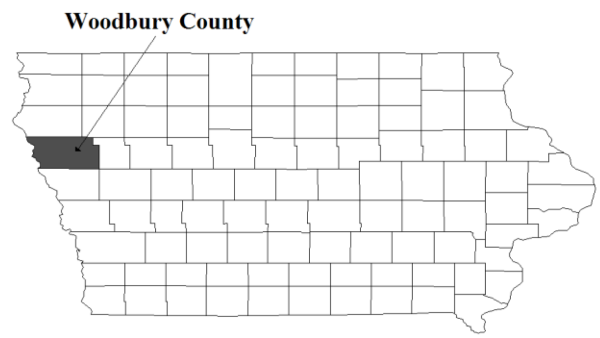
FLOOD INSURANCE STUDY



WOODBURY COUNTY, IOWA
AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER
Anthon, City of	190286	Pierson, City of	190295
Bronson, City of	190287	Salix, City of	190296
Correctionville, City of	190288	*Sergeant Bluff, City of	190297
Cushing, City of	190289	Sioux City, City of	190298
Danbury, City of	190290	Sloan, City of	190299
Hornick, City of	190291	Smithland, City of	190300
Lawton, City of	190292	Winnebago Indian Tribe	190984
Moville, City of	190293	Woodbury County	190536
Oto, City of	190294	Unincorporated Areas	

*No Special Flood Hazard Areas Identified

REVISED: March 2, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER

19193CV000B

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components.

Selected Flood Insurance Rate Map panels for the community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone	New Zone
A1 through A30	AE
B	X
C	X

Initial Countywide Effective Date: September 29, 2011
Revised Countywide FIS Date: March 2, 2015

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	Big Sioux River	04P - 05P
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FLOOD INSURANCE STUDY
WOODBURY COUNTY, IOWA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Woodbury County, including the Cities of Anthon, Bronson, Correctionville, Cushing, Danbury, Hornick, Lawton, Moville, Oto, Pierson, Salix, Sergeant Bluff, Sioux City, Sloan and Smithland, and Winnebago Indian Tribe and the unincorporated areas of Woodbury County (referred to collectively herein as Woodbury County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the City of Sergeant Bluff has no special flood hazard areas (SFHAs) identified.

This current study revises and supersedes previous incorporated and unincorporated flood insurance information in Woodbury County. This information will be used by the communities to update existing floodplain regulations as part of the regular phase of the NFIP. The information will also be used by local and regional planners to further promote sound land use and floodplain development.

For the September 29, 2011 revision, the format of the map panels has changed. Previously, flood-hazard information was shown on both the Flood Insurance Rate Map (FIRM) and Flood Boundary and Floodway Map (FBFM). In the new format, all base flood elevations, cross sections, zone designations, and floodplain and floodway boundary delineations are shown on the FIRM and the FBFM has been eliminated. Some of the flood insurance zone designations were changed to reflect the new format. Areas previous shown as numbered Zone A were changed to Zone AE. Areas previously shown as Zone B were changed to Zone X (shaded). Areas previously shown as Zone C were changed to Zone X (unshaded). In addition, all Flood Insurance Zone Data Tables were removed from the FIS report and all zone designations and reach determinations were removed from the profile panels.

The Digital Flood Insurance Rate Map (DFIRM) and FIS Report for September 29, 2011 countywide study have been produced in digital format. Flood hazard information was converted to meet the FEMA DFIRM database specifications and Geographic Information System (GIS) format requirements. The flood hazard information was created and is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum federal requirements. In such cases, the more restrictive criteria take precedence, and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS report are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The effective hydrologic and hydraulic analyses for the City of Anthon were performed by the U.S. Army Corps of Engineers (USACE), Omaha District. This study was completed in 2004.

The effective hydrologic and hydraulic analyses for the City of Correctionville were performed by Wallace Holland Kastler Schmitz and Company (the Study Contractor) for the Federal Emergency Management Agency (FEMA), under Contract No. EMK-87-C-0148. This study was completed in September 1988.

The effective hydrologic an hydraulic analyses for the City of Sioux City were prepared by the USACE, Omaha District, for the Flood Insurance Administration (FIA), under Inter-Agency Agreement No. IAA-H-19-74, Project Order Nos. 17 and 23, plus H-16-75, Project Order No. 4. This work, which was completed in February, 1977, covered all significant flooding sources formed on the Big Sioux River by the Omaha District Corps in conjunction with the Big Sioux River Flood and Erosion Control Project which was completed in September 1980.

The effective hydrologic and hydraulic analyses for Bacon Creek and the Little Sioux River were performed by Wallace, Holland, Kastler, Schmitz and Company (the Study Contractor) for FEMA, under Contract No. EMW-87-C-0148. This study was completed in September 1988.

The effective hydrologic and hydraulic analyses for the Missouri River were performed by the Omaha District, USACE (Reference 5) and are presented in the FIS for Dakota County, Nebraska (Reference 6).

The hydrologic and hydraulic analyses for the Missouri River for the current study performed by the USACE as part of the Upper Mississippi River System Flow Frequency Study (UMRSFFS). This study was a collaboration of effort between the Rock Island, St. Louis, Kansas City, Omaha, and St. Paul districts and was completed in 2003. The 1-percent-annual-chance flood water surface profile and floodway computations on the Missouri River were performed within HEC-RAS for FEMA under Interagency Agreement No. HSFE07-06-X-0012 by the Kansas City and Omaha districts and were completed in 2007.

The floodplain mapping for the Missouri River was performed by Watershed Concepts for FEMA under Contract No. HSFE07-07-C-0022.

For the 2011 countywide study, new hydrologic and hydraulic analyses were performed by AMEC Earth and Environmental, Inc. for FEMA, under Cooperative Agreement No. HSFE03-07-D-0030. This study was completed in July 2007.

For this countywide Physical Map Revision, the levees on the Big Sioux and Floyd Rivers are shown on the effective FIRM as accredited and providing protection from the 1-percent-annual-chance flood. This study was done under Contract Number HSFEHQ-09-D-0370 and provided by STARR.

Planimetric base map information shown on all FIRM panels was derived from the National Agriculture Imagery Program (NAIP) 2010, 1 meter orthoimagery. These base map files were provided in digital format by the U.S. Department of Agriculture, Data Gateway (USDA) (Reference 7). The elevation data used in this study was provided by the U.S. Geological Survey (USGS) as 10-meter Digital Elevation Models (DEM), by the Iowa Department of Natural Resources (IDNR) as a Woodbury County, Iowa, county-wide 1-meter DEM derived from Light Detection and Ranging (LiDAR) and from FEMA, as a 2-meter DEM derived from LIDAR mass points and breaklines (Reference 27, 28 & 29).

The coordinate system used for the production of this FIRM is the North American Datum of 1983 (NAD 83), State Plane Iowa North, FIPS 1401, feet. Corner coordinates shown on the FIRM are in latitude and longitude referenced to the Lambert Conformal Conic.

1.3 Coordination

1.3.1 Pre-Countywide Study

The City of Anthon

Representatives of the City of Anthon and the USACE coordinated to collect information on the flood hazards and to finalize the scope of the studies. Results of a previous study were also used in this effort. The Little Sioux River at Anthon, Iowa, Technical Assistance was completed by the USACE (Reference 8).

The City of Correctionville

On November 6, 1986, an initial coordination meeting was held in the Woodbury County Courthouse with representatives of FEMA, IDNR, the Woodbury County Engineer’s, Auditor’s, Zoning, Assessor’s, and Disaster Services Offices, Siouxland Interstate Metropolitan Planning Council, The Town of Correctionville, and the Study Contractor. The purpose of this meeting was to determine the availability of the community maps, to discuss the nature and impact of the NFIP, to initiate the data gathering and community input process, and to discuss flood history and other hydrologic data (Reference 9).

During the course of the study, coordination was maintained with the community to ensure efficient and comprehensive data collection and analyses. Contact was also made with the USACE, the IDNR, and the U.S Soil Conservation Service to obtain available information and to discuss flooding situations. Information received from the USGS included gage height records for the gaging stations on the Little Sioux River at Correctionville. Vertical control data used to establish elevation reference marks were also provided by the USGS (Reference 9).

On September 28, 1989, the results of *City of Correctionville, Iowa, Woodbury County FIS* were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, FEMA, and the community.

The City of Sioux City

The identification of streams requiring detailed study was accomplished through joint agreement between personnel of the USACE and the FIA. Information necessary or developing a base map was obtained from the City of Sioux City (Reference 10).

A Consultation and Coordination Officer's (CCO) meeting was held on December 10, 1975, in Sioux City to present to local officials preliminary results of the FIS. Representatives in attendance were from the USACE, the FIA, the City of Sioux City, and the Siouxland Interstate Metropolitan Planning Council (SIMPCO) (Reference 10).

A meeting was held on January 16, 1975, in the offices of the Omaha District USACE attended by representatives of the USACE and the City of Sioux City. The purpose of the meeting was to discuss comments provided by Sioux City officials concerning the preliminary results of the FIS presented on December 10, 1975 (Reference 10).

A meeting was held in Sioux City on April 16, 1976, to discuss the potential Big Sioux River Flood Control Project in conjunction with the FIS. Representatives of the USACE, SIMPCO, Union County, and Sioux City were in attendance (Reference 10).

A meeting was scheduled for April 21, 1976 to be held in Sioux City. The purpose of this meeting was to further discuss water surface elevations and floodway and floodplain delineation. This meeting, however, was postponed at the request of officials of Sioux City (Reference 10).

Final CCO meetings were held in Sioux City in the afternoon and evening of November 30, 1976, and in the evening of December 1, 1976. The purpose of the afternoon meeting was to present the final results of the FIS to local officials. The evening meetings were held to inform the general public of the results and to gain their comments. One, on November 30, was held in Riverside, a suburb of Sioux City, to discuss the Big Sioux River. The other, held on the first of December in Sioux City, City Hall was for discussion pertinent to Perry Creek, the Floyd River, and Bacon Creek (Reference 10).

A meeting was held in Sioux City on August 1, 2013, to discuss study results on the Big Sioux FCP Levee and Floyd River FCP Levee certification/accreditation and to discuss with HR Green the potential options for the City to pursue to reduce the flood risks shown on the preliminary FIRM. Representatives of the HR Green, FEMA, Iowa DNR, Woodbury County, and Sioux City were in attendance.

Woodbury County Unincorporated Areas

On November 6, 1986, an initial coordination meeting, held in the Woodbury Count Courthouse, was attended by representatives of FEMA, the IDNR, the Woodbury County Engineer's, Auditor's, Zoning, Assessor's, and Disaster Services Offices; Siouxland Interstate metropolitan Planning Council; the Town of Correctionville; and the Study Contractor. The purpose of the meeting was to determine the availability of community maps, to discuss the nature and impact of the NFIP, to initiate the data gathering and community input process, and to discuss flood history and other hydrologic data (Reference 11).

During the course of the study, coordination was maintained with the community to ensure efficient and comprehensive data collection and analyses. Contact was also made with the USACE, the IDNR, and the NCRS to obtain available information and to discuss flooding situations. Information received from the USGS included gage height records for the gaging stations to the Little Sioux River at Correctionville. Vertical control data used to establish elevation reference marks were also provided by the USGS (Reference 11).

On August, 8, 1990, the results of the *Woodbury County, Iowa, Unincorporated Areas FIS* were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, FEMA and the community (Reference 11).

1.3.2 September 29, 2011 Countywide Study

The initial CCO meeting was held November 20, 2006, and attended by representatives of FEMA, Woodbury County, the Cities of Moville, Sergeant Bluff, and Sioux City; Rose Engineering, PBS & J, LDR, Flat Earth Planning and Black and Veatch.

The results of the study were reviewed at the final CCO meeting held on Mach 10, 2010 and attended by representatives of the Cities of Anthon, Correctionville, Lawton, Moville, Oto, Salix, Sergeant Bluff, Sioux City, Sloan and Smithland and representatives of Woodbury County, AMEC Earth & Environmental, FEMA, IDNR, Sloan State Bank, Veenstra & Kimm, Inc. and local residents. All problems raised at that meeting have been addressed in this study.

2.0 <u>AREASTUDIED</u>

2.1 **Scope of Study**

2.1.1 Pre-Countywide Study

<u>The City of Anthon</u>

The *City of Anthon, Iowa, Woodbury County FIS* covered the incorporated areas of the City of Anthon.

A detailed flood elevation study was performed along the Little Sioux River from 2.5 miles downstream to a point about a half mile upstream of the city limits of Anthon. The study length was approximately 3.6 miles (Reference 8).

<u>The City of Correctionville</u>

The *City of Correctionville, Iowa, Woodbury County, FIS* covered the incorporated area of the City of Correctionville, Woodbury County, Iowa. Flooding caused by overflow of the Little Sioux River and Bacon Creek was studied in detail. The areas studied were selected with priority given to all know flood hazard areas and areas of projected development or proposed construction through September 1993. The scope and methods of the study were proposed to and agreed upon by FEMA and the City of Correctionville (Reference 9).

The City of Sioux City

The *City of Sioux City, Iowa, Woodbury County, FIS* covered the incorporated areas of the City of Sioux City, Iowa. Sioux City does not exercise any extraterritorial zoning jurisdiction, therefore the study falls entirely within the corporate limits.

Five streams were studied in this report. They are the Missouri River, Big Sioux River, Floyd River, Perry Creek, and Bacon Creek. All were studied by detailed methods except the Missouri River, the old Floyd River channel which is an outlet for Bacon Creek to the Missouri River, and Bacon Creek upstream from the SCS Dam No A-3 located upstream from Maple Street. These were studied by approximate methods as directed by the FIA. Areas between Perry Creek and the Floyd River were designated shallow flooding and ponding areas (Reference 10).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development or proposed construction for the next five years through February 1982 (Reference 10).

Approximate methods of analysis were used to study those areas having low development potential and/or minimal flood hazards as identified at the initiation of the study. The scope and methods of the study were proposed to and agreed upon by the FIA (Reference 10).

Woodbury County Unincorporated Areas

The *Woodbury County, Iowa, Unincorporated Areas FIS* covered the unincorporated areas of Woodbury County, Iowa. The incorporated areas within the county were excluded from this study. Flooding caused by overflow of the Missouri River, the Little Sioux River, and Bacon Creek was studied in detail (Reference 11).

