individuals in the reconstruction process, and to help reduce future damage and other impacts from similar flood events.

The recommendations parallel the topics discussed in Chapter 6. They are presented in four sections: Section 7.1 Building Performance, Section 7.2 Risk and Communication, Section 7.3 Hazard Mitigation Assistance Programs, and Section 7.4 Floodplain Management.

7.1 Building Performance

7.1.1 Basements

The primary observation related to basements was the failure of unreinforced walls.

Recommendation #1: NFIP regulations require residential property owners of substantially damaged buildings in the SFHA to remove their below-BFE basements. This requirement applies unless the community has obtained a basement exception from FEMA and the basement is certified by a design professional to resist flood loads. When repairing a non-substantially damaged building in the SFHA, serious consideration should be given to filling in the basement with sand, gravel, or other granular fill material up to a level that allows crawl space access only beneath the first floor. Cohesive soils such as clay may also be used, but granular soils are typically easier to work with when filling a basement. If a crawl space is created, permanent openings must be installed in accordance with FEMA NFIP TB 1 (August 2008).

Recommendation #2: When repairing a non-substantially damaged building and not filling the basement as discussed in Recommendation #1, all basement walls should be evaluated to determine if they have adequate reinforcement. Specifically, foundation walls constructed of unreinforced Concrete Masonry Units (CMUs) should be reinforced during repair. Other modifications like replacing unreinforced basement slabs can make a foundation system more resistant to flooding and should be considered. The owner should consult with a qualified structural engineer or architect in this regard. Consideration should also be given to permanently relocating utilities to a higher floor of the building, above expected flood levels, along with any vulnerable contents that cannot be evacuated easily and quickly. FEMA 348, *Protecting Building Utilities from Flood Damage*, provides retrofitting techniques for floodproofing existing utilities, including elevation/relocation and component protection.

Recommendation #3: Homeowners should exercise extreme caution if their basement is flooded. Specifically, homeowners should not pump water out of a basement immediately following a flood. Even after the flood crest has passed and floodwaters have receded, homeowners should avoid removing water from a basement too quickly. Removing floodwater too quickly could cause basement wall and floor failure due to hydrostatic forces on the outside face of the wall. When removing/pumping water from a basement, homeowners should pump the water level down only approximately 2 feet, mark the level, and wait overnight. If the water level rises overnight, it is too early to drain the basement. When the water stops rising, the homeowner can continue pumping approximately 2 feet of water at a time and again test the following day for rising water levels before pumping further. Although most property owners impacted by the 2008 floods knew not to pump out their basements, post-disaster advisories from FEMA, state, and local emergency management officials should alert homeowners on proper techniques and timing for pumping out basements after floodwater recedes. These advisories would be beneficial for all homeowners, but especially for those new to the area.

Recommendation #4: In communities in which a basement exception has been granted by FEMA, community officials must ensure that basements are constructed in accordance with 44 CFR §60.6(c). Basements in the SFHA should be allowed only in communities that meet the criteria, and the basements must be certified by a registered engineer or architect.

7.1.2 Foundations

The MAT observed some foundations that were exposed to high-velocity floodwater and hydrodynamic forces, as well as erosion and scour. In addition, the team observed connection failures between the foundation and the superstructure in a number of older pre-FIRM buildings.

> ***Recommendation #5:*** Communities should consider open foundation requirements for buildings that are constructed in potential high-velocity flow areas, such as those along river bends and immediately adjacent to the floodway. Open foundations are found on buildings that are built on piles, posts, piers, or columns with the building's first floor elevated above the BFE. The pile, post, pier, or column embedment depth must be designed to account for the maximum potential erosion and scour depths, as determined by a design professional familiar with site specific building design issues, including flooding. In the limited areas visited by the MAT that were exposed to high-velocity floodwater, buildings elevated on open foundations performed better than buildings on closed foundations. Figure 7-1 is an example of a residential single-family house on an open foundation that was exposed to high-velocity floodwater.

Figure 7-1.
This residential building on an open foundation was able to withstand the hydrodynamic forces; note the opening in the wall, which is indicative of high-velocity floodwater (Oakville, Iowa).

7.1.3 Openings

Properly designed openings in foundation walls are intended to allow floodwater to reach equilibrium (equal levels) on both sides and reduce the probability of damage caused by hydrostatic loads. An absence of openings in the foundation walls of post-FIRM buildings was widespread in the communities visited by the MAT. In addition, in some cases where openings were present, the openings were obstructed or too high, thus reducing their effectiveness.

Recommendation #6: Ensure openings in foundation walls are in accordance with FEMA TB 1 (August 2008), which provides guidance on foundation openings. In addition, ensure that existing openings remain free of obstruction so that they serve their purpose.

7.1.4 Damage Inspections

Based upon interviews with local officials, several communities were overwhelmed by the volume of required inspections immediately following the Midwest floods of 2008. Jurisdictions had to complete substantial damage inspections throughout the SFHA, perform plan reviews and process permits throughout their community, and conduct code compliance inspections of repairs at a volume much larger than their normal workload.

Recommendation #7: The City of Cedar Rapids and several other jurisdictions contacted local home builder and building official associations to help identify potential inspectors. They conducted training for identified candidates and used these individuals to help expand their building department workforce and complete required post-disaster inspections as well as plan reviews and code inspections during recovery. The MAT recommends communities consider this approach in their response and recovery planning. In addition, the MAT recommends FEMA develop standard operating procedures to support local jurisdictions with conducting Residential Substantial Damage Inspections and urge jurisdictions to adopt/enforce the latest building code.

Recommendation #8: With respect to substantial damage inspections, State NFIP Coordinators and communities should consider updating their floodplain management ordinances so their substantial damage and improvement criterion is cumulative, i.e., the sum of permitted repairs and improvements over the life of the property versus the current replacement value. This cumulative approach is recognized in the CRS and can help communities reduce their flood risk, especially those with pre-FIRM properties that sustain repetitive losses.

7.1.5 Elevation

Several residential elevation projects, both existing and ongoing, were visited by the MAT; the overarching observation was that the higher the floor system (in some cases up to 4 feet above the BFE), the better the building performed.

Recommendation #9: All new construction, substantial improvements, and repair of substantially damaged properties should follow flood damage-resistant criteria and be elevated above the BFE as specified by ASCE 24 (dwellings have 1 foot of freeboard and critical facilities have 2 to 3 feet; temporary facilities are allowed to be at the BFE). The ASCE 24 design and elevation requirements apply to utilities and attendant equipment as well. Property owners and developers should weigh the potential savings from damages avoided against the upfront cost of elevating a few feet higher. The potential for lower flood insurance rates as a result of lower flood risk should also be taken into account. As highlighted in Chapter 5, homeowners who carry flood insurance and are substantially damaged can use Increased Cost of Compliance funds to help finance an elevation project. As previously stated in Recommendation #1, if the elevation project is a substantial improvement, the elevated property must be constructed on foundations with proper openings and without basements unless they are in compliance with 44 CFR §60.6(c). The most effective way for communities to utilize the flood damage-resistant design and construction criteria in ASCE 24 is to adopt and enforce the International Codes (IBC and IRC), which incorporate ASCE 24 by reference.

