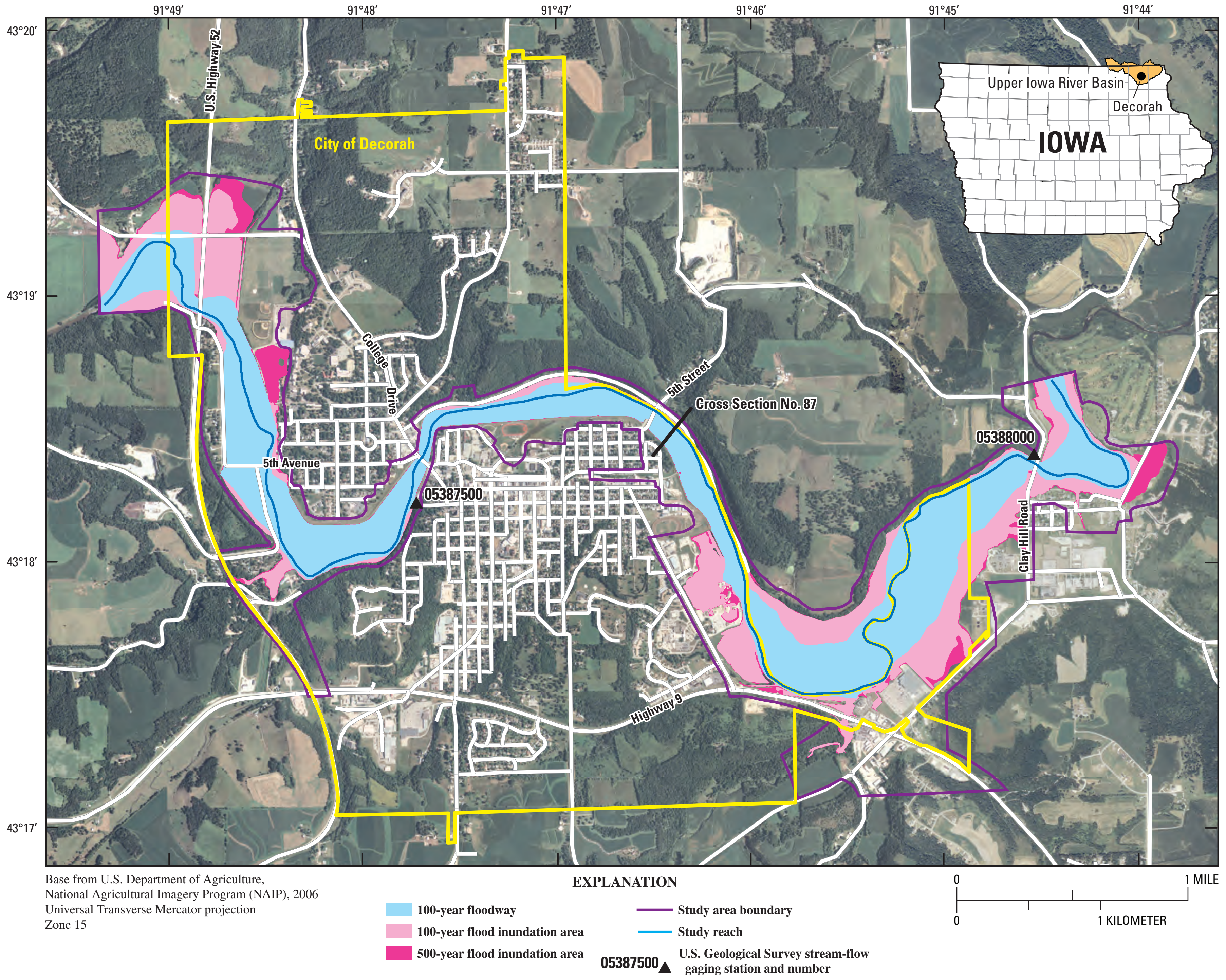

Figure 1. Location of the study area, 100-year floodway, and 100- and 500-year flood boundaries on the Upper Iowa River, near Decorah, Iowa.

Introduction

The city of Decorah, Iowa, has experienced severe flooding from the Upper Iowa River resulting in property damage to homes and businesses. Streamflow data from two U.S. Geological Survey (USGS) streamflow-gaging stations, the Upper Iowa River at Decorah, Iowa (station number 05387500), located upstream from the College Drive bridge; and the Upper Iowa River near Decorah, Iowa (station number 05388000), at the Clay Hill Road bridge (locally known as the Freeport bridge) were used in the study. The three largest floods on the Upper Iowa River at Decorah occurred in 1941, 1961, and 1993, for which the estimated peak discharges were 27,200 cubic feet per second (ft^3/s), 20,200 ft^3/s, and 20,500 ft^3/s, respectively. Flood-discharge information can be obtained from the World Wide Web at URL (uniform resource locator) *http://waterdata.usgs.gov/nwis/*. In response to the need to provide the City of Decorah and other flood-plain managers with an assessment of the risks of flooding to properties and facilities along an 8.5-mile (mi) reach of the Upper Iowa River, the USGS, in cooperation with the City of Decorah, initiated a study to map 100- and 500-year flood-prone areas.