Areas having low development potential or minimal flood hazards were previously studied using approximate analyses. The results were shown on the FBFM for Woodbury County, Iowa (Reference 12), and are incorporated into this FIS.

The areas studied were selected with priority given to all known flood hazards and areas of projected development or proposed construction through September 1993. The scope and methods were proposed to and agreed upon by FEMA and Woodbury County (Reference 11).

2.1.2 September 29, 2011 Countywide Study

This FIS report covers the geographic area of Woodbury County, Iowa, including the incorporated communities listed in Section 1.1.

For this study, AMEC Earth & Environmental, Inc. did not perform any new hydrologic and hydraulic analyses on those areas previously studied by detailed methods which were previously selected with priority given to all known flood hazards and areas of projected development or proposed construction. AMEC performed redelineation on all previously detailed studies in accordance with FEMA Guidelines and Specifications.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. Included in these analyses were Bacon Creek, Big Creek, Big Whiskey Creek, Bitter Creek, Bover Ditch, Camp Creek, Coon Creek, Cottonwood, Dead Man Creek, Deer Creek, Ditch, Dutch Creek, East Branch, East Fork Wolf Creek, East Morningside Creek, Elliot Creek, Farmers Ditch, Fern Creek, Floyd River, Hanford Creek, Hawk Creek, Keller Creek, Koker Creek, Little Sioux River, Little Whiskey Creek, Lum Hollow Creek, Maple River, McElhaney Creek, Miller Creek, Moorehead Creek, Moose Creek, Mud Creek, Muddy Creek, Parnell Creek, Pierson Creek, Reynolds Creek, Rock Creek, Smokey Hollow, Threemile Creek, West Fork Little Sioux River, West Mud River, Wolf Creek and associated named and unnamed tributaries. The scope and methods of study were proposed, and agreed upon, by FEMA, representatives of Woodbury County and the State of Iowa.

2.2 Community Description

Woodbury County, in northwest Iowa, is bordered on the north by Plymouth and Cherokee Counties, Iowa; on the east by Ida County, Iowa, on the south by Monona County, Iowa; and on the west by Thurston and Dakota Counties, Nebraska, and Union County, South Dakota. The county is served by Interstate 29, U.S. Highways 20 and 75, State Highway 31, Soo Line Railroad and Chicago and North Western Railroad. According the U.S Census Bureau the estimated 2009 population was 102,831(Reference 13).

The topography of the county consists of two extremes-- the very flat, broad floodplains of the Missouri River and the Little Sioux River--contrasted by undulating to steep soils in the uplands. The upland areas are covered with a loess mantle that is as much as 100 feet thick in places (Reference 14). The soils in the river bottom lands make up about 39-percent of the county.

The climate in Woodbury County is characterized by cold winters and hot summers. January, the coldest month, has an average temperature of 18.7 degrees Fahrenheit (°F), and July, the hottest month, has an average temperature of 74.9 °F. The average annual temperature is 48.5°F. The average annual precipitation varies from .59 inches in January (the driest month) to about 3.75 inches in May (the wettest month) with an annual average of 25.98 inches (Reference15).

A major portion of Woodbury County consists of the City of Sioux City. Sioux City is located in northwest Woodbury County. It is the largest city in western Iowa, having an estimated 2006 population of 83,262. (Reference 13). Today, Sioux City is the upstream terminus of the Missouri River inland waterway system and is served by several barge lines. Meatpacking is still a strong economic factor, together with agriculture and related industries, electronics, tools, machinery, industrial and farm equipment, chemicals, and pharmaceuticals. Sioux City serves a wide retail trade area. It is served by: Interstate Highway 29; U.S Highways 75, 77 and 20; Iowa State Highways 12 and 377; the Illinois Central Gulf Railroad; the Chicago and Northwestern Transportation Company; the Chicago, Milwaukee, St. Paul & Pacific Railroad; the Sioux City Municipal Airport; Graham Field; and ship lines on the Missouri River (Reference 10).

Sioux City is situated at the confluence of the Missouri River and Big Sioux River, Perry Creek, Floyd River, and Bacon Creek. Topography in the Sioux City area varies greatly, ranging from flat valleys to rolling hills to steep bluffs.

The Missouri River begins in southwest Montana, east of Continental Divide near Three Forks, Montana, at the juncture of the Jefferson, Madison, and Gallatin Rivers. The river flows generally east and south through a semi-arid region for approximately 1,580 miles to Sioux City. Elevations in the basin range from approximately 12,000 feet in the upper basin to approximately 1,100 feet at Sioux City. The drainage area of the Missouri River at Sioux City is approximately 314,660 square miles at the USGS gaging station located near the U.S Highway 20-77 bridge. The Missouri River floodplain within the corporate limits of Sioux City is used for a variety of reasons such as commercial, industrial, and agricultural developments (Reference 10).

The Big Sioux River drains approximately 9,565 square miles in eastern South Dakota, southwestern Minnesota, and northwestern Iowa. It begins about 70 miles north of Watertown, South Dakota. Elevations in the basin generally range between 2,000 feet and 1,100 feet. Primary floodplain uses in Sioux City are commercial, industrial, residential, agricultural and recreational.

The Floyd River begins approximately 30 miles west of Spencer, Iowa, near elevation 1,500 feet and flows southwest to Sioux City at an elevation of about 1,100 feet. The drainage area at Sioux City is approximately 956 square miles lying entirely in northwest Iowa. Flood plain uses in Sioux City are primarily agricultural, residential, commercial and industrial.

Perry Creek drains an area of approximately 73 square miles in northwest Iowa. It begins about 9 miles west of LeMars, Iowa. Elevations in the basin range from approximately 1,500 feet to approximately 1,100 feet. Floodplain uses are similar to those for the Floyd River.

Bacon Creek is a relatively small stream originating approximately one mile east of the Sioux City corporate limits. It has a basin drainage area of about 6.5 square miles and has basin elevations ranging from about 1,420 feet to about 1,100 feet. Floodplain uses in Sioux City are primarily commercial and residential.

The floodplains in Sioux City contain commercial, industrial and residential developments and public utilities. Numerous city streets, highways and rail lines cross the floodplains. Continuing economic development within the study area is expected and pressures leading to intensified floodplain use will undoubtedly accompany such development.

2.3 Principal Flood Problems

The Missouri River historically was a major flood problem for the western portion of Woodbury County. The greatest flood on the Missouri River was in April 1952, with a discharge at Sioux City of 441,000 cubic feet per second (cfs). This situation, however, has changed considerably since six dams and reservoirs were constructed on the Missouri River upstream of Sioux City. These flood-control structures have essentially eliminated the threat of the 1-percent-annual-chance flood in Woodbury County from the Missouri River. Unfortunately, because of reservoir operations mandated by upstream conditions and tributary inflow downstream of the dams, flooding is still possible. Flooding may also result from ice effects, in which large pads of ice create blockages causing rapid increases in upstream elevations (Reference 5).

Other major sources of flooding within Woodbury County are the Little Sioux River, the West Fork Little Sioux River, and Bacon Creek. A gaging station has existed on the Little Sioux River at Correctionville since 1918. Floods equal to or exceeding the 2-percent-annual-chance flood have occurred in 1951, 1953, 1954, 1962, 1965, 1969, 1983 and 1984. Record floods during the spring and summer of 1993 and again in 2007 have caused significant flooding along the Missouri River in Woodbury County (Reference 16 & 30).

Sioux City lies partially within the flood plains of the Missouri River, Big Sioux River, Floyd River, Perry Creek and Bacon Creek, which are the City's principal flood problems. Flooding from these streams can occur in Sioux City as a result of rapid snowmelt, heavy rainfall or combinations thereof. The effects can also influence flooding, especially on the Missouri River the Big Sioux River and the Floyd River. Flooding on these streams under open river conditions would normally be of relatively long duration with ample warning prior to the peak. However, flooding due to Perry Creek and especially Bacon Creek could result from heavy rainfall on a relatively local basis creating short duration flooding with little warning prior the peak. With this variation in peaking time and flood duration within Sioux City depending upon the particular stream flooding, flood fighting and evacuation procedures to be utilized in Sioux City during flood periods must also be varied (Reference 10).

The Big Sioux River, like the Missouri River, has historically been a flood problem for Sioux City. It had little flood control prior to 1979 and has flooded portions of Sioux City in 1951, 1952, 1960, 1962 and 1969. All were essentially snowmelt runoff floods. The 1969 flood was the flood of record on the Big Sioux River at Sioux City, having a recurrence interval of 62 years. This flood caused damages estimated at 3 million dollars at 1975 price levels in North Sioux City and Sioux City (Reference 10).

However, this has changed considerably since construction of a levee system and channel recertification upstream from Route 29. The USACE's flood control project has essentially eliminated the threat of major flooding to the developed area of Sioux City from the Big Sioux River (Reference 10).

Numerous floods have occurred in the Floyd River Basin since the late 1800s. Of these, the floods of 1892, 1926, 1934, 1952 and 1953 were considered major. The largest and most damaging of these floods was that of 1953 in which 4,628 people were driven from their homes and 14 people died. A flood of this magnitude is in excess of the 1-percent-annual-chance flood. Fortunately, the recurrence of flooding of this magnitude in Sioux City due to the Floyd River has decreased considerably due to channel and levee work completed by the USACE in the 1960s (Reference 10).

Perry Creek has also flooded numerous times since the late 1800s. The largest of these floods occurred in 1944 when floodwaters covered a 330 block area containing 914 residences and 256 businesses. A flood of this magnitude has a recurrence interval of 17 years (Reference 10).

Bacon Creek has undoubtedly flooded many times since the area was settled. Little information is available on past flooding probably because of the flash flood phenomenon characteristic of Bacon Creek. Records indicate, however, that a flood did occur in the Greenville area of Sioux City in July 1955 as a result of heavy rainfall. Many residences and business places were damaged due to that flood (Reference 10).

The Little Sioux River and Bacon Creek contribute to flooding within the corporate limits of Correctionville. A gaging station has been in existence on the Little Sioux River at

Correctionville since 1918. Since the gage was established, flood levels equaling or exceeding the 2-percent-annual-chance flood have occurred in 1951, 1953, 1954, 1962, 1965, 1969, 1983 and 1984. The most severe flood during this period was the 1965 flood, which had a recurrence interval of 65 years. The most severe flood of record occurred prior to the gage installation in 1891. An account of the June 23 and 24, 1891, flood indicated a high-water mark 3.5 feet higher than the 1965 flood at Correctionville. However, a local resident stated that the mark was high because of water released when a mill dam failed on Bacon Creek east of Correctionville (Reference 9 and 16).

2.4 Flood Protection Measures

There a number of flood protection measures in place which influence and effect flooding in Woodbury County, Iowa.

Several major dams and reservoirs are located in the Missouri River Basin upstream from Woodbury County. Of these dams and reservoirs, six are located on the main stem of the Missouri River and provide significant flood protection from the Missouri River. The six dams are: Fort Peck near Glasgow, Montana; Garrison near Garrison, North Dakota; Oahe near Pierre, South Dakota; Big Bend near Chamberlain, South Dakota; Fort Randall near Lake Andes, South Dakota; and Gavins Point near Yankton, South Dakota. This system of dams and reservoirs has significantly reduced the 1-percent-annual-chance flood discharge on the Missouri River in Woodbury County, Iowa.

A number of flood control structures have also been constructed within Woodbury County to control and improve flooding in the area. The following list highlights protection measures within the county taken to control and protect Woodbury County from flooding events.

<u>Missouri River</u>
Systems of bank stabilization works are located along the Missouri River in Sioux City. These works protect Sioux City from bank erosion along the Missouri River (Reference 10).

<u>Big Sioux River</u>
Flood and erosion control projects have been constructed by the USACE for the lower Big Sioux River in Sioux City. This project combines channel improvements; levee construction and bank stabilization in order to better protect Sioux City. This Big Sioux FCP Levee was accredited on July 3, 2012 and a study is shown as accredited on the FIRM (Reference 10).

<u>Floyd River</u>
The USACE constructed flood-control works on the lower Floyd River which were completed in 1966. This project consisted of channel modifications, levee construction and erosion control. The project begins near 46th Street on the right bank and continues about 7,000 feet downstream from 46th Street on the left bank and ends at the mouth of the Floyd River. This Floyd River FCP Levee was accredited on July 3, 2012 and a study is shown as accredited on the FIRM. (Reference 10).

<u>Perry Creek</u>
A number of flood-control structures exits on Perry Creek to protect the City of Sioux City. The (NRCS) has constructed some erosion control structures in the upper basin.

These structures however, provide little, if any flood peak reduction from less frequent floods at Sioux City. Since 1905 the City of Sioux City has undertaken numerous improvements of the Perry Creek channel. These improvements include construction of a conduit, bank stabilization measures and channel straightening. The conduit extends from West 8th Street downstream to the confluence with the Missouri River. From the conduit to the corporate limits of Sioux City a straightening of the channel on Perry Creek has been developed to improve flood protection in the area. A levee also exists along the banks of Perry Creek in the area which is contained by the straightened channel. However, it has been determined by the USACE that this levee does not meet the 90-percent non-exceedance probability that the 1-percent-annual-chance flood will be contained within the levee (Reference 10 & 31).

Bacon Creek

The NRCS has constructed a flood- and erosion −control project in the Upper Bacon Creek Basin. This project consisted of the installation of terraces, grassed waterways, grade stabilization structures, flood water retarding and sediment-control structures and a multipurpose structure. Once operational, these structures began to reduce flooding at Sioux City (Reference 10).

Little Sioux River

There is also a levee along portions of the right bank of the Little Sioux River (Reference 8).

Sioux City has adopted a Flood Control Manual delegating responsibilities for operation and maintenance of the Big Sioux Levee and outlining a warning system and a schedule of flood protection measures to be followed during the threat of a flood. Also included in the manual is a schedule of levee and equipment inspections and regular drills.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood-hazard data required for this study. Flood events of a magnitude that is expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent- annual-chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at shorter intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 **Hydrologic Analysis**

3.1.1 Pre-Countywide Analyses

<u>The City of Anthon</u>

Hydrologic analyses were carried out to establish peak discharge-frequency relationship for Little Sioux River, which was studied by detailed methods.