Recommendation #10: When elevating an existing structure, it is critical to ensure it is properly secured to the new foundation. The MAT observed several ongoing elevation projects where the foundation was being prepared with connections to properly secure the structure to the foundation. Proper connection between the elevated home and the new foundation should be required for all new construction and substantial improvements, in accordance with Chapter 4 of the IRC. Although most failures occurred in older buildings with unreinforced foundation walls, an emphasis on the importance of continuous load paths (specifically ensuring a connection with the foundation) needs to be maintained, especially given the number of potential elevation projects in the area.

7.1.6 Backflow Prevention

The lack of backflow prevention devices caused avoidable flooding in buildings, especially those outside the SFHA.

Recommendation #11: Backflow prevention valves should be installed, both within and outside the SFHA, on sanitary sewer and basement floor drain pipes; this will avoid sewer flow into a building when wastewater flow increases due to rainfall and surcharging events that create sufficient pressure to cause sewage to flow backwards. Backflow valves can utilize this backwards pressure to block drain pipes temporarily and prevent return flow. The types of valves range from check valves or backflow preventer valves, which open to allow flow out of the structure but close when the flow reverses, to gate valves, which are closed manually. These valves would not fully protect the facility from inundation by surface floodwater, but they would avert sewer water flowing into it via drain pipes. The owner should consult with a qualified engineer to determine the effectiveness of installing a backflow prevention valve in the building.

7.1.7 Critical Facilities

In general, most critical facilities visited by the MAT performed well structurally, but the ability of the facility to remain operational after a major flood event was an issue in several cases.

Recommendation #12: Critical facilities should be sited outside the 0.2-percent-annual-chance floodplain. For federally funded activity involving critical facilities, these facilities should not be constructed without a thorough analysis under the provisions of EO 11988. If federal funds are provided, the facilities should be elevated above the 0.2-percent-annual-chance flood elevation or in accordance with the freeboard requirements of ASCE 24-05 and FEMA 543. In addition, critical contents, including public documents, electrical and mechanical equipment, and any critical or expensive equipment should be located above the 0.2-percent-annual-chance flood level, in accordance with FEMA 543. As a short-term solution to reduce recovery time, existing facilities that cannot be relocated or elevated sufficiently should relocate critical functions/services, create a back-up, and/or floodproof equipment and interior finishes. The long-term strategy should be to relocate the facility entirely outside the 0.2-percent-annual-chance floodplain.

Recommendation #13: Equipment and utilities should not be located at or below ground level in critical facilities in or near a floodplain. Electrical, mechanical, and security equipment should be located well above the BFE, in accordance with FEMA 543. Rooms where critical activities, such as operations, take place and that house patients who cannot be relocated quickly should also be located well above the BFE. Facility managers for critical facilities located in or near a floodplain should utilize the "Checklist for Building Vulnerability of Flood-Prone Critical Facilities" in FEMA 543 to help identify and address their flood susceptibility, as illustrated in Figures 7-2 and 7-3.

Figure 7-2.
The primary access road to the Des Moines Water Works is expected to be under several feet of water during a 1-percent-annual-chance flood (Des Moines, Iowa).

Figure 7-3.
The Des Moines Water Works incorporated a secondary access road along the berm system that protects the treatment plant from flooding (Des Moines, Iowa).

Recommendation #14: Critical facilities should have emergency operations plans and checklists in place for response to disasters. For example, a wastewater treatment facility should have contact information for its major customers as part of the facility's emergency action plan so that customers can reduce inflows to the treatment facility, if necessary, in the event of a major flood. As another example, a correctional facility should have detailed plans outlining the evacuation of prisoners.

Recommendation #15: Accurate flood predictions depend on many parameters including the flood characteristics of the stream and basin, the time of year, the pre-flood basin conditions, among others. Because of the variability of these parameters from flood to flood, accurate prediction of flood size and flood timing is not always possible. It is important for emergency managers, homeowners, critical facility managers, and others to take this into consideration when preparing for a flood. Critical facilities located in the floodplain should add 2 feet of freeboard to the estimated crest elevations when preparing for flood events, similar to the freeboard requirement of 2 feet for essential facilities in ASCE 24.

Recommendation #16: Facility managers responsible for critical facilities should perform a comprehensive vulnerability assessment, including an evaluation that addresses the loss of municipal utilities (i.e., electrical power, water, sewer, and communications). In addition, critical facility managers should take preventive measures to ensure replacement equipment (e.g., pumps, generators, etc.) and essential supplies (e.g., fuel) are staged outside of the floodplain so that they are readily available and accessible following a flood. Equipment that cannot be relocated should be elevated or floodproofed so that repair times are reduced after floodwater recedes.

7.2 Risk and Communication

Based on conversations with several floodplain managers in communities affected by the flooding, there is still a widespread misperception of flood risk among homeowners. The mitigation planning process, as required by the Stafford Act, is a good tool for this purpose. The process includes the development of comprehensive risk and capability assessments that can be used to guide decision making. The process also includes the participation of a wide range of stakeholders who play a role in setting goals and identifying mitigation actions.

Recommendation #17: Government, at all levels, must improve flood risk communication and education. Through a variety of outreach efforts implemented repeatedly, property owners should be made aware of their exposure to flood risk and of the magnitude of flooding at their general location when flooding is imminent. The FIRM could provide critical support for this outreach by showing more comprehensive flood risk information indicating residual flood risk outside the SFHA boundary. For example, it should show whether a levee/floodwall is or is not certified and the respective floodwater surface elevations so people understand the flood risk that exists even in areas "protected" by levees and floodwalls.

Recommendation #18: Development behind structural flood control measures, such as levees, floodwalls, or dams, should be controlled over the life of the flood control measure to ensure the development that occurs subsequent to the flood control measure does not actually increase an area's flood risk. In addition, due to land development upstream and other hydrologic and hydraulic factors, the flood control measure may not provide the same of level of protection as when it was originally designed. Communities and developers protected by these structures should integrate redundant flood reduction measures to help limit damages when the design level of the flood control measure is exceeded. As illustrated by damages in communities like Oakville, Iowa, flood control measures may not provide complete protection from severe flooding. Redundant flood risk reduction measures include requiring that new construction be built to a certain elevation, requiring flood-resistant materials at lower elevations, and/or elevating critical interior functions above the BFE. Figure 7-1 is an example of a residential building behind a levee that was elevated on an open foundation and, as a result, suffered much less damage than buildings nearby that were not elevated and that were built on closed foundations.