Purpose and Scope

The purpose of this report is to describe a flood-plain study of the Upper Iowa River in the vicinity of Decorah, Iowa. Results of the study provide Decorah with sufficient data to describe flood hazards along an 8.5-mi reach of the Upper Iowa River. Community and local planners can use this report to evaluate hazards and manage the flood plain in Decorah. The study area and study reach are shown in figure 1.

Study Area Description

The Upper Iowa River Basin is located in northeast Iowa and southeast Minnesota (fig. 1). The Upper Iowa River headwaters begin in southeast Minnesota, and the river flows through extreme northeast Iowa to the mouth at the Mississippi River. The study area of the Upper Iowa River near Decorah extends from about 0.75 mi upstream from the U.S. Highway 52 bridge to about 1 mi downstream from the Clay Hill Road bridge (fig. 1).

The drainage area of the Upper Iowa River is 511 square miles (mi^2) near the College Drive bridge, and is 568 mi^2 at the Clay Hill Road bridge (Larimer, 1957). The flood plain near Decorah is characterized by narrow, bluff-walled valleys in which the flood plain is constricted to less than 300 feet (ft) in width (Iowa Natural Resources Council, 1958).

The slope of the Upper Iowa River is 6.5 feet per mile (ft/mi) along the study reach. Channel banks along the study reach are steep-sloped and lined with trees and vegetation. Land use along the study-reach flood plain is predominately urban, with some agricultural fields at the upstream and downstream ends of the reach.

Hydrologic Analysis

Standard hydrologic analysis methods were used to determine the flood-hazard data required for the Upper Iowa River flood-plain study. Two flood events of a magnitude that are expected to be equaled or exceeded once, on average, during any 100- or 500-year period (recurrence interval) were selected as having special significance for flood-plain management. These two flood events, commonly termed the 100- and 500-year floods, have a 1 and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the average long-term period between floods of a specific magnitude, rare floods could occur at shorter intervals, or even within the same year.

Hydrologic analyses were performed to estimate flood-frequency discharges for selected recurrence intervals for the Upper Iowa River flood-plain study. The 100- and 500-year flood-frequency discharge estimates computed for three sites along the Upper Iowa River are listed in table 1. Flood-frequency discharge estimates were computed from a statistical analysis of annual-peak discharge records collected during 84 years at two USGS streamflow-gaging stations (1952–2006 for station 05387500 and 1914, 1919–27, 1933–1952 for station 05388000). Statistical analysis followed the standard log-Pearson Type III method as outlined by the Interagency Advisory Committee on Water Data (1982).

Hydraulic Analysis

The Hydrologic Engineering Center's River Analysis System (HEC-RAS, version 4.0 Beta), a one-dimensional, hydraulic-flow model developed by the U.S. Army Corps of Engineers (USACE) (U.S. Army Corps of Engineers, 2006), was used to model the study reach of the Upper Iowa River near Decorah. The HEC-RAS program was designed specifically for application in flood-plain management and flood-insurance studies to evaluate floodway encroachment and to simulate estimated flood inundation (U.S. Army Corps of Engineers, 2006). The HEC-RAS model was used to compute water-surface elevations and develop flood-inundation areas along the Upper Iowa River study reach for the 100- and 500-year flood discharges (table 1).

Table 1. Flood-frequency estimates for the Decorah flood-plain study.

[ft^3/s, cubic feet per second]

Flooding source and location	Drainage area in square miles	Peak discharges (ft^3/s) 100-Year	500-Year
Upper Iowa River at U.S. Highway 52, Decorah	473	22,600	29,400
Upper Iowa River at Decorah (station number 05387500) near College Drive bridge, Decorah	511	23,400	30,400
Upper Iowa River near Decorah (station number 05388000) Clay Hill Road bridge (Freeport bridge), Decorah	568	24,600	32,000

The City of Decorah provided topographic data for the flood study that included 41 stream channel cross sections, 2-ft and 1-ft elevation contours within the study area (determined by aerial photogrammetric surveys and land surveys through the river channel), and bridge plans (Clay Hill Road, 5th Street, College Drive, and U.S. Highway 52) for this study. WHKS & Co, Mason City, Iowa, provided all cross section and model data for the 5th Avenue bridge (L.A. Narigon, P.E., WHKS & Co., written commun., 2007).