The hydrology for the City of Anthon effective study was developed using the historical period of record from the USGS Survey stream gage at Correctionville, Iowa, including the estimated discharge from the flood of 1891. Because of the close proximity of Anthon to Correctionville (approximately 9 miles) and the lack of major tributaries joining the Little Sioux River in that reach, the hydrology developed by analyzing the record at Correctionville is considered appropriate for use in Anthon. Hydrology developed for this study compares very well with that developed at the source location for the Correctionville, Iowa FIS report dated August 15, 1990, when the flood of 1891 is excluded. With inclusion of the flood of 1891, the 1-percent-annual-chance flood is about 5,300 cubic feet per second higher. The hydrologic analysis for the Little Sioux River determined the magnitude of the 10-, 2-, 1- and the 0.2-percent-annual-chance floods and results are listed in Table 3 Summary of Discharges. The results shown in Table 3 and used in the hydraulic analysis do not contain the expected probability adjustment due to the long length of record at this stream gage (Reference 8).

<u>The City of Correctionville</u>

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each riverine flooding source studied in detail affecting the community. Peak discharges for the Little Sioux River were taken from Table 3, Summary of Discharges of the USGS Report 87-4132 (Reference 17). This table lists magnitude and frequency of flood frequency equations (Reference 17). Peak discharge-drainage area relationships for the 10-, 2-, 1- and 0.2-percent-annual-chance floods of each flooding source studied in detail in the community are shown in Table 3.

<u>The City of Sioux City</u>

Hydrologic analyses were conducted to establish the peak discharge frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail in the community.

Hydrologic analyses for this FIS consisted of determining the 10-, 2-, 1- and 0.2-percent-annual-chance floods. The Environmental Protection Agency (EPA) <u>Storm Water Management Model</u>, was used for determining flood flows on Bacon Creek. This model uses basin and channel input data along with rainfall data to determine runoff magnitude. The U.S. Weather Bureau Technical Publication No. 40 was used to select the rainfall over the basin (Reference 18 and 19). The discharge-probability relationship for the Floyd River was developed from the period of record at the James, Iowa stream flow gage using Beard’s technique (Reference 20). The 2-percent-annual-chance record (1934 through 1973) was segregated into snowmelt and rainfall events with discharge-probability curves developed for each group. These curves were combined on a probability basis and adjusted for the drainage area at Sioux City to obtain the final discharge probability relationships for the Floyd River.

The discharge-probability relationship for Perry Creek was developed from 31 years of record at the 38th Street gaging station in Sioux City. The analyses were accomplished using the Guidelines for Determining Flood Flow Frequency as outlined in the U.S. Water Resources Council Bulletin No. 17 dated March 1976 (Reference 21). This analysis was a log –Pearson Type III without adjustment for expected probability. The data developed at the 38th Street gage was extrapolated to the mouth and to the Plymouth-Woodbury County line.

The discharge-probability relationship for the Big Sioux River at Sioux City was based on 43 years of stream gaging records at the Akron, Iowa gaging station. Maximum annual rainfall and snowmelt flood peaks at Sioux City were determined by routing the Akron Hydrographs to Sioux City. From these data, probability curves at Sioux City were developed for the maximum annual rainfall flood series and the maximum annual snowmelt flood series. The snowmelt and rainfall curves were then combined dot obtain the all-season probability curve at Sioux City.

The hydrologic analysis on the Missouri River at Sioux City was conducted in previous studies by detailed methods for the USACE.

Discharges for the 0.2-percent-annual-chance floods of Perry Creek and the Floyd River were determined by extrapolation of a graph of flood discharges computed for frequencies of up to 100 years. The Standard Project Flood of Reference 1 was used in lieu of the 0.2-percnet-annual-chance flood of the Big Sioux River.

The resultant flood flows for each stream studied in detail are shown in Table 3, Summary of Discharges.

The City of Sioux City First Revision

Information on historic floods on the Big Sioux River was developed by the USACE during work on the Federal Flood and Erosion Control Project. During the period from 1870 to 1973, a total of 79 floods of varied magnitude occurred in the Big Sioux River Basin. Twelve of these were general floods affecting the river through most of its length. Since the 1950’s the Big Sioux River has flooded in 1951, 1952, 1960, 1962, 1969, 1984 and 1993. The 1984 and 1993 floods were due to heavy rainfall runoff, while the other floods were mainly due to snow melt. Peak flood discharges in cubic feet per second (cfs) at the Akron, Iowa, stream gage are tabulated in Table 1, Recent Major Flood Peak Discharges at Akron Gage.

Table 1: Recent Major Flood Peak Discharges at Akron Gage

Year	Discharge (cfs)
1951	28000
1952	33000
1960	49500
1962	54300
1969	80800
1984	52200
1993	66700

The largest flood of record on the Big Sioux River in Union County was the snow melt flood of April 1969.

Big Sioux River peak flood discharges were developed in 1996 by the USGS and were published in the report Estimation of Flood Flows on the Big Sioux River Between Akron, Iowa and North Sioux City, South Dakota.

The USGS has operated a stream gaging station on the Big Sioux River at Akron, Iowa since 1929. A flood-frequency analysis for the Akron gage was developed using the log-Pearson Type III procedure recommended by the U.S. Interagency Advisory Committee on Water Data, Bulletin 17B for the 10-, 2-, 1- and 0.2-percent-annual-chance recurrence intervals.

To develop peak flood discharges at selected locations from the Akron gaging station to North Sioux City, several methods were examined. The method selected was the use of drainage-area ratios raised to specific exponents to transfer the Bulletin 17B flood-frequency results for Akron to the selected downstream locations.

The overflow across Interstate Highway 29 between McCook Lake and the Park Jefferson interchanges, located in Union County, South Dakota (Unincorporated Areas), was modeled using the split flow option in HEC-2. Flow across the Interstate was computed with the highway grade acting as a broad crested weir with a weir coefficient of 2.5. Big Sioux River flows crossing the Interstate were assumed to flow into McCook Lake and Lake Goodenough and not to return to Big Sioux River. The flows across Interstate Highway 29 are shown in Table 2, Flows Across Interstate 29.

Table 2: Flows Across Interstate 29	
Flood Event	Flow Across Interstate 29 (cfs)
10-percent-annual-chance	0
2-percent-annual-chance	0
1-percent-annual-chance	4900
0.2-percent-annual-chance	46400

<u>Woodbury County Unincorporated Areas</u>

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each riverine flooding source studied in detail affecting the community.

Peak discharges for the Little Sioux River were obtained from the USGS (Reference 22). The discharges for Bacon Creek were determined using regional equations (Reference 17). The discharges for the Missouri River were obtained from the USACE (Reference 5).

Peak discharge-drainage area relationships for the 10-, 2-, 1- and 0.2-percent-annual-chance floods of each flooding source studied in detail for the community are shown in Table 3.

3.1.2 September 29, 2011 Countywide Analysis

Discharges for approximate hydrologic studies were computed by Black & Veatch. Black & Veatch and AMEC did not perform new detailed hydrology for those streams previously studied by detailed methods. The USACE performed a detailed hydrologic analysis for the

Missouri River as described below.

The hydrologic analysis for the streams to be studied by approximate methods was performed using the Nebraska Department of Natural Resources N-FACT tool (Reference 24) and regional regression equations for ungaged sites. Regression-weighted estimates for ungaged sites on gage streams were calculated, where applicable (Reference 25).

The USACE performed hydrologic and hydraulic analysis for Perry Creek in Sioux City. This study was incorporated by AMEC as part of this new countywide study.

As part of this countywide FIS, AMEC incorporated a Letter of Map Revision (LOMR) studied on Perry Creek in Sioux City by the USACE in July of 2007. The USACE developed a rainfall and runoff model using HEC-HMS. The rainfall and runoff model was then calibrated to a gage analysis performed by the USACE located at the intersection of Perry Creek and 38th Street, Sioux City, Iowa (Station ID 06600000). Detailed information can be found in the hydrology report developed by the USACE (Reference 1).

Upper Mississippi River System Flow Frequency Study Methodology

Major Upper Mississippi River Basin flooding during the 1990s resulted in significant losses, as well as raised questions regarding the frequency of the associated flood events. Reevaluation of the Upper Mississippi River System became necessary to address the questions resulting from the Great Flood of 1993, and was facilitated based on the availability of new topographic data, new computational techniques, and about 20 more years of recorded hydrologic data since the previous study of the Mississippi River had been performed in 1979. This is generally true for the Missouri River as well. The last major effort to comprehensively determine Missouri River flow frequencies was in 1962. The additional record of more than 35 years included the major events of 1993 downstream of Nebraska City and the 1997 large volume flood in the upper reaches of the Missouri River.

The UMRSFFS was undertaken starting in 1998 with the purpose to update the discharge-frequency relationships and associated water-surface profiles for the Mississippi River from St. Paul, Minnesota to the confluence of the Ohio River; for the Illinois River from Lockport, Illinois to its mouth; and for the Missouri River from Gavins Point Dam to its mouth. Five USACE Districts participated in the study: Rock Island, St. Louis, St. Paul, Kansas City, and Omaha. The study was completed in 2003.

The hydrologic analysis for the UMRSFFS utilized a combination of the following methods and approaches to determine discharge-frequency relationships: 100 years of record from 1898 to 1998; the log-Pearson Type III distribution for unregulated flows at gages; main stem flows between gages determined by interpolation of the mean and standard deviation for the annual flow distribution based on drainage area in conjunction with a regional skew; flood control reservoir impacts defined by developing regulated versus non-regulated relationships for discharges; extreme events determined by factoring up major historic events; Hydrologic Engineering Center, Hydrologic Modeling System (HEC-HMS) and/or HEC-1 models for the main tributaries; and the USACE One-Dimensional Unsteady Network Flow Model (UNET) unsteady flow program to address hydraulic impacts. In situations where historic records were not adequate or appropriate to develop discharge frequency relationships or to verify the results, hydrologic modeling was used to create synthetic flows based on rainfall. Gage records for all streams were carefully evaluated.

The computation of unregulated flow frequency relationships on the Missouri River upstream of the Kansas River required special consideration due to the combination of the two historic peak flow periods consisting of the plains snowmelt of the early spring and the mountain snowmelt and plains rainfall of the late spring/early summer. An additional concern related to the Missouri River was flow depletion due to irrigation and reservoir evaporation. Historic depletions were added to the observed flow record to help obtain unregulated flows, while historic depletions were adjusted to present level depletions for computation of the regulated flow record.

The result of the hydrologic aspects of the study was a discharge and related frequency of occurrence for stations or given cross section located along each of the principle main stem rivers. For more detailed information on each of the hydrologic methodologies used to determine discharges, the reader is encouraged to consult the report cited as Reference 1 in Section 9.0 of this FIS.

The results of this countywide FIS are shown in Table 3, Summary of Discharges.

Table 3: Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-Percent Annual-Chance	2-Percent Annual-Chance	1-Percent Annual-Chance	0.2-Percent Annual-Chance
BACON CREEK					
At Mouth	34	3,940	6,570	7,920	11,200
BACON CREEK (NEAR SIOUX CITY)					
At Mouth	6.52	2,700	4,600	5,600	8,800
Rustin Street	6.11	2,300	4,000	4,950	7,800
Below Junction with South Branch	5.61	1,900	3,350	4,150	6,600
Above Junction with South Branch	4.72	920	1,700	2,150	3,550
Below Junction with North Branch	4.03	660	1,200	1,500	2,400
Above Junction with North Branch	1.64	500	850	1,050	1,650
Below NRCS Dam	1.12	110	220	250	450
BIG SIOUX RIVER					
Upstream of Burlington Northern Railroad	7,489	35,300	70,400	84,173[1]	95,622[1]
Just downstream of confluence of Broken Kettle Creek	7,454	35,300	70,200	88,800	141,000
Just downstream of confluence of Rock Creek	7,343	35,000	69,400	87,700	138,000
Just downstream of confluence of Brule Creek	7,259	34,800	68,900	86,800	137,000
At USGS gaging station number 0648550 located in the City of Akron, Iowa	6,937	34,000	66,700	83,500	129,000

[1]Decrease in flow with increase in area is result of overflow across Interstate 29

Table 3: Summary of Discharges (Contiunued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-Percent Annual-Chance	2-Percent Annual-Chance	1-Percent Annual-Chance	0.2-Percent Annual-Chance
FLOYD RIVER					
At mouth	918	16,800	42,500	60,000	96,800
LITTLE SIOUX RIVER					
At Anthon	2,616	17,500	31,200	38,400	58,800
At State Highway 31	1,500	16,400	27,700	33,100	48,100
MISSOURI RIVER					
At Blackbird Creek (River Mile 697.4)	*	86,900	120,300	141,500	197,300
At Omaha Creek (River Mile 719.6)	*	85,200	119,000	140,000	195,000
At Floyd River (River Mile 731.3)	315,541	83,700	117,900	138,600	192,900
At Perry Creek (River Mile 732.2)	*	78,400	113,900	133,900	185,600
At Sioux City, IA (River Mile 732.4)	314,600	78,300	113,800	133,800	185,400
At Big Sioux River (River Mile 734)	*	78,400	113,800	133,800	185,400
**PERRY CREEK					
38th Street	65.1	5840	10372	12608	18498
**PLUM CREEK					
At mouth	*	292	520	630	925

*Unavailable

**Incorporated from USACE LOMR

3.2 **Hydraulic Analyses**

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

3.2.1 Pre-Countywide Analyses

The City of Anthon

Little Sioux River was studied by detailed methods as indicated in Section 2.1. A water-surface profile for the 1-percent-annual-chance flood was computed using the USACE standard step-backwater computer program, Hydrologic Engineering Center River Analysis System, or HEC-RAS, Version 3.1 (Reference 3). The HEC-RAS program is used for calculating water-surface profiles for steady, gradually varied flow in natural or man-made channels.

Cross sections and bridge data for the hydraulic model were field surveyed by the USACE in September of 1998 and March of 1999. Additional topographic information was obtained from a USGS 7.5-minute quadrangle map for the Anthon area (Reference 8).