Recommendation #19: Programs like FEMA's Flood Smart help educate the public on flood insurance and risk. Local floodplain managers should use Flood Smart and/or other means to communicate flood risk to property owners in their area, including those located outside the SFHA. Property owners share the responsibility of making themselves aware of their own flood risk. The property owners whose property flooded must realize that their property is in a floodplain and at risk of being flooded again. By rebuilding in that location, they are accepting flood risk and, ultimately, their responsibility to understand that risk and address it; this is especially important for those who were not substantially damaged and, thus, are not required to be brought into compliance with local flood damage reduction regulations that were not in effect at the time of the building's original construction. Inundation maps illustrating the 0.2- and 1-percent-annual-chance floods, as well as the 2008 floods, are an effective way to communicate this risk. In addition, floodplain managers can use modeling software to help communicate flood risk prior to a flood and support decision making during response operations. As an example, the Johnson County Iowa Emergency Operations Center utilized HAZUS-MH to develop estimates of potential impacts to their infrastructure. Modeling software could also be used to help bring together critical flood information like the BFE, flood stage, crest, and peak discharge to help emergency managers facilitate response and recovery operations.

Recommendation #20: The MAT observed facilities with historic flood levels marked on walls as a reminder. Local floodplain managers should consider applying the same concept and mark traffic signal and sign posts with historic flood elevations or the 1-percent and 0.2-percent-annual-chance flood elevations throughout the floodplain to help communicate the level of flood risk to the public. Also, to help educate residents about the residual risk associated with structural flood damage reduction measures, local officials should consider placing signs stating: "This area is a floodplain protected by levees or dams; these structures could overtop or fail resulting in flood depths of 'X' feet in this area." This is similar to the requirements in Executive Order 11988, which requires federal facilities that have suffered flood damage or are located in an identified flood hazard area to delineate past and probable flood height to enhance public awareness of flood hazards. Figure 7-4 is an example of a wall marked with historic flood levels from 1903 to 1993.

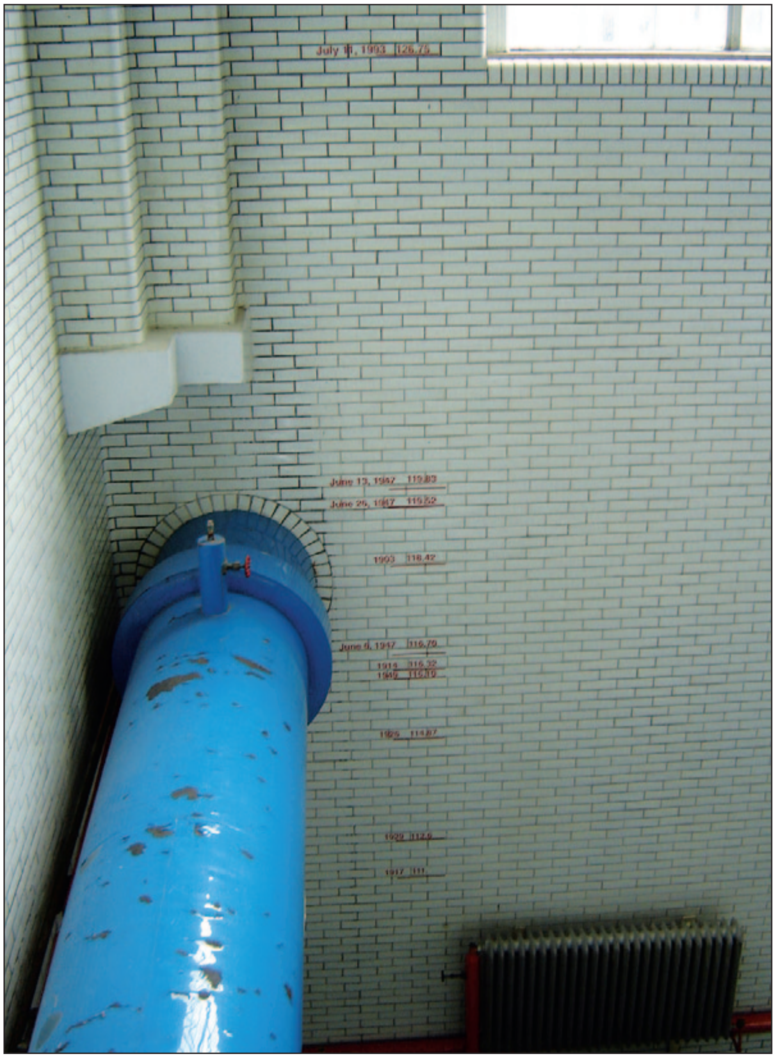

Figure 7-4.
The Des Moines Water Works has marked historic flood levels at their pumping facility for more than 90 years (Des Moines, Iowa).

7.3 Hazard Mitigation Assistance Programs

The MAT visited the site of several FEMA-funded acquisition projects; these sites demonstrated the success of the acquisition strategy.

> ***Recommendation #21:*** The MAT recommends that acquisition be considered by states and communities with access to HMGP funds. Acquisition is the most effective mitigation measure, leaving no residual risk for property to be damaged. Following the 2008 floods, both Iowa and Wisconsin set acquisitions as their top priority for mitigation projects. It is important for floodplain managers and local government officials to take a holistic approach to acquisition projects; not only should the individual properties be removed from the floodplain, but also all associated infrastructure. By integrating hazard mitigation planning into recovery planning, floodplain managers can ensure that ongoing mitigation/reconstruction efforts are consistent with long-term plans.

Recommendation #22: FEMA and other federal agencies should continue mitigation grant programs to support communities in pursuing opportunities to prevent future loss of life and property from hazard impacts. In addition, communities should identify and budget funding to finance mitigation projects internally. For example, the Milwaukee Metropolitan Sewage District Flood Management Program manages over $100 million annually for mitigation projects through funding collected from sewage disposal fees. Their projects include creating increased temporary water storage, improving the sewer system to avoid backups during floods, and acquiring developed property to convert to open space or undeveloped property to ensure it remains open.

7.4 Floodplain Management

7.4.1 Sources of Debris

Whether it is unanchored fuel tanks, shipping containers from a port, or rail cars from a rail bridge, each disaster has its common and unique types of debris. The MAT observed various operations and activities that local floodplain managers should consider monitoring to help limit potential debris during a flood.

Recommendation #23: Floodplain managers and residents must be aware of potential sources of debris and ensure actions are taken to remove them from the floodplain or ensure they are properly anchored. Specifically, FEMA should continue education and outreach of its existing guidance for anchoring fuel tanks. When anchored in accordance with FEMA's guidance, the tanks remain in place and are functional after floodwater recedes. In addition, local floodplain managers and residents should conduct assessments of their areas to secure or relocate unanchored items, such as supplies staged in a storage yard, recreational equipment, or patio furniture when floods are imminent. At the state level, NFIP coordinators should address limiting potential sources of debris in their model floodplain management ordinance.