The HEC-GeoRas (U.S. Army Corps of Engineers, 2005) computer program was used to extract flood-plain cross sections from the elevation-contour data provided by the City of Decorah. HEC-GeoRas is a package of geographic information system (GIS) computer code specifically designed to view and manipulate geospatial data for use in HEC-RAS computer modeling. A total of 186 cross sections were extracted about every 200 ft along the study reach. Extracted cross sections located at or near the measured cross sections, were compared to the measured sections for quality assurance purposes. Extracted cross sections were extended to the lateral limit of the study area using the photogrammetric survey data. A typical HEC-RAS cross section and profile are shown in figures 2 and 3. Results from the HEC-RAS model were imported into ArcGIS (Environmental Systems Research Institute, Inc., 2004) using HEC-GeoRAS post processor routines. The 100- and 500-year flood-inundation areas and 100-year floodway boundary were then created using water-surface elevations interpolated from the HEC-GeoRas post processor in ArcGIS. The floodway is defined as the channel of a river, or other watercourse, and the adjacent land areas that must be reserved in order to discharge the 100-year flood without cumulatively increasing the water-surface elevation by more than a designated height of 1 ft (Federal Emergency Management Agency (FEMA), 2003).

Water-surface elevations for the 100- and 500-year floods and the 100-year floodway boundary, computed at all cross sections from the HEC-RAS model, were used by HEC-GeoRAS routines to intersect with the elevation-contour data provided by City of Decorah. The results of the intersection of the water-surface elevations and elevation-contour data are the 100- and 500-year flood-inundation areas and the 100-year floodway boundary (fig. 1).

Limitations and errors associated with developing flood-inundation areas are dependent on the topographic data, hydrologic data, and one-dimensional hydraulic modeling used in a flood-plain study. A USGS review of the elevation-contour data provided by the City of Decorah determined that the FEMA elevation accuracy requirement of 1.2 ft, at a 95-percent confidence level, may be met for the 2-ft contour data (Federal Emergency Management Agency (FEMA), 2003).

Model results indicate that the present levee system through Decorah retains the 100- and 500-year floods throughout the main sections of the city. Model results indicate that the 500-year flood may overtop the levee reach on the east bank upstream of the 5th Avenue bridge. The 100- and 500-year flood-inundation areas may be better defined by using more detailed topographic data, such as LIDAR (Light Detection and Ranging), in the future (Bales and others, 2007).