The main channel of Little Sioux River has an average active channel width of approximately 300 feet though it varies widely at a few cross sections. The main channel slope is 3.6 feet per mile. Roughness coeffecients (Manning's –n) for the channel were set at 0.035 and 0.070 for the overbank areas. The selection of roughness coefficients were made based on the results of previous studies conducted along channels with similar geometries and the amount of development along certain cross sections. No known high water marks established during prior flood events were available to calibrate the results of the hydraulic model.

The HEC-RAS program uses Manning's equation to calculate friction losses between cross sections. The roughness coefficient values, used in this study were determined, by field inspections, photographs, and engineering judgment. The roughness coefficients for this study were set at 0.035 for the channel and varied from 0.035 to 0.050 for the over banks. Other losses, such as loses due to contraction and expansion of flow between cross sections, are described in terms of a coefficient times the absolute value of the change in velocity head between adjacent cross sections. When the velocity head increases in the down stream direction, a contraction coefficient is used; and when the velocity head decreases, an expansion coefficient is used. The contraction and expansion coefficients were set at 0.1 and 0.3 respectively, for the channel and 0.3 and 0.5 at bridge locations. Ineffective flow areas were also set at appropriate cross sections to reflect areas where no flow is being conveyed downstream, such as near bridges, embankments, and where velocities are near zero.

The starting water-surface-elevation for the Little Sioux River was set based on normal depth calculations using a surveyed water-surface grade determined from the actual water surface at the time of the survey.

The City of Correctionville

Cross sections for the backwater analyses were based on field surveys. Elevation data for the structural geometry of all bridges were obtained either from construction drawings or from field surveys.

Roughness coefficients (Manning's "n") were chosen by engineering judgment and based on field observation and aerial photographs. Roughness values for the channels ranged from 0.033 to 0.045, with floodplain values ranging from 0.04 to 0.10.

The starting water-surface elevations were determined using the slope-area method. The elevation for the Little Sioux River was compared to historic flood profiles for reasonableness.

Water-surface elevations for the 1-percent-annual-chance flood were developed using the HEC-2 step-backwater computer program. Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals (Reference 9).

The City of Sioux City

All streams were studied by detailed methods except for the Missouri River, the old Floyd River channel between the Missouri River and Bacon Creek, and Bacon Creek upstream from SCS Dam A-3. These were studied by approximate methods.

Water-surface elevations of floods of the selected recurrence intervals on the Big Sioux River, Perry Creek downstream from station 150+50, Bacon Creek, and the Floyd River upstream from station 235+00 were computed through use of the USACE backwater computer program HEC-2. The upper portion of Perry Creek and the lower portion of the Floyd River were computed by using an in-house program developed by the Omaha District USACE. Head losses at bridges were computed using either bridge routines contained in the Missouri River bridge (River Mile 729). The approximate study on the old Floyd River channel between the Missouri River and Bacon Creek is based upon prior USACE studies which evaluated the capacity of the channel. The approximate study on Bacon Creek upstream from the SCS Dam A-3 was based upon spillway elevations for the dam (Reference 10).

The water-surface elevations for Perry Creek in this study are the same as those contained in Flood Plain Information, Sioux City, Iowa, Volume I, Perry Creek, except for the reach of Perry Creek downstream from Lindenwood Street. Water-surface elevations for Perry Creek contained in General Design Memorandum No. MF-1 Floyd river, Sioux City, Iowa, were computed by an in-house program developed by the USACE (Reference 3). Difficulties were encountered in the lower reach when using HEC-2 to compute a floodway for this study based upon 1-percent-annual-chance flood elevations developed by the in-house program. To alleviate this situation, HEC-2 was utilized to determine the flood elevations in the reach below Lindenwood Street. This resulted in some minor differences ranging from +0.5 foot between the water-surface elevations contained in the Flood Plain Information report for Sioux City, Iowa, and in this study (Reference 10).

Cross sections for the hydraulic analyses on the Big Sioux River (upstream from the levee project and downstream from Route 29), Perry Creek, Bacon Creek, and the upper end of the Floyd River (upstream from approximately the location of the left bank levee tie-off to the approximate end of the control project) were determined in 1972 by photogrammetric methods utilizing photographic data gathered by SIMPCO in 1968 (Reference 10). This data was supplemented with 2-foot contour interval mapping on Perry Creek and by additional cross-section survey data on the Big Sioux River—both provided by the USACE. Cross-section data on the Floyd River downstream from this reach and on the Big Sioux River within the levee project was based on the flood-control project design cross sections (References 10).

Roughness factors (Manning's "n") for computations for the Missouri River were assigned to match previously obtained high-water marks. Roughness factors for computations on the Big Sioux River, Perry Creek, Floyd River, and Bacon Creek were selected on the basis of visual inspection and engineering judgment. Table 5 and 6 provide Manning's –n values used in this study for those streams studied by detailed methods.

The shallow flooding areas between Perry Creek and the Floyd River were determined by backwater computations utilizing HEC-2, engineering judgment, and SIMPCO mapping (Reference 10).

The approximate study on the Missouri River is based upon a detailed hydraulic study conducted by the USACE in 1973. This study ran from the confluence of the Big Sioux and Missouri Rivers downstream on.

Starting water-surface elevations for the Missouri River analysis were based upon normal depth computations and prior high-water marks.

Coincident discharges on the Missouri River for floods of the selected recurrence intervals on the Big Sioux River, the Floyd River, and Perry Creek were determined. In all cases, the coincident Missouri River discharge was 35,000 (cfs) due to operation of the upstream main stem dams. Starting water-surface elevations on the Big Sioux River, Floyd River, and Perry Creek were based on stage-discharge relationships developed for the Missouri River at the mouth of each respective stream. Starting water-surface elevations for Bacon Creek were determined to be at critical depth where Bacon Creek flows into the old Floyd River channel.

Flood elevations are often increased due to ice or debris blockages which restrict flow of water through the channel or bridges. The hydraulic analyses for this study, however, are based on the effects of unobstructed flow. The flood elevations shown on the profiles are valid only if the hydraulic structures remain unobstructed and dams and other flood control structures operate properly and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Elevation reference marks used in this study are shown on the maps.

<u>The City of Sioux City Revision</u>

The Federal Flood and Erosion Control Project levess, mentioned in Section 2.4 Flood Protection Measures, provide protection against a design discharge of 98900 cfs plus three feet of freeboard. The design is based on providing protection against that portion of USACE's Standard Project Flood that can be delivered to the Big Sioux River channel through the project area. A USACE Standard Project Flood is defined as the flood that may be expected from the most severe combination of meteorological and hydrologic conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located. During the design of the Federal Project, the Standard Project Flood was determined to not be physically possible for such large Big Sioux River flood discharges to be conveyed down through the North Sioux City area to the river's confluence with the Missouri River. An explanation of Big Sioux River flow reductions can be found below.

Local interests have constructed levees at many locations along the Big Sioux River in Union County upstream of Sioux City. Most levees are located upstream from the State Route 7 bridge northeast of the City of Jefferson and primarily some protection from the more frequent, smaller flood events but are inadequate to provide protection from larger, rarer floods.

Studies conducted by USACE during the design of the Federal Flood and Erosion Control Project through North Sioux City, South Dakota, and Sioux City, Iowa found that it was not physically possible for large Big Sioux River flood discharges to be conveyed through the North Sioux City area to the river's confluence with the Missouri River. It was determined that for discharges exceeding the magnitude of the 1969 flood (the flood of record), a portion of the flow will overtop the Interstate Highway 29 (located in Union County, South Dakota) road grade upstream of the McCook Lake Interchange, thus bypassing the reach of the Big Sioux River through North Sioux City, South Dakota, and Sioux City, Iowa.

The Interstate Highway grade parallels the Big Sioux River and has a slope which approximates the natural valley slope, but is not much higher than the surrounding topography. During the April 1969, flood, which had a peak discharge at North Sioux City, South Dakota of 77,500 cfs, old U.S. Highway 77 (now State Highway 103), located in Union County, South Dakota, was overtopped by the flood waters and the Interstate Highway was nearly overtopped upstream from the McCook Lake Interchange.

Hydraulic analyses conducted during the design of the Federal Flood and Erosion Control Project showed that for very large floods, floodwaters will overtop the Interstate through much of the reach from the interchange at McCook Lake upstream to the overpass near the Park Jefferson Speedway southeast of the City of Jefferson, South Dakota. The overflows across Interstate 29 flow into McCook Lake to the south and Lake Goodenough to the west which are both located in Union County, South Dakota. The Federal Project design requires a temporary sandbag closure structure across Interstate 29 at the McCook Lake Interchange to prevent flow to the south. The design discharges through the Federal Project were reduced to account for flows going across the Interstate grade. Because of the width of the Interstate highway grade, it was considered to act as high ground.

Water-surface profiles for Big Sioux River were developed using the USACE HEC-2 step-backwater computer program.

A HEC-2 model was available for the reach of the Big Sioux River through North Sioux City to near the Woodbury-Plymouth County, Iowa boundary. This model was for the design conditions of the Federal Flood and Erosion Control Project and was used for the April 1983, City of North Sioux City, South Dakota, and April 12, 1983, City of Sioux City, Iowa FISs. This HEC-2 model was modified to run on the May 1991 version of HEC-2 for the personal computer and to more accurately follow the as-built conditions of the flood control project.

The design conditions model was extended upstream to near Park Jefferson for an unpublished 1992 hydraulic study. Cross sections for this extension were field surveyed in 1992.

A new HEC-2 hydraulic model was created to develop water-surface profiles for the reach from near Park Jefferson upstream to the City of Akron, Iowa. Cross sections were obtained by photogrammetric methods from aerial photography taken in June of 1996. The underwater geometry of the cross sections was based on field surveys taken at selected locations in October 1996.

Bridge data were obtained from the Iowa Department of Transportation, the Plymouth County, Iowa Highway Department and from field surveys. Topographic data for the area north of McCook Lake was provided by the City of North Sioux City, South Dakota.

Starting water-surface elevations for Big Sioux River at its confluence with the Missouri River were based on a rating curve developed for the April 12, 1983, City of Sioux City, Iowa, FIS.

The overflow across Interstate Highway 29 between McCook Lake and the Park Jefferson interchanges, located in Union County, South Dakota (Unincorporated Areas), was modeled using the split flow option in HEC-2. Flow across the Interstate was computed with the highway grade acting as a broad crested weir with a weir coefficient of 2.5.

Roughness coeffecients (Manning's "n" values) were determined by several methods. In the reach through the Federal Flood and Erosion Control Project, the design "n" values were initially used. Upstream from the project, channel and overbank –n values were determined by field inspection and aerial photography. Roughness values were calibrated to the high water marks taken following the 1984 flood. The channel and overbank roughness values used for Big Sioux River are shown in Table 5, Manning's –n Values.

In order to match the high water marks from the 1984 flood, it was necessary to make encroachments for effective flow areas at certain locations due to the effects of the local agricultural levees. Stage and discharge measurements from the stream gage located in the City of Akron, Iowa, show that the stage-discharge relationship there is significantly influenced by local levees. The Akron gage stage-discharge relationship may change as local levees fail during the course of a flood event.

Woodbury County Unincorporated Areas

Cross-section data for the Missouri River were obtained from aerial topographic maps; other cross-section data were obtained by field survey. Bridge data were obtained from construction drawings and/or field survey.

Roughness coefficients (Manning's "n" values) for the Missouri River, the Little Sioux River, and Bacon Creek were chosen by engineering judgment and based on field survey and aerial photographs. Roughness coefficients for the Missouri River ranged from 0.0175 to 0.025 forthe channel and from 0.035 to 0.15 for the overbanks. The roughness values for the Little Sioux River and Bacon Creek ranged from 0.033 to 0.045 for the channel and from 0.04 to 0.10 for the overbanks.

The starting water-surface elevations for the Missouri River were based on the downstream backwater computations. Starting water-surface elevations for the Little Sioux River and Bacon Creek were determined using the slope-area method. The elevations for the Little Sioux River were compared with historic flood profiles for reasonableness.

The water-surface elevations for floods of selected recurrence intervals on the Missouri River were determined using a modified HEC-2 standard step-backwater computer program. Water-surface elevations for the 1-percent-annual-chance flood for the Little Sioux River and Bacon Creek were developed using the HEC-2 step-backwater computer program.

All elevations are referenced to the (NGVD29). Elevation reference marks used in this study are shown on the maps and described in Table 4 labeled Elevation Reference Marks (Reference 11).

Table 4: Elevation Reference Marks			
REFERENCE MARK	FLOOD INSURANCE RATE MAP PANEL	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
1	0016	1140.87	60d spike in power pole located on northwest corner of intersection of County Highway L36 and 150th Street
2	0016	1126.57	60d spike in transformer pole located on north side of 150th Street, about 1,600 feet west of County Highway L36
3	0016	1142.73	60d spike in transformer pole on north side of tee intersection located between State Highway 31 and Hackberry Street
4	0016	1130.14	Chiseled cross on southeast corner of U.S. Highway 20 bridge over the Little Sioux River
5	0016	1122.49	High water gage on north side of State Highway 31 bridge over the Little Sioux River
6	0016	1117.46	Iowa Department of Transportation concrete monument located on State Highway 31, about 30 feet west of gate to Copeland Park
7	0016	1148.11	60d spike in power pole located on northeast corner of intersection between County Highway D22 and Knotty Pine Street

Roughness values (Manning's "n") are listed below in Table 5.