7.4.2 Executive Order 11988

EO 11988 requires federal agencies to avoid any adverse impacts on the floodplain through development when there is an alternative to locating or affecting the floodplain.

Recommendation #24: FEMA and other federal agencies should ensure EO 11988 is being properly implemented when funding recovery projects to help reduce future flood damages. Specifically, critical facilities should be relocated outside the 0.2-percent-annual-chance floodplain whenever possible.

7.4.3 Floodplain Management, Flood Insurance, and Mapping

A FIRM identifies the special flood hazard areas and the risk premium zones applicable to a community, and helps lenders determine if a property is required to carry flood insurance. In addition, a FIRM commonly serves as a local floodplain manager's primary resource to communicate flood risk to the public.

Recommendation #25: Local jurisdictions should continue to integrate freeboard requirements into their floodplain management ordinances and require homeowners to build above the BFE. In urban areas, jurisdictions may wish to consider adopting the 0.2-percent-annual-chance elevation as the design flood elevation because, as development increases, so does the community's exposure and flood risk. Communities should strengthen floodplain management regulations to require new construction to be elevated to at least 1 foot above the BFE and follow flood-resistant design and construction criteria as outlined in ASCE 24. Several ongoing elevation projects observed by the MAT were designed to be 3 feet above the BFE. This design decision was based upon experiences from recent events as well as knowledge of neighboring properties that were not elevated high enough to avoid flooding during events that exceeded the 1-percent-annual-chance flood (see Figure 7-5).

Figure 7-5.
The property on the left was elevated to the BFE after flooding in 1993 (no freeboard) and flooded in 2008; after the 2008 floods, the homeowner of the ongoing elevation project on the right decided to raise his home 1 foot above the high water mark for the 2008 floods, which is almost 4 feet above the BFE (Iowa City, Iowa).

Recommendation #26: FIRMs should continue to delineate the current flood zones for the purposes of designating risk levels and setting flood insurance rates. However, communities should understand the flooding hazards of the entire watershed area. The 2008 Midwest floods illustrated that the 1-percent-annual-chance flood is not the limit of the floodplain; most communities visited by the MAT experienced a flood that exceeded the SFHA boundaries. A property owner located just outside the SFHA or in an inundation area protected by a certified levee should consider taking preventive measures to reduce flood damages; floodwater may not stop at the SFHA boundary and a structural flood control measure may be overtopped or otherwise fail. Education and outreach material should emphasize that the NFIP guidelines are the minimum requirements and that designers, planners, builders, and property owners should take additional measures in floodprone areas.

Recommendation #27: Through the map modernization initiative, local communities receive complete digital delivery of their FIRM. This digital delivery enables communities to overlay their flood hazards on their built environment in the geographic information system (GIS) platform. Taking full advantage of this can help communities communicate flood risk more effectively and better plan for and prioritize mitigation projects. Most of all, it enables communities to use the information to conduct stronger risk assessments and more accurately identify flood vulnerabilities throughout their community. The MAT recommends that the digital delivery include a depth and velocity grid that can be used to determine the extent and dynamics of flooding throughout the floodplain, identify more detailed levels of risk within the SFHA, help the community plan with their built environment information, and possibly even support design professionals with deciding on a foundation design. To communicate this risk, local floodplain managers may consider using different colors to indicate different levels of flooding in and outside of the SFHA. Note: Several of the rapid recovery maps (including those for Mahaska County, Iowa) developed under Disaster Number 1763 included digital delivery with a depth grid.

Recommendation #28: Ensure education and outreach materials reach property owners outside the SFHA, so they understand that flood insurance can be purchased anywhere within a community or legal entity that satisfactorily participates in the NFIP; this material should especially be sent to those property owners that are protected by a levee. State and local officials should promote the purchase of flood insurance as well.

Recommendation #29: The MAT recommends that federal, state, and local officials increase their emphasis on Increased Cost of Compliance coverage after a flood through outreach materials to homeowners and/or NFIP insurance agent workshops. In addition, NFIP workshops for insurance agents should stress the agents' role in informing homeowners of the importance of carrying flood insurance even if they are outside the SFHA, regardless of whether or not they obtained a loan from a federally regulated lending institution for their property.

Recommendation #30: Three of the communities visited by the MAT participated in the CRS program. However, not many homeowners were aware of the program or that a community's efforts beyond the NFIP minimum standards could reduce flood insurance premiums for the community's property owners by 5 to 45 percent. Through education and outreach, federal, state, and local officials should promote the CRS program so that it is considered by potential homeowners or renters in the area in the same way potential buyers look for strong school districts and competitive property taxes.

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C

Acronyms and Glossary of Terms

Acronyms

A

ASCE	American Society of Civil Engineers

B

BFE	Base Flood Elevation

C

CBC	Commercial Building Code
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIS	Community Information System
CMU	concrete masonry unit

CRPD	Cedar Rapids Police Department
CRS	Community Rating System
CT	Computed Tomography

D

DHS	Department of Homeland Security
DMA 2000	Disaster Mitigation Act of 2000
DNR	Department of Natural Resources

E

EO	Executive Order
EOC	Emergency Operations Center
ESC	Education Services Center

F

FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FY	Fiscal Year

G

GIS	geographic information system

H

HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program

I

IATL Iowa Advanced Technology Labs

IBC International Building Code

IBHS Institute for Business and Home Safety

ICC International Code Council

I-Codes IBC, IRC, and the IEBC

IEBC International Existing Building Code

IMU Iowa Memorial Union

IRC International Residential Code

J

JFO Joint Field Office

L

LOMR Letter of Map Revision

LOMR-F Letter of Map Revision Based on Fill

M

MAT Mitigation Assessment Team

MGD million gallons per day

MRI Magnetic Resonance Imaging

N

NFIA National Flood Insurance Act

NFIP National Flood Insurance Program

NOAA National Oceanic and Atmospheric Administration

NWS National Weather Service

O

ONA	Other Needs Assistance

P

PA	Public Assistance
PDA	Preliminary Damage Assessment
PDM	Pre-Disaster Mitigation
PNP	Private Nonprofit

R

RFC	Repetitive Flood Claims
RSDE	Residential Substantial Damage Estimate

S

SFHA	Special Flood Hazard Area
SOI	Secretary of the Interior
SRL	Severe Repetitive Loss

T

TB	Technical Bulletin

U

UBC	Uniform Building Code
UDC	Uniform Dwelling Code
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

UST	underground storage tank
UW	University of Wisconsin

V

VFD	Variable Frequency Drives

W

WWTF	Wastewater Treatment Facility

Glossary of Terms

100-year flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year.

500-year flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year.

ASCE 7 – National design standard issued by the American Society of Civil Engineers, *Minimum Design Loads for Buildings and Other Structures*, which gives current requirements for dead, live, soil, flood, wind, snow, rain, ice, and earthquake loads, and their combinations, suitable for inclusion in building codes and other documents.