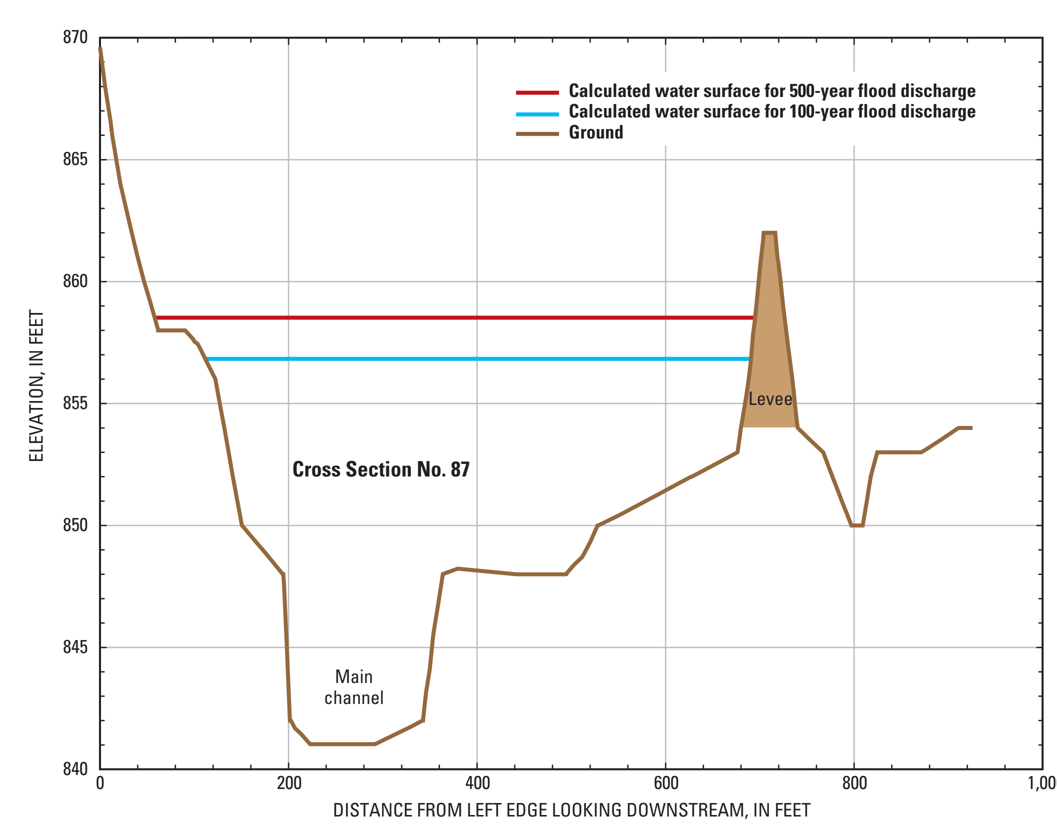

Figure 2. Typical HEC-RAS cross section 87, looking downstream.

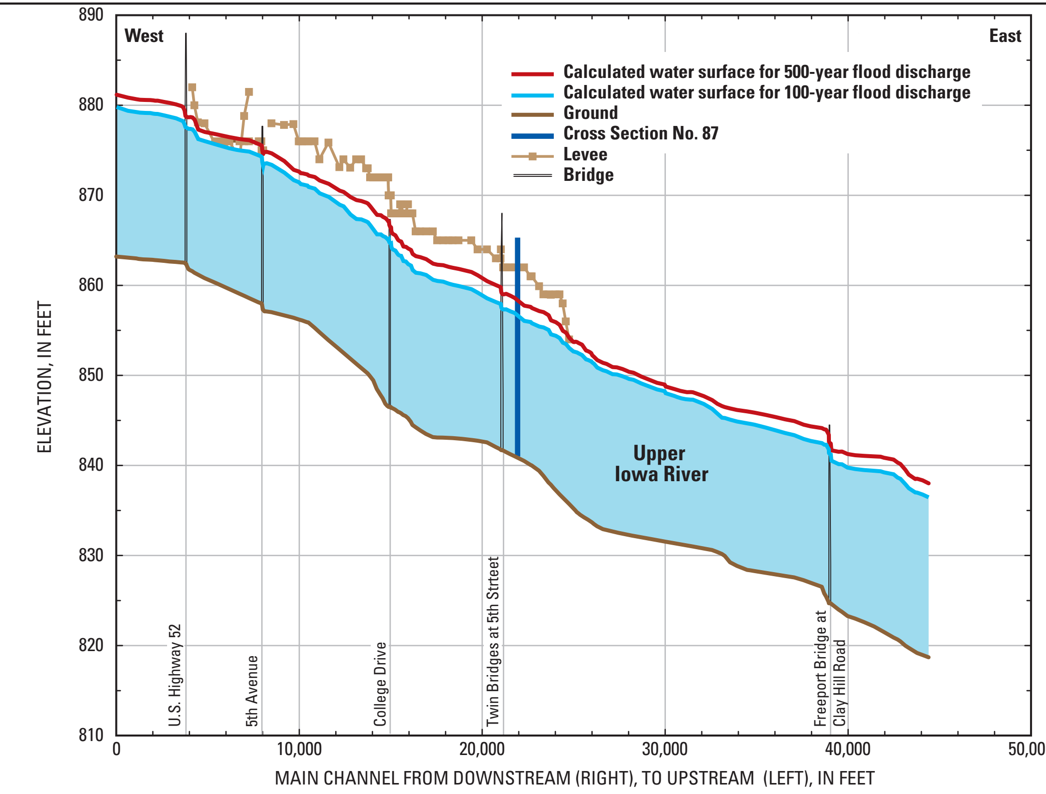

Figure 3. Typical HEC-RAS profile.

Summary

Flood-frequency discharges, water-surface elevation profiles, flood-inundation areas, and a floodway boundary were computed in cooperation with the City of Decorah, Iowa, for an 8.5-mi reach of the Upper Iowa River in the vicinity of Decorah. The City of Decorah can use this flood study to manage flood-prone areas along the Upper Iowa River in the vicinity of Decorah. Maps depicting the 100- and 500-year flood-inundation areas and the 100-year floodway boundary were estimated for the study reach using land-surveyed and aerially-surveyed elevation data, and one-dimensional HEC-RAS modeling.

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Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Map Jacket Photo. Upper Iowa River looking upstream of 5th Street bridge. Photograph by D.E. Christiansen, U.S. Geological Survey.

Flood-Plain Study of the Upper Iowa River in the Vicinity of Decorah, Iowa

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2008