Table 5: Manning's "n" Values		
STREAM NAME	MAIN CHANNEL	OVERBANKS
Buffalo Creek[1]	0.037-0.039	0.055-0.065
Buffalo Creek[4]	0.035-0.040	0.040-0.075
Culpepper Creek[1]	0.040-0.050	0.045-0.060
Culpepper Creek[2]	0.020-0.060	0.020-0.070
Granby Creek[1]	0.040-0.045	0.050-0.065
Hatchery Branch[4]	0.025-0.060	0.040-0.058
Hickory Creek[1, 4]	0.030-0.055	0.055-0.080
High School Branch[4]	0.035-0.040	0.040-0.075
Little Lost Creek[1]	0.035	0.050-0.055
Lost Creek[1]	0.050	0.080
MacDougal Branch[1]	0.035	0.050-0.055
Shartel Branch[4]	0.025-0.060	0.040-0.058
Shoal Creek[1, 3, 5]	0.040-0.050	0.045-0.080
South Indian Creek[1]	0.038-0.040	0.060-0.065
South Creek[1]	0.035-0.045	0.045-0.055
Thurman Creek[1]	0.035-0.045	0.045-0.060
Tin Cup Creek[1]	0.045-0.050	0.045-0.060
West High School Branch[4]	0.035-0.040	0.040-0.075
Wolf Creek[2]	0.020-0.060	0.030-0.060

3.2.2 September 29, 2011 Countywide Analysis

For this countywide analysis, AMEC did not perform any new detailed studies. All the streams which were previously delineated detailed study areas were redelineated as part of the countywide analysis. The detail studied streams that were not re-studied as part of this countywide study appear as "profile base lines" on the maps. These "profile base lines" provide a link to the flood profiles included in the FIS report. The detail-studied stream centerline may have been digitized or redelineated as part of this revision. The "profile base lines" for these streams were based on the best available data at the time of their study and are depicted as they were on the previous FIRMs. In some cases, where improved topographical data was used to redelineate floodplain boundaries, the "profile base line" may deviate significantly from the channel centerline or may be outside the (SFHA).

Locations of the original selected cross sections used in the hydraulic analyses are shown in the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The delineation of the approximate 1-percent-annual-chance flood boundaries was based on 1-percent-annual-chance flood depths computed by Black & Veatch. Hydraulic analyses were performed using both the N-FACT Tool and the HEC-RAS model, version 3.1.3 (Reference 3). N-FACT performs normal depth calculations and assists in generating draft approximate 1-percent-annual-chance flood boundaries. HEC-RAS was used to model Farmer's Ditch, Garretson Ditch, West Fork Ditch, lower Wolf Creek and the old lower West Fork Little Sioux River. Ditches tributary to Farmer's Ditch and Garretson Ditch were also modeled in HEC-RAS. These streams are located in the flat region of southwestern Woodbury County and have average slopes ranging from 0.0001 to 0.0004. N-FACT was used for all remaining streams.

Manning's "n" values used were assumed based on typical flooding conditions of the streams. A Manning's "n" value of 0.05 was used throughout.

The USACE performed new hydrologic and hydraulic analysis as part of a LOMR for Perry Creek in Sioux City in July 2007. This study was incorporated by AMEC as part of this new countywide study. The USACE developed HEC-RAS version 4.0 Beta models for Perry Creek and Plum Creek. A detailed discussion can be found in the hydraulic report developed by the USACE (Reference 1). Discharges used for the LOMR of Perry Creek and Plum Creek were developed during the USACE hydrologic phase. Cross section geometry was taken from as-built survey data completed in April 2007. The USACE used survey points to create a digital terrain model (DTM). The cross sections were then extracted from the DTM using the MicroStation V8 2004 and InRoad 2004 software packages. All elevations were referenced to NGVD29. Critical depth was used as the downstream boundary condition for the steady flow model. Roughness values (Manning's "n" values) were selected based off field observations and surveys. A composite Manning's "n" values of 0.037 were utilized. Contraction and expansion (C&E) coefficients were set to 0.1 and 0.3, respectively, through most of the project reach. Near most bridges the C&E coefficients were increased to 0.3 and 0.5. The C&E coefficient near pedestrian bridges was left at 0.1 and 0.3 because they do not have piers. Upstream from the project reach (RS 15200-RS 20631) the C&E coefficients were increased to 0.2 and 0.4 to reflect the additional losses associated with the hydraulically unimproved channel.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

<u>Upper Mississippi River System Flow Frequency Study Methodology</u>

The main hydraulic tool used to determine flood elevations along the Missouri River was the UNET unsteady flow computer modeling program (Reference 2). Included in the UNET model were the main stem of the Mississippi River, several of its main tributaries, navigation dams, and the levees and levee systems. Hydrographic surveys were assembled from navigation channel maintenance surveys, dam periodic inspection surveys, and environment management project surveys. These surveys date from 1997 or later. For areas where no digital hydrographic surveys were available, such as in some side channels and chutes, depths were estimated from the most current printed surveys available. Bluff-to-bluff digital terrain data collected in 1995 and 1998 were used to supplement the channel survey data (Reference 4). Model development consisted of constructing HEC-RAS models from the original cross-sections, adding in ineffective flow areas or obstructions as necessary, and then converting the models to UNET.

The cross section stationing used in the Missouri River model was based on existing USACE River Mile markers of 1960 (Reference 26). The reach length between cross sections is based on a model centerline developed for the HEC-RAS converted model of the UMRSFFS. (Reference 1). The distances between cross sections shown in the floodway data table and flood profile were created using the cross section stations based on the 1960 River Miles. While the calculated distance between cross sections using the 1960 River Miles are similar to the measured distance along the model centerline, some differences may occur. This difference in distance does not affect the calculated water surface elevation at each cross section shown on the floodway data table and flood profile, nor does it affect the placement of the base flood elevations on the map.

The UNET model was calibrated to reproduce recorded flood hydrographs for a selected period of record. The UNET model was calibrated to both stage and discharge at gaging locations primarily by adjusting roughness coefficients and estimated lateral inflows. Annual peak flows and peak stages from the period of record run of the calibrated UNET model were used to develop rating curves for each cross section location. Using these station rating curves and the station frequency flows developed during the hydrology phase, frequency elevation points were obtained for each cross section location. Connecting the corresponding points resulted in flood frequency profiles. These profiles were coordinated among the computational teams and appropriate adjustments were made to assure consistency.

Some special considerations and techniques were required to address especially complex flow reaches. The confluences of the Missouri and Illinois Rivers with the Mississippi relied primarily on development of graphical stage-probability relationships for backwater-impacted cross sections. These were created using a graphical Weibull approach. The graphical period-of-record stage-probability curves were combined to blend a consistent and reasonable profile for each probability flood. Confluences of many other smaller streams with the main stem also exhibited backwater effects resulting in discontinuities in the profiles. A computer routine was developed to smooth the profile in these reaches so as to form a consistent, reasonable transition through the zone of backwater.

The 1-percent-annual-chance water surface elevation profile was calculated using the HEC-RAS 3.1.3 computer program (Reference 3). Upon completion of the UMRSFFS, FEMA funded the USACE to compute a floodway for the studied reach of the Missouri River. This floodway determination consisted of converting the hydraulic data from UNET to HEC-RAS, calibrating the HEC-RAS steady-state models to the UMRSFFS results for the 1-percent-annual-chance profile, and performing the floodway computations. The 1-percent-annual-chance elevations from this calibrated HEC-RAS model were used as the basis to delineate the associated 1-percent-annual-chance floodplain and correspond to the base flood elevation shown on the maps. The 10-, 2-, and 0.2-percent-annual-chance elevations shown on the flood profiles were plotted using the original UNET elevations.

For more detailed information on each of the hydraulic methodologies used to calculate flood elevation profiles, the reader is encouraged to consult the report cited as Reference 1 in Section 9.0 of this FIS.

Table 6: Manning's "n" Values for the Missouri River

FLOODING SOURCE	CHANNEL "n"	OVERBANK "n"
MISSOURI RIVER	0.017 – 0.10	0.22 – 0.99

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

To accurately convert flood elevations for Woodbury County from the NGVD29 datum to the newer NAVD88 datum, the following procedure was implemented. The vertical datum shift was calculated for each corner of the USGS 7.5-minute topographic quadrangle maps located inside or within 2.5 miles of the county boundary using the USACE conversion program, Corpscon 6.0.1 (Reference 23). A resulting countywide conversion factor of 0.507 ft was applied to all components of the FIS that display flood elevations.

Methods for the Missouri River

The studied reach of the Missouri River spans multiple counties in multiple states, and the river forms the actual border between adjacent counties. The UMRSFFS was originally performed using the NGVD29 vertical datum. Applying an average countywide datum shift to convert to NAVD88 would have resulted in a mismatch of elevations between counties. Therefore, in order to perform the most accurate vertical datum conversion possible, and to maintain consistency in approach across county lines, the datum conversion for the Missouri River was performed on a cross-section by cross-section basis, rather than by applying an average county-wide or stream-wide value

Table 7: Vertical Datum Conversion

USGS Quad	Corner	Latitude	Longitude	Conversion from NGVD29 to NAVD88
Sioux City North	SW	42.499	96.500	0.531 ft
James	SW	42.499	96.375	0.604 ft
Union Center SW	SW	42.499	96.250	0.597 ft
Union Center SE	SW	42.499	96.125	0.525 ft
Kingsley	SW	42.499	96.000	0.505 ft
Pierson	SW	42.499	95.875	0.479 ft
Washta	SW	42.499	95.750	0.440 ft
Sergeant Bluff	SW	42.374	96.375	0.518 ft
Lawton	SW	42.374	96.250	0.535 ft
Moville	SW	42.374	96.125	0.531 ft
Correctionville NW	SW	42.374	96.000	0.502 ft
Correctionville	SW	42.374	95.875	0.456 ft
Cushing	SW	42.374	95.750	0.466 ft
Luton	SW	42.249	96.250	0.499 ft
Climbing Hill	SW	42.249	96.125	0.495 ft
Oto	SW	42.249	96.000	0.509 ft
Correctionville SE	SW	42.249	95.875	0.495 ft
Holstein SW	SW	42.249	95.750	0.436 ft

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the NGVD29 and NAVD88, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242
(301) 713-4172 (fax)

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages state and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS report provides 1-percent-annual-chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2-percent-annual-chance floodplains; and a 1-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles and Floodway Data tables. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. For this countywide study, between cross sections, the boundaries were interpolated and delineated using USGS 10-meter DEMs (Reference 27).

Methods for the Missouri River

Between cross sections along the Missouri River, the boundaries were interpolated using a 2-meter DEM created from LIDAR derived mass points and break lines (Reference 28).

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards Zones A, AE, X, and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM. The approximate floodplain boundaries in this study were delineated using USGS 10-meter DEMs. However, approximate floodplain boundaries in the

Cities of Lawton and Moville were delineated using the Iowa Department of Natural Resources (IDNR) Woodbury County, Iowa countywide 1-meter DEM derived from LIDAR (Reference 29).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

Methods for the Missouri River

Upon completion of the UMRSFFS, FEMA funded the USACE to compute a floodway for the studied reach of the Missouri River. This floodway determination consisted of converting the hydraulic data from UNET to HEC-RAS, calibrating the HEC-RAS steady-state models to the UMRSFFS results, and performing the floodway computations.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 8, Floodway Data Tables). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

Along streams where floodways have not been cited, the community must ensure that the cumulative effect of development in the floodplain will not cause more than a 1.0-foot increase in the base flood elevations at any point within the community

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation (WSEL) of the base flood more than 1.0-foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

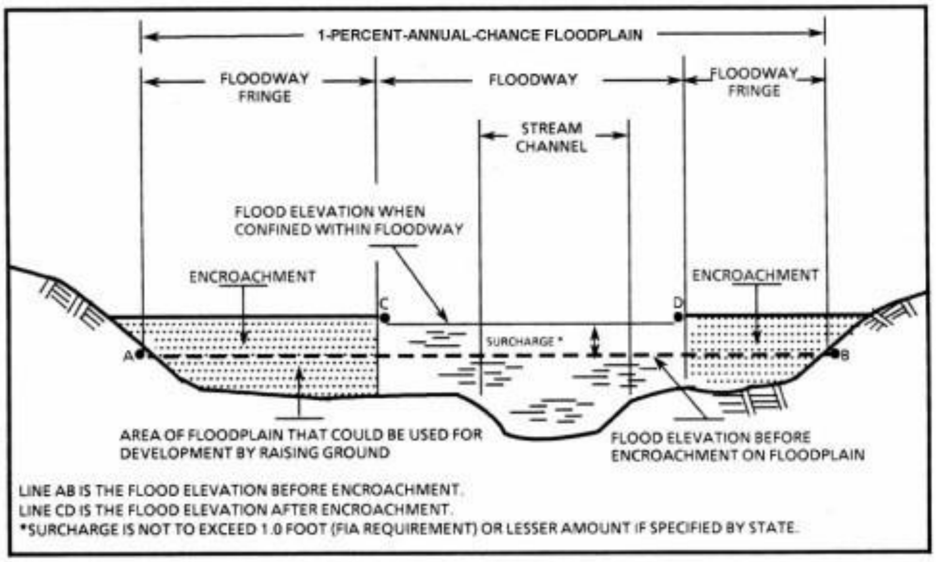

Figure 1. Floodway Schematic

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bacon Creek								
A	0	158	245	7.1[2]	1091.9	1091.9	1092.1	0.2
B	400	175	551	3.0[2]	1093.4	1093.4	1093.7	0.3
C	800	256	888	1.8[2]	1093.6	1093.6	1094.0	0.4
D	1,000	255	200	7.5[2]	1094.2	1094.2	1094.2	0.0
E	1,270	180	254	5.7[2]	1097.7	1097.7	1098.5	0.8
F	1,540	177	392	3.5[2]	1101.9	1101.9	1102.0	0.1
G	1,790	252	802	1.7[2]	1102.5	1102.5	1102.8	0.3
H	2,220	200	212	5.9[2]	1106.2	1106.2	1106.4	0.2
I	2,470	131	335	3.6[2]	1109.9	1109.9	1110.9	1.0
J	2,770	150	379	3.0[2]	1112.7	1112.7	1113.2	0.5
K	3,065	120	253	4.3[2]	1116.0	1116.0	1116.5	0.5
L	3,310	63	795	6.2	1116.1	1116.1	1116.7	0.6
M	3,545	47	558	8.7	1116.7	1116.7	1117.2	0.5
N	3,760	54	606	7.9	1117.9	1117.9	1118.3	0.4
O	4,010	41	529	9.0	1118.8	1118.8	1119.1	0.3
P	4,360	45	608	7.7	1120.6	1120.6	1120.8	0.2
Q	4,590	62	680	6.8	1121.5	1121.5	1121.7	0.2
R	4,670	53	662	7.0	1129.5	1129.5	1130.5	1.0
S	5,050	50	594	7.6	1130.4	1130.4	1131.3	0.9

[1] Feet Above Confluence with Old Floyd River Channel
[2] Mean Velocity is Based on Overland Flow Only