ASCE 24 – National design standard issued by the American Society of Civil Engineers, *Flood Resistant Design and Construction*, which outlines the requirements for flood resistant design and construction of structures in flood hazard areas.

Base Flood Elevation (BFE) – Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.

Berm – A small levee, typically built from fill dirt.

Capillary action – Commonly referred to as "wicking," capillary action is the process by which water in liquid form climbs upward through materials in opposition to the force of gravity.

cfs – Cubic feet per second, the unit by which discharges are measured (a cubic foot of water is about 7.5 gallons).

Closed foundation – Structure foundation that is enclosed on all sides (e.g., stem wall, basement, or crawl space) that is permanently closed to floodwaters.

Continuous load path – A load path is the route taken by a force as it makes its way through a structure. When a building has a continuous load path, the force is eventually transferred to and resisted by the ground. A continuous load path usually requires the use of metal connectors, fasteners (such as nails and screws), and strong wall design.

Corbel – a piece of stone or extension of concrete jutting out of a wall to carry any superincumbent weight.

Critical and essential facilities – Facilities that, if damaged, would present an immediate threat to life, public health, and safety as defined by ASCE 7. Critical and essential facilities include, but are not limited to, hospitals, emergency operations centers, water systems, and utilities.

Crest – The peak stage or elevation reached or expected to be reached by the floodwaters of a specific flood at a given location.

Dam – Any artificial barrier that impounds or diverts water and that: (1) is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of 50 acre-feet or more.

Design flood event – The greater of the following two flood events: (1) the base flood, affecting those areas identified as SFHAs on a community's FIRM; or (2) the flood corresponding to the area designated as a flood hazard area on a community's flood hazard map or otherwise legally designated.

Erosion – Process by which floodwaters lower the ground surface in an area by removing upper layers of soil.

Executive Order 11988 – Requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities" for the following actions: (1) acquiring, managing, and disposing of federal lands and facilities; (2) providing federally-undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities.

Fetch – The distance along open water or land over which the wind blows.

Floodborne debris impact – Floodwater moving at a moderate or high velocity can carry floodborne debris that can impact buildings and damage walls and foundations.

Floodway fringe – The portion of the SFHA that is outside of the floodway.

Flood gauge/gage – An instrument that measures/monitors the height of floodwater at a given location.

Flood Insurance Rate Map – An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community.

Floodwall – A long, narrow concrete or masonry wall built to protect land from flooding.

Floodway – The channel of a river or other watercourse and that portion of the adjacent floodplain that must remain unobstructed to permit passage of the base flood without cumulatively increasing the water surface elevation more than a designated height (usually 1 foot).

Freeboard – The height above the base flood added to a structure to reduce the potential for flooding. The increased elevation of a building above the minimum design flood level to provide additional protection for flood levels higher than the 1-percent-annual-chance flood level and to compensate for inherent inaccuracies in flood hazard mapping.

High velocity flow – Typically comprised of floodwaters moving faster than 5 feet per second.

Hydrodynamic force – The force of moving water, including the impact of debris and high velocities.

Hydrostatic force – The pressure put on a structure by the weight of standing water. The deeper the water, the more it weighs and the greater the hydrostatic pressure.

Levee – A manmade structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

Loads – Forces or other actions that result from the weight of all building materials, occupants, and their possessions; environmental effects; differential movement; and restrained dimensional changes. Permanent loads are those in which variations over time are rare or of small magnitude. All other loads are variable loads.

Open foundation – Structure foundation elevated on piles, walls, or other system that is permanently open to floodwaters.

Performance-Based Design – A design methodology that allows a designer to work with an owner to achieve an acceptable level of risk.

Pier foundation – Vertical support member of masonry or cast-in-place concrete that is designed and constructed to function as an independent structural element in supporting and transmitting both building loads and environmental loads to the ground. Typical pier foundations are constructed on footings.

Reinforced concrete – Concrete with steel mesh or bars embedded in it to increase its tensile strength.

Riverine – Of or produced by a river. Riverine floodplains have readily identifiable channels.

Seepage – The process of floodwater flowing slowly into or out of something through small holes.

Slab-on-grade foundation – Type of foundation in which the lowest floor of the house is formed by a concrete slab that sits directly on the ground.

Special Flood Hazard Area – Portion of the floodplain subject to inundation by the base flood.

Stafford Act – Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288. This Act constitutes the statutory authority for most federal disaster response activities especially as they pertain to FEMA and FEMA programs.

Steel moment frame – In steel moment frame buildings, the ends of the beams are rigidly joined to the columns so that the buildings can resist lateral wind forces without the assistance of additional braces or walls.

Stem wall foundation – A type of foundation that uses masonry block and is reinforced with steel and concrete. The wall is constructed on a concrete footing, back-filled with dirt, and compacted, and the slab is then poured on top.

Stillwater – A rise in the normal level of a water body.

MIDWEST FLOODS of 2008 IN IOWA & WISCONSIN

D Midwest Floods Recovery Advisories

FEMA has prepared Recovery Advisories that present guidance for design, construction, and restoration of buildings in areas subject to riverine flooding. To date, two advisories have been prepared and are included in this appendix:

- Considerations for Rebuilding Your Flood-Damaged House
- Design Considerations for Improving Critical Facility Functionality During Flood Events

These Advisories are also available online at http://www.fema.gov/library/viewRecord.do?id=3824 where future Advisories will also be posted.

Considerations for Rebuilding Your Flood-Damaged House

FEMA
http://www.fema.gov

MIDWEST FLOODS RECOVERY ADVISORY

Purpose: The Midwest floods of 2008 caused riverine flooding, sanitary sewer back up, levee/floodwall failure or overtopping, and/or rising lake levels, resulting in upwards of $6 billion in damage. Homeowners impacted by the floods are now faced with fundamental rebuilding decisions. This advisory provides information to assist with rebuilding decisions in the aftermath of the 2008 Midwest Floods, as well as any future flood events.

Background:

- The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. The NFIP is a federal program enabling residents in participating communities to purchase flood insurance. Currently 20,000+ communities participate in the NFIP.
- When a community chooses to join the NFIP, it must adopt and enforce minimum floodplain management standards. The floodplain management requirements are designed to prevent new development from increasing the flood risk and to reduce flood damages to new and existing buildings from future flood events.
- The Federal Emergency Management Agency (FEMA) works closely with state and local officials to identify flood hazard areas and flood risks, in particular the Special Flood Hazard Area (SFHA). This is the area that has a 1-percent or greater chance of being flooded in any given year. FEMA maps this and other flood hazard areas on Flood Insurance Rate Maps (FIRMs).
- Flood insurance is required for insurable structures within the SFHA to compensate floodplain occupants for flood damages and to remove some of the financial burden of flood losses from taxpayers, such as for Federal disaster assistance and casualty loss deductions under Federal income taxes.
- For more information about NFIP regulations, FIRMs, flood insurance policies, and preparation and recovery during flood events, please visit the official site of the NFIP: http://www.floodsmart.gov/.

Flood Insurance Rate Map (FIRM) – The community's official FEMA map delineating both the flood hazard areas and the risk insurance premium zones.

Special Flood Hazard Area (SFHA) – The area that has a 1-percent or greater chance of flooding in any given year. A structure located within the SFHA has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Flood insurance is mandatory for properties located within the SFHA that receive Federal financial assistance.

How to Determine Your Flood Risk:

- Using the FIRM, you can determine your house's location relative to the flood risk zones. If your house is located within the SFHA, you can also determine the elevation of the base (1-percent annual chance) flood elevation (BFE) at your location. You can then compare your floor elevations with the BFE and determine your risk of damage from flooding.
- Non-SFHA Zones B, C, and X are areas outside the 1-percent-annual-chance flood risk, or 100-year, floodplain. It is important to note that even if your house is located within a non-SFHA, there is still a possibility that your house will be subjected to flood damage and possibly even catastrophic flooding. Figure 1 shows an example of a FIRM with arrows indicating pertinent information.

NFIP Regulations That May Impact Your Decision to Rebuild

If your house was damaged during a flood and is located within the SFHA, you need to be aware of NFIP regulations related to substantial improvement, substantial damage, and the increased cost of compliance provision in flood insurance policies, as you make a decision to rebuild.

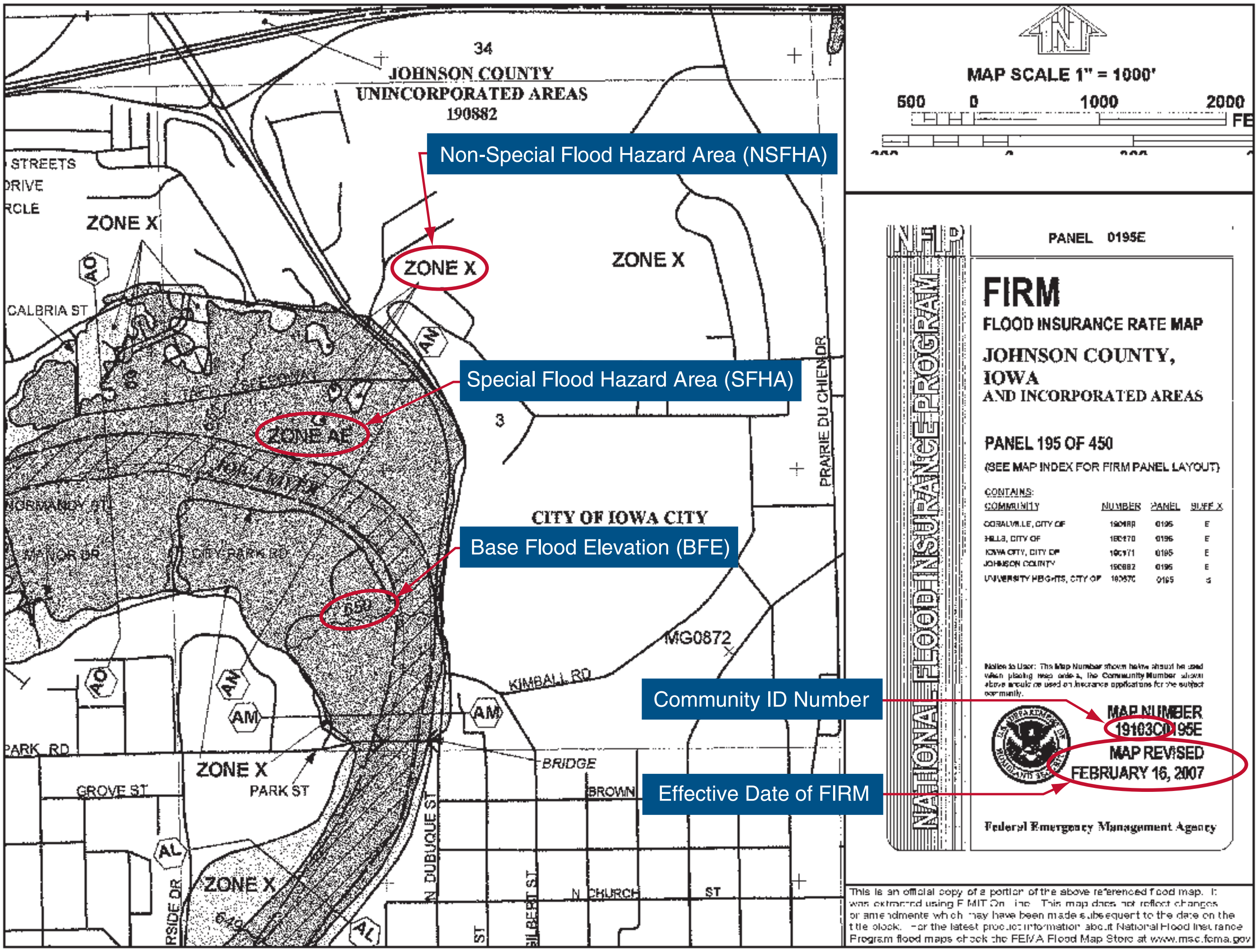

Figure 1. A FIRM panel illustrating information pertinent to the homeowner

Substantial improvement means any reconstruction, rehabilitation, addition, or other improvement of a structure when the cost of the improvement equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. The term includes structures that have incurred substantial damage.

Substantial damage means damage of any origin sustained by a structure when the cost of restoring the structure to its pre-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. Substantial damage is determined regardless of the actual repair work performed.

- Floodplain management requirements for new construction apply to substantial improvements, and the structure must be brought into compliance with the NFIP. This can be done by elevating the structure, relocating the structure to an area outside of the SFHA, or demolishing the structure and rebuilding in compliance.
- The substantial damage determination will be made by your local floodplain manager and/or building official, who can help you decide the best option for rebuilding and provide specific details regarding local ordinance requirements.

Increased Cost of Compliance (ICC) is a standard provision in flood insurance policies that pays the policyholder up to $30,000 to comply with a state or local floodplain management law or ordinance affecting repair or reconstruction of a flood-damaged structure. The structure must meet certain eligibility criteria, including a substantial damage or repetitive loss determination by a local official. Mitigation activities eligible for payment are elevation, relocation, and demolition.

Construction funded by ICC payments must be completed within 4 years of the substantial damage determination. ICC funds are available in addition to federal assistance provided to floodproof your house.

Options to Minimize Risk of Future Flooding when Rebuilding

Several options are available for protecting your house from future flood damage. Building codes, floodplain management policies, local regulations, and personal preferences must all be taken into account. Choosing the right option requires research, planning, contacting local officials, and benefit-cost assessments (e.g., relocating or elevating the building will impact flood insurance premiums, while other options will not).