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

BACON CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bacon Creek								
T	5,440	45	489	9.1	1131.7	1131.7	1132.3	0.6
U	5,870	60	711	6.1	1133.9	1133.9	1134.4	0.5
V	6,120	54	671	6.4	1134.2	1134.2	1134.9	0.7
W	6,460	34	314	13.4	1134.9	1134.9	1135.2	0.3
X	6,710	80	867	4.8	1138.3	1138.3	1139.0	0.7
Y	7,050	53	846	2.5	1138.6	1138.6	1139.6	1.0
Z	7,210	55	750	2.8	1140.1	1140.1	1141.0	0.9
AA	7,550	53	485	4.3	1140.2	1140.2	1141.1	0.9
AB	7,960	66	745	2.7	1140.7	1140.7	1141.6	0.9
AC	8,540	49	466	4.2	1141.1	1141.1	1141.9	0.8
AD	9,100	56	493	3.8	1141.7	1141.7	1142.6	0.9
AE	9,710	76	805	2.3	1142.3	1142.3	1143.1	0.8
AF	10,280	45	271	6.3	1142.4	1142.4	1143.2	0.8
AG	10,750	51	286	5.9	1145.3	1145.3	1145.4	0.1
AH	11,350	54	401	4.1	1147.0	1147.0	1147.1	0.1
AI	11,440	63	787	2.1	1154.6	1154.6	1155.6	1.0
AJ	11,870	69	890	1.8	1154.7	1154.7	1155.7	1.0
AK	12,480	57	553	2.7	1154.8	1154.8	1155.8	1.0
AL	12,950	43	380	2.4	1155.1	1155.1	1156.0	0.9
AM	13,520	42	325	2.2	1155.4	1155.4	1156.3	0.9

[1] Feet Above Confluence with Old Floyd River Channel

TABLE

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

BACON CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bacon Creek								
AN	13,850	46	257	2.4	1155.6	1155.6	1156.5	0.9
AO	13,980	111	1288	0.4	1172.8	1172.8	1173.8	1.0
AP	14,360	57	610	0.7	1172.8	1172.8	1173.8	1.0
AQ	14,830	66	614	0.4	1172.8	1172.8	1173.8	1.0

[1] Feet Above Confluence with Old Floyd River Channel

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

BACON CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Big Sioux River								
A	2,560	302/120	8313	10.2	1090.1	1090.1	1090.1	0.0
B	5,825	438/138	9121	9.3	1091.8	1091.8	1091.8	0.0
C	8,580	1688/1330	19910	4.2	1094.0	1094.0	1094.0	0.0
D	10,760	454/270	8122	10.4	1094.7	1094.7	1094.7	0.0
E	13,470	1472/130	12158	6.9	1097.0	1097.0	1097.0	0.0
F	16,745	414/140	8830	9.6	1098.3	1098.3	1098.3	0.0
G	20,710	471/261	10476	8.1	1100.7	1100.7	1100.7	0.0
H	23,920	508/298	9192	9.2	1101.6	1101.6	1101.6	0.0
I	26,530	410/140	9011	9.4	1103.0	1103.0	1103.0	0.0
J	29,510	1298/1100	14642	5.8	1105.2	1105.2	1105.2	0.0
K	32,490	1936/380	18509	4.6	1106.9	1106.9	1106.9	0.0
L	35,395	3404/234	14636	5.8	1108.3	1108.3	1108.3	0.0
M	37,385	6351/251	35251	2.4	1110.1	1110.1	1110.1	0.0

[1] Feet Above Confluence with Missouri River
[2] Total Width / Width within Corporate Limits

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

BIG SIOUX RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
Floyd River								
A	29,075	561	7,765	7.6	1115.8	1115.8	1115.9	0.1
B	30,150	620	9,119	6.5	1116.9	1116.9	1117.1	0.2
C	30,660	435	8,738	6.8	1117.8	1117.8	1117.8	0.0
D	30,825	368	7,173	8.2	1118.3	1118.3	1118.3	0.0
E	30,950	786	9,548	6.2	1118.5	1118.5	1118.5	0.0
F	32,290	1600	15,826	3.7	1118.9	1118.9	1119.7	0.8
G	33,180	1266[2]	18,214	3.2	1119.3	1119.3	1120.3	1.0
H	34,350	801[2]	16,972	3.5	1120.0	1120.0	1120.9	0.9
I	34,860	486[2]	20,277	2.9	1120.5	1120.5	1121.4	0.9
J	35,620	97[2]	14,919	4.0	1120.6	1120.6	1121.6	1.0

[1] Feet Above Confluence with Missouri River

[2] Floodway width within the Corporate limits of the City of Sioux City

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

FLOODWAY DATA

FLOYD RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Little Sioux River								
A	175	721	7,400	6.7	1100.6	1100.6	1101.2	0.6
B	1,631	681	6,637	7.1	1101.4	1101.4	1101.9	0.5
C	3,695	705	7,139	7.0	1102.5	1102.5	1103.1	0.6
D	4,881	336	5,722	6.7	1103.1	1103.1	1103.8	0.7
E	5,135	338	5,795	6.6	1103.3	1103.3	1104.0	0.7
F	5,901	993	9,435	6.3	1103.9	1103.9	1104.6	0.7
G	9,938	881	15,000	4.3	1105.1	1105.1	1105.5	0.4

[1] Feet Above Limit of Detailed Study

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

LITTLE SIOUX RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Missouri River								
BDD	707.86	748[3]	17,332	8.1	1064.2	1064.2	1065.1	0.9
BDE	708.36	724[3]	17,271	8.1	1064.7	1064.7	1065.6	0.9
BDF	708.66	711[3]	16,316	8.6	1064.9	1064.9	1065.8	0.9
BDG	709.06	685[3]	17,874	7.8	1065.6	1065.6	1066.4	0.8
BDH	709.36	734[3]	17,566	8.0	1065.9	1065.9	1066.6	0.7
BDI	709.85	1,483/293	25,143	5.6	1066.8	1066.8	1067.4	0.6
BDJ	710.25	2,039/272	30,019	4.7	1067.2	1067.2	1067.7	0.5
BDK	710.65	2,110/318	33,592	4.2	1067.4	1067.4	1068.1	0.7
BDL	711.05	1,909/365	27,535	5.1	1067.5	1067.5	1068.2	0.7
BDM	711.45	4,387/3135	43,037	3.3	1067.7	1067.7	1068.5	0.8
BDN	711.85	5,044/4,629	33,480	4.2	1067.9	1067.9	1068.7	0.8
BDO	712.25	5,570/5,232	38,300	3.7	1068.5	1068.5	1069.2	0.7
BDP	712.65	6,008/5,657	28,710	4.9	1068.8	1068.8	1069.5	0.7
BDQ	713.04	6,297/5,966	34,767	4.0	1069.3	1069.3	1069.9	0.6
BDR	713.45	5,575/5,233	42,145	3.3	1069.9	1069.9	1070.5	0.6
BDS	713.84	3,560/3,235	23,962	5.8	1070.0	1070.0	1070.6	0.6
BDT	713.95	4,094/3,842	28,292	5.0	1070.2	1070.2	1070.8	0.6
BDU	714.25	3,170/2,875	35,188	4.0	1071.0	1071.0	1071.5	0.5
BDV	714.64	2,255/1,771	29,210	4.8	1071.3	1071.3	1071.8	0.5

[1] Miles Above Confluence with Mississippi River. Distance based on the 1960 River Mile stationing, which may not match the measured distance along the profile baseline shown on the maps.
[2] Total Width / Width Inside of County
[3] Floodway Located Outside of County

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

MISSOURI RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Missouri River								
BDW	715.04	817/375	19,459	7.2	1071.6	1071.6	1072.0	0.4
BDX	715.44	815/505	17,803	7.9	1071.8	1071.8	1072.2	0.4
BDY	715.84	905/442	18,329	7.6	1072.3	1072.3	1072.6	0.3
BDZ	716.04	977/408	19,040	7.4	1072.6	1072.6	1073.0	0.4
BEA	716.24	896/451	19,194	7.3	1072.7	1072.7	1073.2	0.5
BEB	716.64	738/348	17,078	8.2	1073.0	1073.0	1073.5	0.5
BEC	717.04	997/307	21,107	6.6	1073.5	1073.5	1074.0	0.5
BED	717.45	1,467/1,005	21,521	6.5	1073.8	1073.8	1074.5	0.7
BEE	717.84	1,858/1,440	25,534	5.5	1074.6	1074.6	1075.2	0.6
BEF	718.25	1,762/1,539	21,709	6.4	1074.8	1074.8	1075.4	0.6
BEG	718.65	1,278/425	21,563	6.4	1075.1	1075.1	1075.8	0.7
BEH	719.05	1,767/223	18,013	7.7	1075.5	1075.5	1076.0	0.5
BEI	719.45	2,310/303	22,221	6.2	1076.1	1076.1	1076.7	0.6
BEJ	719.85	1,698/381	19,809	7.0	1076.2	1076.2	1077.0	0.8
BEK	720.25	1,146/405	19,523	7.1	1076.5	1076.5	1077.5	1.0
BEL	720.65	1,050/775	19,466	7.1	1077.2	1077.2	1077.9	0.7
BEM	721.05	1,140/679	17,871	7.8	1077.4	1077.4	1078.2	0.8
BEN	721.45	755/269	17,945	7.7	1077.9	1077.9	1078.8	0.9
BEO	721.85	738/302	17,422	8.0	1078.3	1078.3	1079.2	0.9
BEP	722.25	750/356	17,069	8.1	1078.8	1078.8	1079.6	0.8

[1] Miles Above Confluence with Mississippi River. Distance based on the 1960 River Mile stationing, which may not match the measured distance along the profile baseline shown on the maps.
[2] Total Width / Width Inside of County

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

MISSOURI RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Missouri River								
BEQ	722.65	687/186	15,988	8.7	1079.2	1079.2	1080.0	0.8
BER	723.05	701/441	16,729	8.3	1079.6	1079.6	1080.5	0.9
BES	723.45	790/399	17,247	8.0	1080.1	1080.1	1081.0	0.9
BET	723.86	730/416	17,222	8.1	1080.6	1080.6	1081.4	0.8
BEU	724.25	708/445	16,734	8.3	1081.0	1081.0	1081.7	0.7
BEV	724.65	663/343	16,179	8.6	1081.4	1081.4	1082.1	0.7
BEW	725.05	739/545	16,949	8.2	1081.9	1081.9	1082.6	0.7
BEX	725.45	725/482	17,055	8.1	1082.3	1082.3	1083.0	0.7
BEY	725.85	732/502	17,578	7.9	1082.8	1082.8	1083.4	0.6
BEZ	726.25	684/403	17,109	8.1	1083.2	1083.2	1083.8	0.6
BFA	726.65	724/439	17,422	8.0	1083.6	1083.6	1084.2	0.6
BFB	726.69	724/432	17,454	7.9	1083.7	1083.7	1084.2	0.5
BFC	726.69	724/425	17,493	7.9	1083.7	1083.7	1084.3	0.6
BFD	727.05	794/412	18,751	7.4	1084.2	1084.2	1084.7	0.5
BFE	727.46	829/420	18,579	7.5	1084.5	1084.5	1085.1	0.6
BFF	727.86	683/385	16,830	8.2	1084.7	1084.7	1085.3	0.6
BFG	728.26	701/462	16,852	8.2	1085.1	1085.1	1085.7	0.6
BFH	728.62	721/472	17,209	8.1	1085.5	1085.5	1086.1	0.6
BFI	728.63	721/470	17,250	8.0	1085.6	1085.6	1086.2	0.6
BFJ	728.65	738/457	17,364	8.0	1085.7	1085.7	1086.2	0.5

[1] Miles Above Confluence with Mississippi River. Distance based on the 1960 River Mile stationing, which may not match the measured distance along the profile baseline shown on the maps.
[2] Total Width / Width Inside of County

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

MISSOURI RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Missouri River								
BFK	729.1	828/372	17,707	7.8	1086.1	1086.1	1086.7	0.6
BFL	729.46	655/351	16,900	7.9	1086.6	1086.6	1087.0	0.4
BFM	729.86	702/420	17,604	7.6	1087.0	1087.0	1087.5	0.5
BFN	730.27	695/222	17,425	7.7	1087.4	1087.4	1087.8	0.4
BFO	730.47	742/177	17,387	7.7	1087.6	1087.6	1088.0	0.4
BFP	730.48	742/176	17,447	7.7	1087.6	1087.6	1088.1	0.5
BFQ	730.57	558/16	14,228	9.4	1087.7	1087.7	1088.1	0.4
BFR	730.66	611/32	15,639	8.6	1088.0	1088.0	1088.5	0.5
BFS	731.06	862/269	18,561	7.2	1088.9	1088.9	1089.4	0.5
BFT	731.47	757/429	17,406	7.7	1089.4	1089.4	1089.8	0.4
BFU	731.87	763/497	17,507	7.6	1090.0	1090.0	1090.3	0.3
BFV	732.09	877/493	18,740	7.1	1090.6	1090.6	1090.7	0.1
BFW	732.27	695/342	17,663	5.8	1090.8	1090.8	1091.2	0.4
BFX	732.67	937/320	22,768	4.5	1091.2	1091.2	1091.6	0.4

[1] Miles Above Confluence with Mississippi River. Distance based on the 1960 River Mile stationing, which may not match the measured distance along the profile baseline shown on the maps.
[2] Total Width / Width Inside of County

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

MISSOURI RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Perry Creek								
A	2,871	132	1,271	10.1	1107.7	1107.7	1107.7	0.0
B	3,770	150	1,717	7.8	1110.9	1110.9	1110.9	0.0
C	4,160	143	1,735	7.3	1111.8	1111.8	1111.8	0.0
D	4,728	171	1,902	6.7	1112.9	1112.9	1112.9	0.0
E	5,800	151	1,804	7.0	1114.2	1114.2	1114.2	0.0
F	6,586.5	160	1,855	6.9	1115.4	1115.4	1115.4	0.0
G	7,374	154	1,785	7.1	1116.4	1116.4	1116.4	0.0
H	7,802	161	1,868	6.8	1117.4	1117.4	1117.4	0.0
I	8,103	158	1,897	6.7	1118.0	1118.0	1118.0	0.0
J	9,285	160	1,875	6.8	1119.6	1119.6	1119.6	0.0
K	9,955	159	1,857	6.8	1120.4	1120.4	1120.4	0.0
L	10,700	158	1,817	7.0	1121.3	1121.3	1121.3	0.0
M	12,310	138	1,604	7.9	1123.6	1123.6	1123.6	0.0
N	12,800	137	1,559	8.1	1124.3	1124.3	1124.3	0.0
O	15,310	125	1,303	9.8	1128.2	1128.2	1128.2	0.0
P	15,535	99	1,177	10.8	1128.8	1128.8	1128.8	0.0
Q	15,667	128	1,455	8.7	1130.3	1130.3	1130.3	0.0
R	15,862	86	1,345	9.4	1130.7	1130.7	1130.7	0.0
S	17,151	130	1,743	7.3	1138.4	1138.4	1138.5	0.1