Relocate to a site outside of the SFHA:

- If your house is structurally sound, it may be possible to move it to a higher elevation on the same lot or to another location outside of the floodplain.

Participate in a buyout or acquisition program:

- Property acquisition is the most permanent form of flood hazard mitigation. It removes people and property from harm's way forever. In a property acquisition project, the community buys private property, acquires title to it, and then clears it. By law, that property, which is now public property, must forever remain open space land. The community can use it to create public parks, wildlife refuges, etc., but it cannot sell it to private individuals or develop it.
- Property acquisitions work the same way as any other real estate transaction. Property owners who want to sell their properties will be given fair prices for them. It is an opportunity for people who live in or near hazard areas to relocate to a safer location.
- If you are interested in a buyout, you can contact your community's floodplain manager to see if a buyout program is available in your community.

Elevate the house:

- This is one of the most common mitigation methods. When a house is properly elevated, the living area will be above less severe potential flood conditions (such as less than the 0.2-percent-annual-chance flood). Most houses can be elevated; however, the cost of elevation varies based upon multiple factors such as the size of the house; type of foundation (e.g., slab-on-grade, crawlspace, basement); whether the house is wood-frame, masonry, or concrete; and the required elevation, which is based upon the BFE.
- Although elevating a substantially damaged house can be expensive, it can also provide a number of benefits such as reducing future flood damage, lowering your insurance premium, adding value to the house, increasing usable space for parking or storage, improving the appearance of the house, helping protect contents, and reducing anxiety about future floods. For more information regarding elevating your house, please refer to the guidance document *Above the Flood: Elevating your Floodprone House* (FEMA 347) (see next page for website).

What elevation should I use when rebuilding/elevating my home? The FIRM establishes the expected elevation of floodwater during the 1-percent-annual-chance flood event (the BFE). In general, you should elevate the top of the lowest floor to this elevation. It is important that you contact your local floodplain management official because he/she can tell you the locally mandated flood elevation. Many states and local jurisdictions add an additional factor of safety, called a "freeboard" requirement, to the flood elevation. You should also ask your local officials how recent flood heights compare to the mapped 1-percent-annual-chance and 0.2-percent-annual-chance flood elevations. In general, the higher you elevate above the BFE, the more likely you are to prevent future flood damages, and the lower your flood insurance premiums might be.

Elevate the utilities:

- Utilities in existing houses can often be effectively protected from flood damage. The easiest and most practical time to undertake this effort is during a renovation or repair project. If your house has been substantially damaged and/or is being substantially improved, the NFIP requires that its utility systems be protected from flood damage to the same criteria required for new construction. However, if your house has suffered less than substantial damage, you have three basic options for protecting utilities.

- **Replace the system with a like system** – This option is typically the least expensive option, but provides no improved protection from future flood damage.
- **Elevate your utilities** – This option is usually the most costly, but it can protect you from the inconvenience of repeated future flood damages and is highly recommended by floodplain managers. For more information on protecting the utilities in your house, please refer to the guidance document *Protecting Building Utilities from Flood Damage* (FEMA 348) (see below for website).
- **Implement low-cost retrofits to utility systems** – For a minimal additional cost, large benefits may be realized especially when protecting from smaller future flooding events. For example, two short electrical panel boards can be elevated side-by-side versus one long panel that stretches from the floor to the ceiling.

Wet and Dry Floodproofing:

- Wet floodproofing prevents or provides resistance to damage from flooding by allowing floodwater to enter the house. Allowing floodwater to enter portions of the house (such as a crawl space or unfinished basement) equalizes the interior and exterior pressures on the wall during a flood. Equalized pressures reduce the likelihood of structural damage during a flood event. For information on wet floodproofing your house, please refer to the document *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (TB 7-93) (see below for website).

Floodproofing – Any combination of structural and non-structural additions, changes, or adjustments to structures that reduce or eliminate flood damage to structures and their contents.

- Another way to floodproof your house and its contents is sealing it so that floodwater cannot enter. This method, referred to as "dry floodproofing," encompasses a variety of measures. Popular methods of dry floodproofing include applying a waterproof coating or membrane to the exterior walls of the house, installing watertight shields over openings, and strengthening walls so that they can withstand the pressures of floodwater and the impacts of flood-borne debris.

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Design Considerations for Improving Critical Facility Functionality During Flood Events

FEMA
http://www.fema.gov

MIDWEST FLOODS RECOVERY ADVISORY

Purpose: This advisory provides recommendations for reducing the effects of flooding on existing critical facilities. It specifically applies to the essential critical facility systems that must remain functional during and after flood events, including:

- Electrical systems (including power, life-safety, communication, and IT equipment)
- Plumbing systems (including water, sanitary, and mechanical piping)
- Heating, ventilating, and air conditioning (HVAC) systems
- Specialized equipment (including conveyance, medical, and detention equipment)
- Non-specialized equipment that may require a long lead time to procure

This advisory discusses two techniques for reducing flood damages to essential critical-facility systems: elevation and dry floodproofing.

Key Issues

FEMA identifies and maps flood hazard areas on its Flood Insurance Rate Maps (FIRMs). One of these areas is the Special Flood Hazard Area (SFHA), which is an area within a floodplain having a 1-percent or greater chance of flood occurrence in any given year.[1] Another area typically depicted on FIRMs is the 0.2-percent-annual-chance flood.[2] People often have a mistaken understanding of this and believe that if a building is located outside of a mapped flood hazard area, it has no risk of flooding. The Midwest floods of 2008 demonstrated the fallacy of this assumption. Many of the buildings that were damaged or destroyed by flooding, including numerous critical facilities, were located outside of the SFHA and, in some cases, outside the 0.2-percent-annual-chance flood area as well. In many observed instances, assumptions regarding flood risk had led to design decisions that made buildings vulnerable to the extraordinary flooding experienced in 2008. Actions taken now can help to reduce damage from future flood events.

The potential for flooding, even for buildings outside of mapped SFHAs, should be considered during the reconstruction of damaged buildings. Even if the probability of repetitive flooding is small, both the cost of repairs and the critical nature of the facility warrant a careful consideration of relatively low-cost design solutions for mitigating future potential flood damages.

To what types of critical facilities do these loss reduction techniques apply?

Schools, fire and police stations, emergency operations centers, water treatment plants, detention facilities, essential government buildings, and other facilities can all benefit from appropriate flood mitigation measures. Recommendations included in this advisory may also be beneficial to buildings not historically considered critical, such as banks, data centers, etc.

Techniques for Reducing Flood Losses

Elevation

In general, essential building systems should be elevated to at least the 0.2-percent-annual-chance flood elevation and higher if it is practical to do so. If sufficient data is not available or if this level of protection is not feasible, utilities should be elevated to at least 2 feet above the 1-percent-annual-chance flood elevation.