[1] Feet Above Downstream End of Underground Conduit

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

PERRY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Perry Creek								
T	20,191	120	1,374	9.2	1141.4	1141.4	1141.9	0.5
U	20,321	154	1,570	8.1	1142.7	1142.7	1143.2	0.5
V	20,631	450	5,964	2.1	1144.1	1144.1	1144.7	0.6
W	20,961	227	2,633	5.5	1145.4	1145.4	1146.1	0.7
X	21,251	201	2,041	7.2	1145.4	1145.4	1146.3	0.9
Y	21,361	470	4,448	3.3	1146.4	1146.4	1147.4	1.0
Z	21,891	300	2,720	5.3	1146.6	1146.6	1147.5	0.9
AA	24,001	643	5,054	2.8	1148.3	1148.3	1149.2	0.9
AB	25,131	130	2,329	6.1	1148.9	1148.9	1149.8	0.9
AC	25,941	115	1,796	7.8	1149.3	1149.3	1150.2	0.9
AD	26,931	246	2,648	5.3	1151.0	1151.0	1151.9	0.9
AE	27,441	162	2,115	6.6	1151.4	1151.4	1152.3	0.9
AF	27,561	268	2,681	5.2	1152.1	1152.1	1153.0	0.9
AG	28,171	150	2,151	6.4	1152.5	1152.5	1153.4	0.9
AH	28,901	150	1,238	11.0	1152.7	1152.7	1153.6	0.9
AI	29,521	152	2,537	5.4	1156.9	1156.9	1157.4	0.5
AJ	29,981	206	2,078	6.5	1157.1	1157.1	1157.5	0.4
AK	30,916	280	4,054	3.3	1158.2	1158.2	1158.9	0.7
AL	31,981	348	3,225	4.9	1158.5	1158.5	1159.3	0.8
AM	32,901	136	2,176	6.1	1158.9	1158.9	1159.7	0.8

[1] Feet Above Downstream End of Underground Conduit

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

PERRY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Plum Creek								
A	14,250	133	1,480	0.4	1127.4	1127.4	1127.4	0.0
B	15,177	34	453	1.4	1127.4	1127.4	1127.4	0.0
C	15,253	21	269	2.3	1127.4	1127.4	1127.4	0.0

[1] Feet Above Downstream end of Underground Conduit

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA AND INCORPORATED AREAS

FLOODWAY DATA

PLUM CREEK

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base (1-percent-annual-chance) flood elevations (BFEs) or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile (sq. mi.) or that are not otherwise mapped as Zone A, and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM for Woodbury County is, for insurance purposes, the principal result of the FIS. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water- surface elevations of the base (1-percent-annual-chance) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FEMA.

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Woodbury County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the county identified as flood-prone. This countywide FIRM also includes flood-hazard information that was presented separately on FBFMs, where applicable. Historical data relating to the maps prepared for each community are presented in Table 9, Community Map History.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Anthon, City of	January 23, 1974	March 19, 1976	September 18, 1985	September 18, 2007
Bronson, City of	August 30, 1974	April 23, 1976	September 1, 1986	None
Correctionville, City of	February 22, 1974	September 12, 1975 August 16, 1977	August 15, 1990	None
Cushing, City of	August 9, 1974	January 2, 1976	September 18, 1985	None
Danbury, City of	January 9, 1974	April 16, 1976	September 18, 1985	None
Hornick, City of	October 18, 1974	None	September 27, 1985	None
Lawton, City of	August 16, 1974	January 30, 1976	September 1, 1986	None
Moville, City of	February 18, 1977	None	September 1, 1986	None
Oto, City of	September 13, 1974	January 23, 1976	September 29, 2011	None
Pierson, City of	September 13, 1974	May 14, 1976	September 18, 1985	None
**Salix, City of	N/A	N/A	N/A	N/A
*Sergeant Bluff, City of	N/A	None	N/A	None
Sioux City, City of	August 2, 1974	None	August 1, 1979	April 12, 1983 June 6, 2001
**Sloan, City of	N/A	N/A	N/A	N/A
Smithland, City of	November 12, 1976	None	September 27, 1985	None
**Winnebago Indian Tribe	N/A	N/A	N/A	N/A
Woodbury County	August 2, 1977	None	June 17, 1991	None

*No Special Flood Hazard Areas Identified

**This Community does not have map history prior to first countywide mapping

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purpose of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting Federal Insurance and Mitigation Division, FEMA Region VII, 9221 Ward Parkway, Suite 300, Kansas City, Iowa 64114-3372.

9.0 BIBLIOGRAPHY AND REFERENCES

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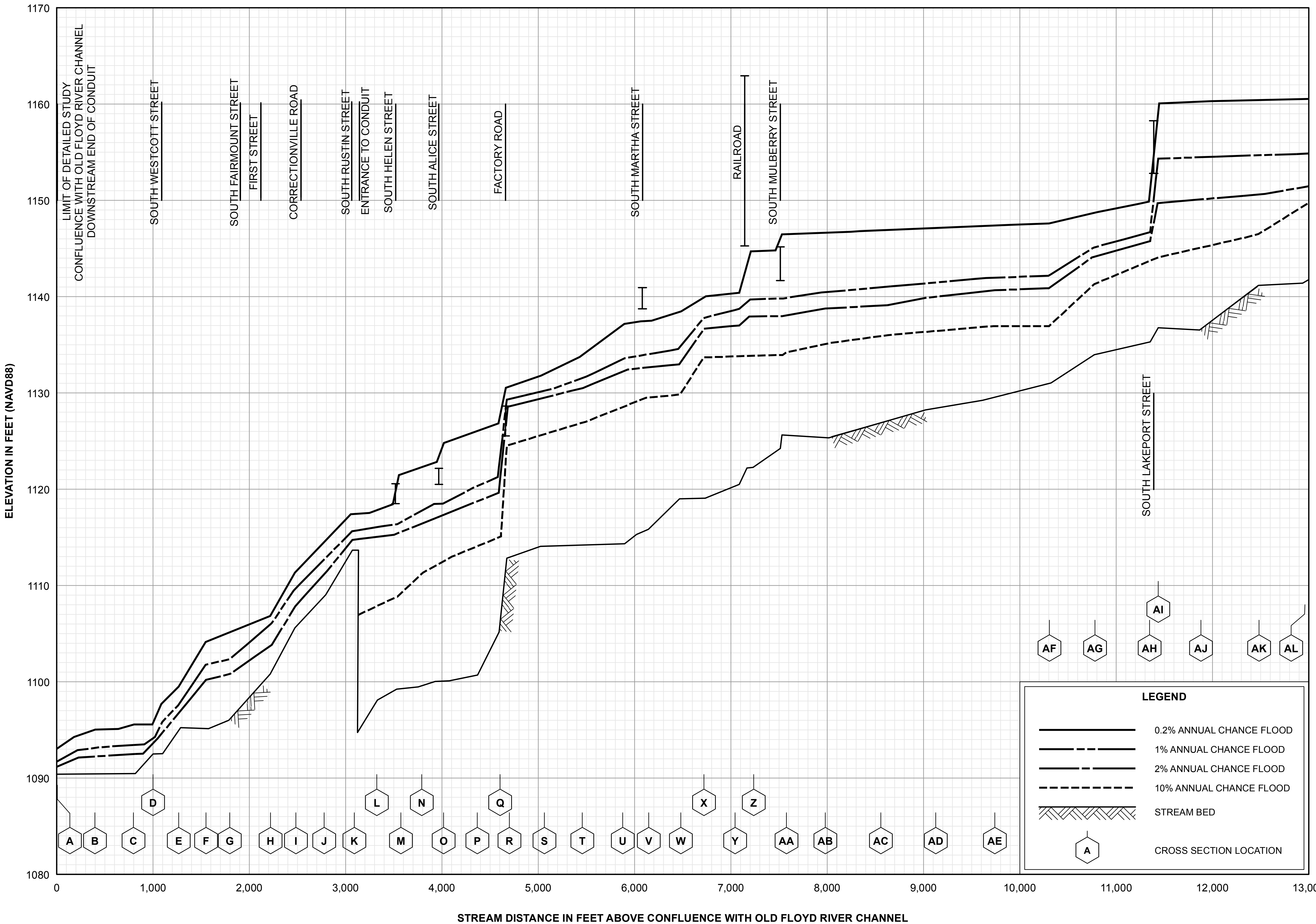