A critical facility located outside the mapped flood hazard area in Iowa flooded during the Midwest floods of 2008. Vulnerable equipment that had been mounted in an **integral cabinet** with control switches and

[1] Also referred to as the "100-year floodplain."

[2] Also referred to as the "500-year floodplain."

indicator lights was damaged when the cabinet was inundated with approximately 3 feet of floodwater (Figure 1). This cabinet can be reconfigured and mounted high enough to avoid future losses. Dual electrical panel boards, which consist of two shorter panels mounted side-by-side, can be used instead of a single, taller panel board. This proposed design allows the bottom of the panels to be placed higher above the floor and would reduce exposure to floodwater. To reduce the vulnerability of the feeders that connect the panelboards to the service equipment, feeder wiring should be run as high as possible. Feeders routed along the ceilings are much less vulnerable than feeders run along or under floors.

When elevating utilities, it is also necessary to consider not only each individual component, but how each is interconnected with other building systems and components. Some **emergency generators** during the Midwest floods of 2008, for example, were elevated and did not flood, but could not function because electrical equipment powered by the generator was installed at lower elevations. The generator shown in Figure 2 did not flood, but it was rendered ineffective because the transfer switch that directs electrical loads from the generator when normal utility power is not available was mounted below the transformer and flooded during the event.

Flooding can damage most **electrical equipment,** and, once flooded, the equipment often needs to be

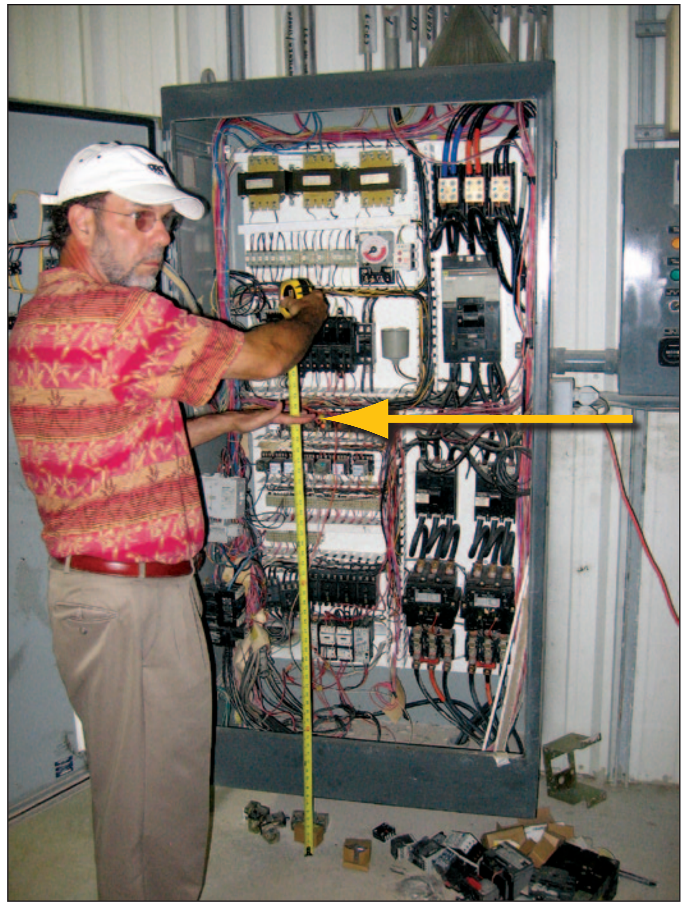

Figure 1. This control cabinet was inundated with approximately 3 feet of floodwater (yellow arrow). Sensitive electronic equipment was damaged (Columbus Junction, Iowa).

Figure 2. This emergency generator—elevated 2 feet above the floor on a concrete base—was not directly affected by floodwaters, but was rendered ineffective because the transfer switch was mounted below the transformer and flooded during the event (Cedar Rapids, Iowa).

Emergency Generators

For emergency generators to protect vital equipment and processes during and after a flood event, the following actions are recommended:

- Locate emergency generators as high as practical. At a minimum, the generator should be placed above the main electrical service equipment and above the utility company pad-mount transformer.
- Locate the emergency generator's transfer switch(es), and all electrical distribution equipment that the generator serves, at elevations that are at least as high as the generator.
- Supply the generator with a reliable source of fuel that will not be interrupted during an event. If a fuel tank is provided on site, anchor tank to resist floatation.

Ensure access is provided to the generator for generator operation, refueling, and, for events where long duration operation may be needed, for periodic maintenance.

completely removed and replaced. Although some electrical devices are designed for submerged use, locating electrical equipment above floodwater, in most cases, is the only effective mitigation measure for reducing flood risk to electrical components. Locating the equipment on a higher floor, for example, can significantly reduce its exposure to flooding. In some cases, locating the equipment on elevated concrete slabs or frames will provide the needed protection. This often is relatively inexpensive, but the effectiveness depends on a number of factors including the anticipated depth of flooding in the location.

Electrical conduits and raceway, on the other hand, often do not need to be removed and replaced after flooding, particularly if exposed to freshwater flooding. Some conduits can be cleaned, dried, and reused (this may require removing and reinstalling conductors). Conduits that provide equipment grounding should only be reused after it can be confirmed that flooding did not adversely affect the electrical continuity of the mechanical connections. If flooding has affected the electrical continuity of the metal raceway, the conduit should be removed and replaced, or a separate bonding conductor should be installed.

Dry Floodproofing

Some equipment can be protected by dry floodproofing. One example of this technique involves constructing **flood barriers** to prevent floodwater from reaching critical equipment. For this and other types of dry floodproofing to be successful, however, equipment to discharge water that can seep through the dry floodproofing (for example, sump pumps connected to emergency power) needs to be installed, and structural systems need to be put in place to resist the large buoyancy forces that dry floodproofing can create. Without installing costly and expensive equipment, dry floodproofing is typically effective for only up to 3 to 4 feet of floodwater (dry floodproofing over 4 feet is typically impractical due to strength and buoyancy considerations).

Conclusions

Hazard mitigation measures should be incorporated into all stages and at all levels of planning and designing for the reconstruction and rehabilitation of existing critical facilities. Building professionals and decision makers should seek information and guidelines for implementing a variety of mitigation measures to reduce the vulnerability to damage and disruption of operations during severe flood events. By building more robust critical facilities that can remain operational during and after a major disaster, people's lives and the community's vitality can be better preserved and protected.

Additional Resources

- *Risk Management Series Design Guide for Improving Critical Facility Safety from Flooding and High Winds* (FEMA 543) (Available at http://www.fema.gov/library/viewRecord.do?id=2441)
- *Protecting Building Utilities from Flood Damage* (FEMA 348) (Available at http://www.fema.gov/library/viewRecord.do?id=1750)
- FEMA Technical Bulletins (Available at http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)

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