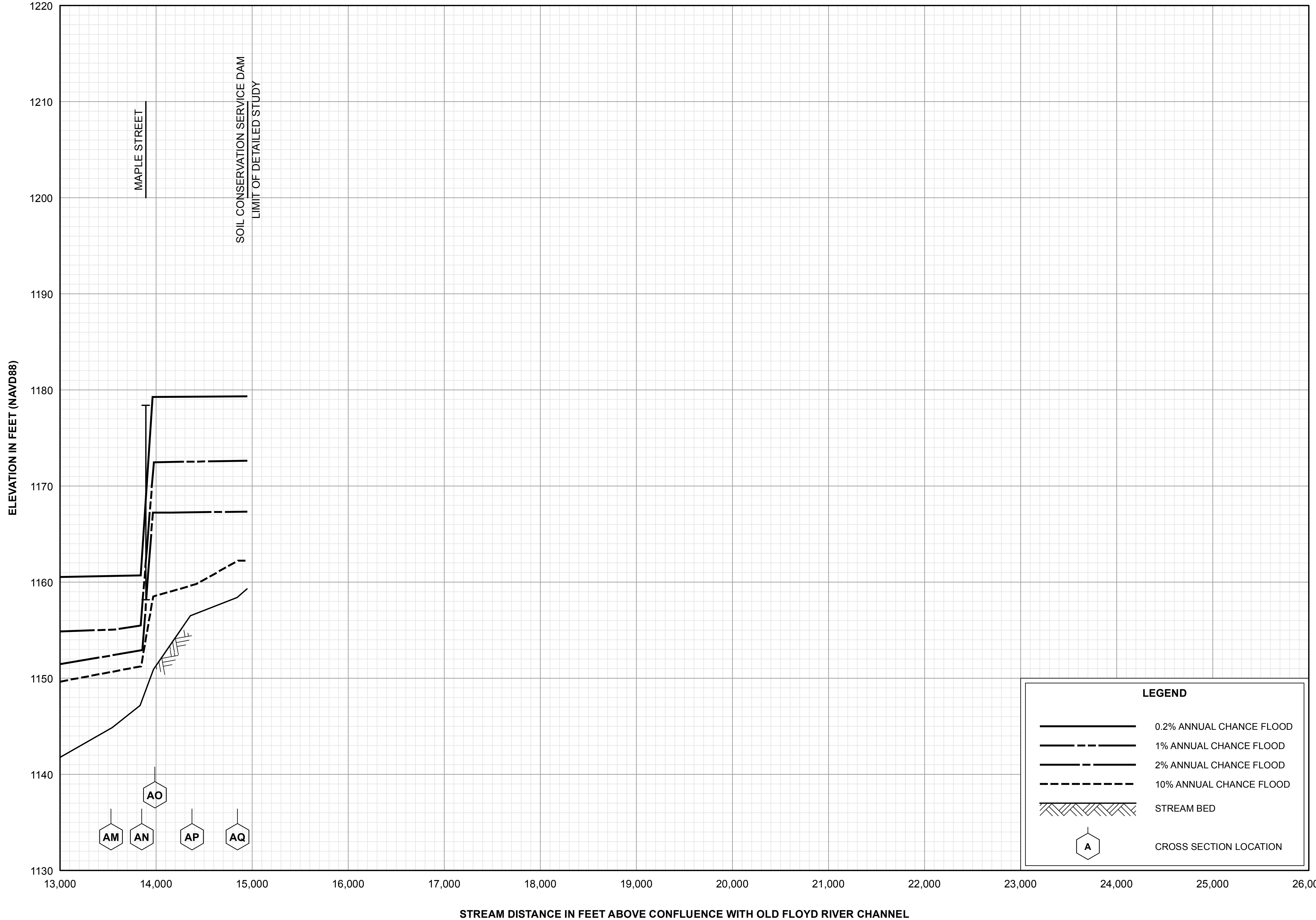
FLOOD PROFILES

BACON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

01P



FLOOD PROFILES

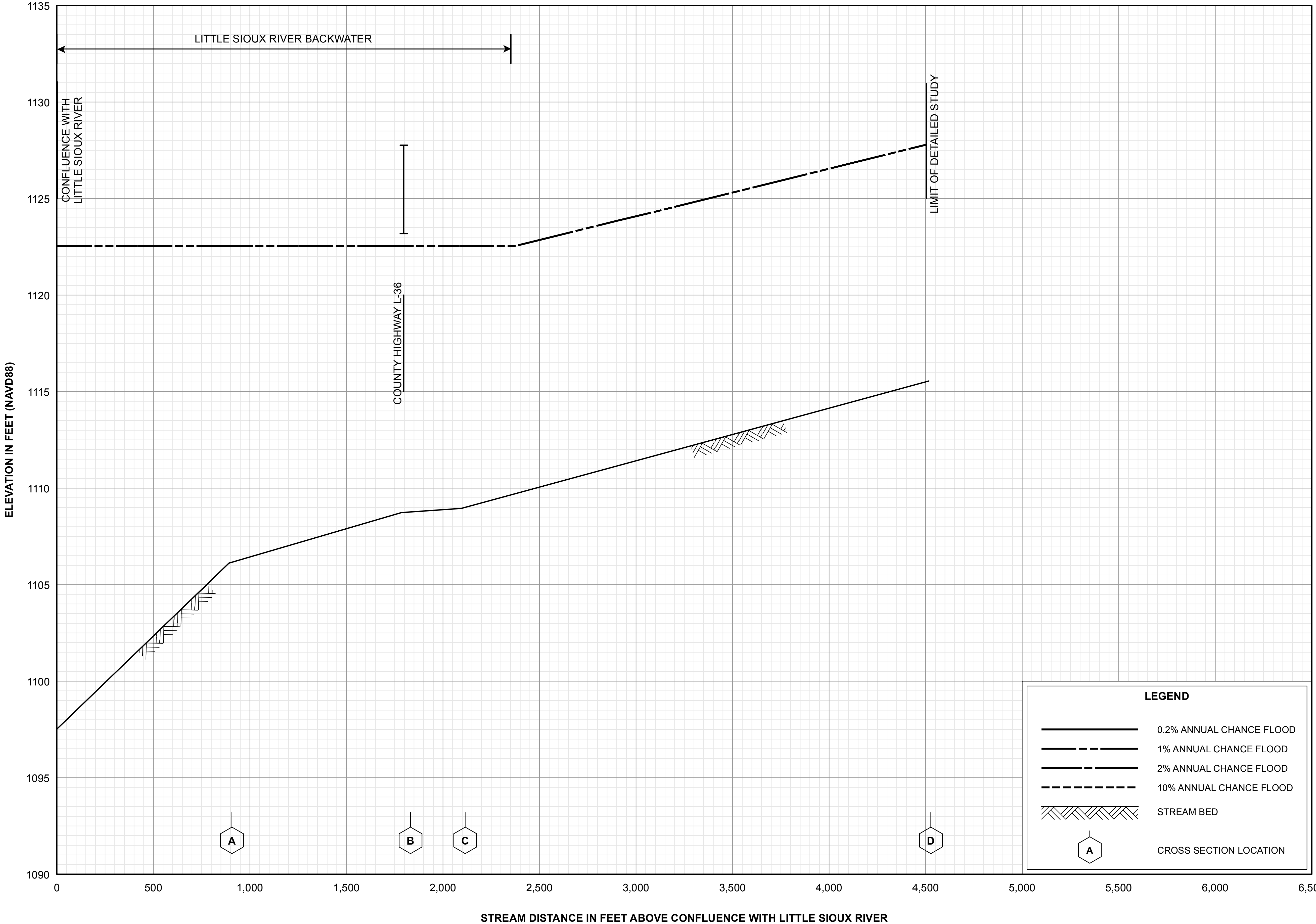
BACON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS

02P



FLOOD PROFILES

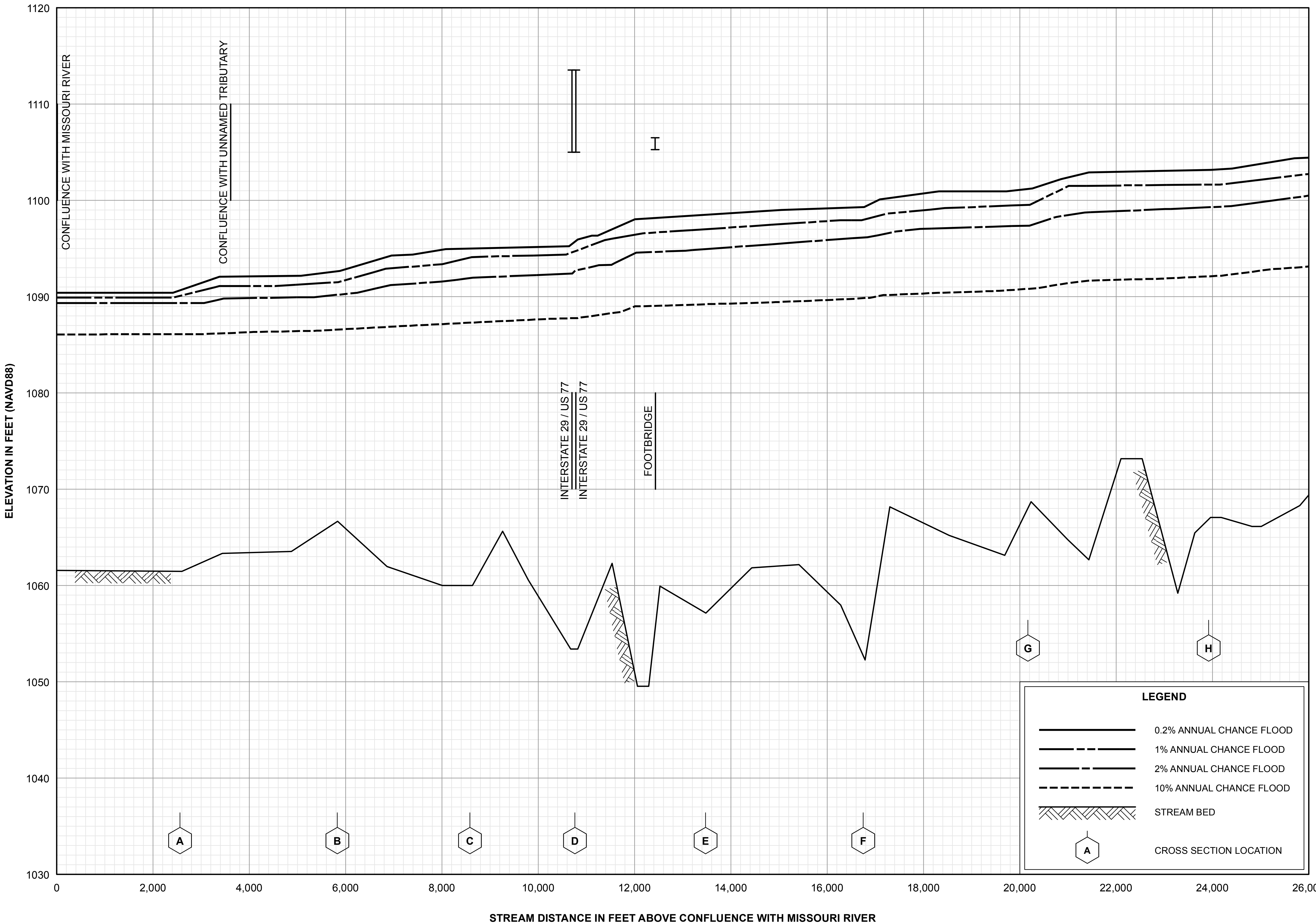
BACON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS

03P



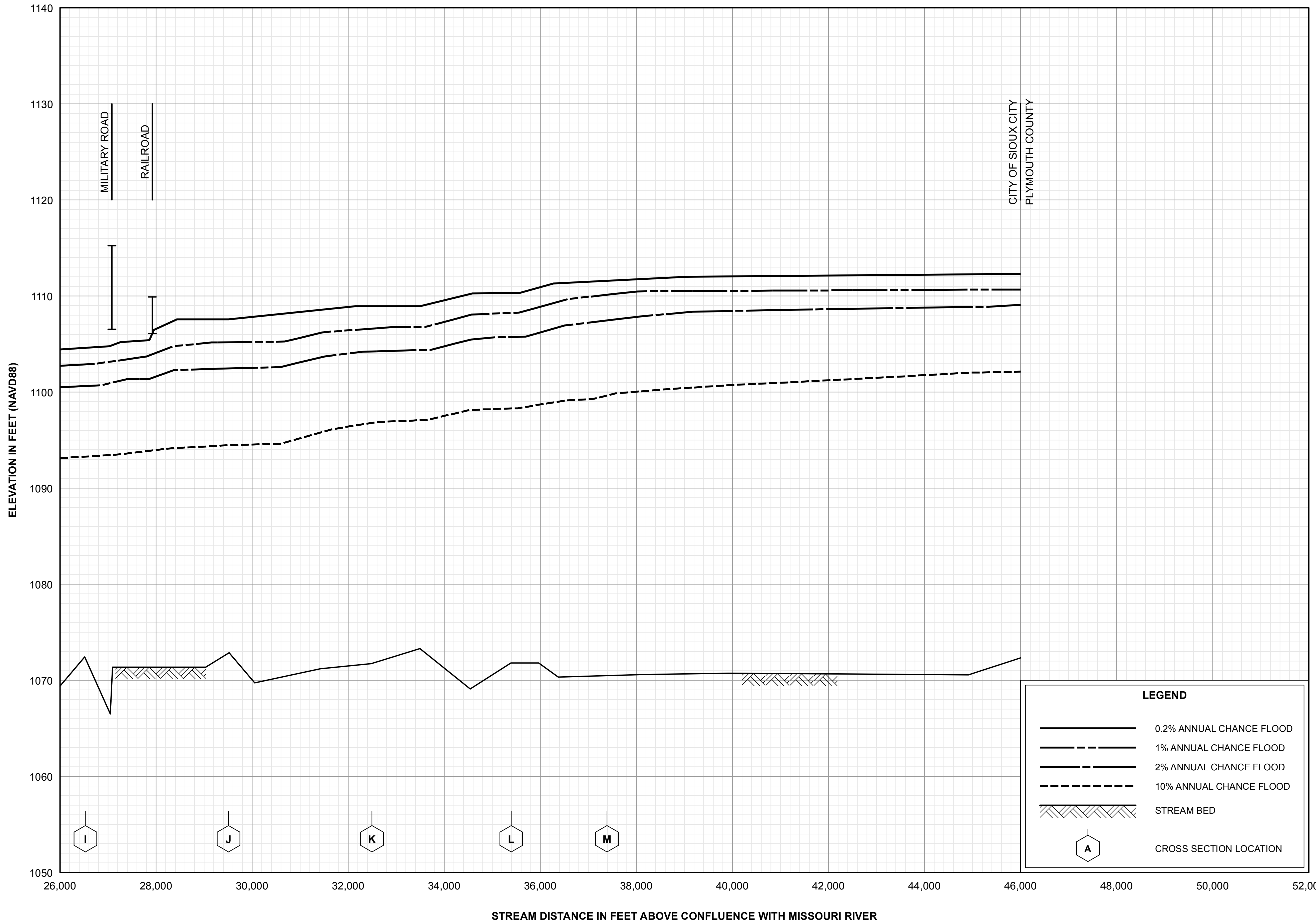
FLOOD PROFILES

BIG SIOUX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED ARES

04P



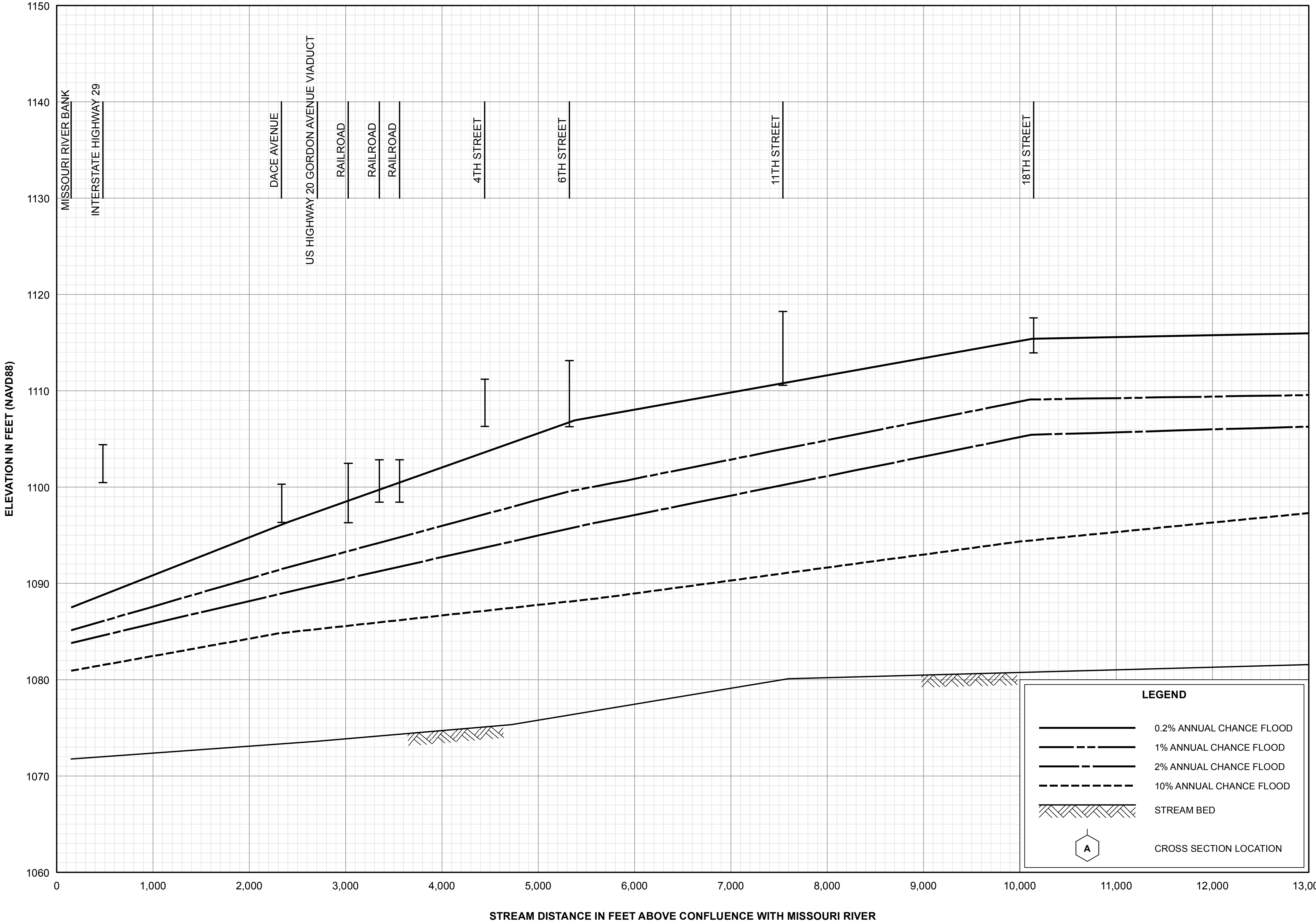
FLOOD PROFILES

BIG SIOUX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED ARES

05P



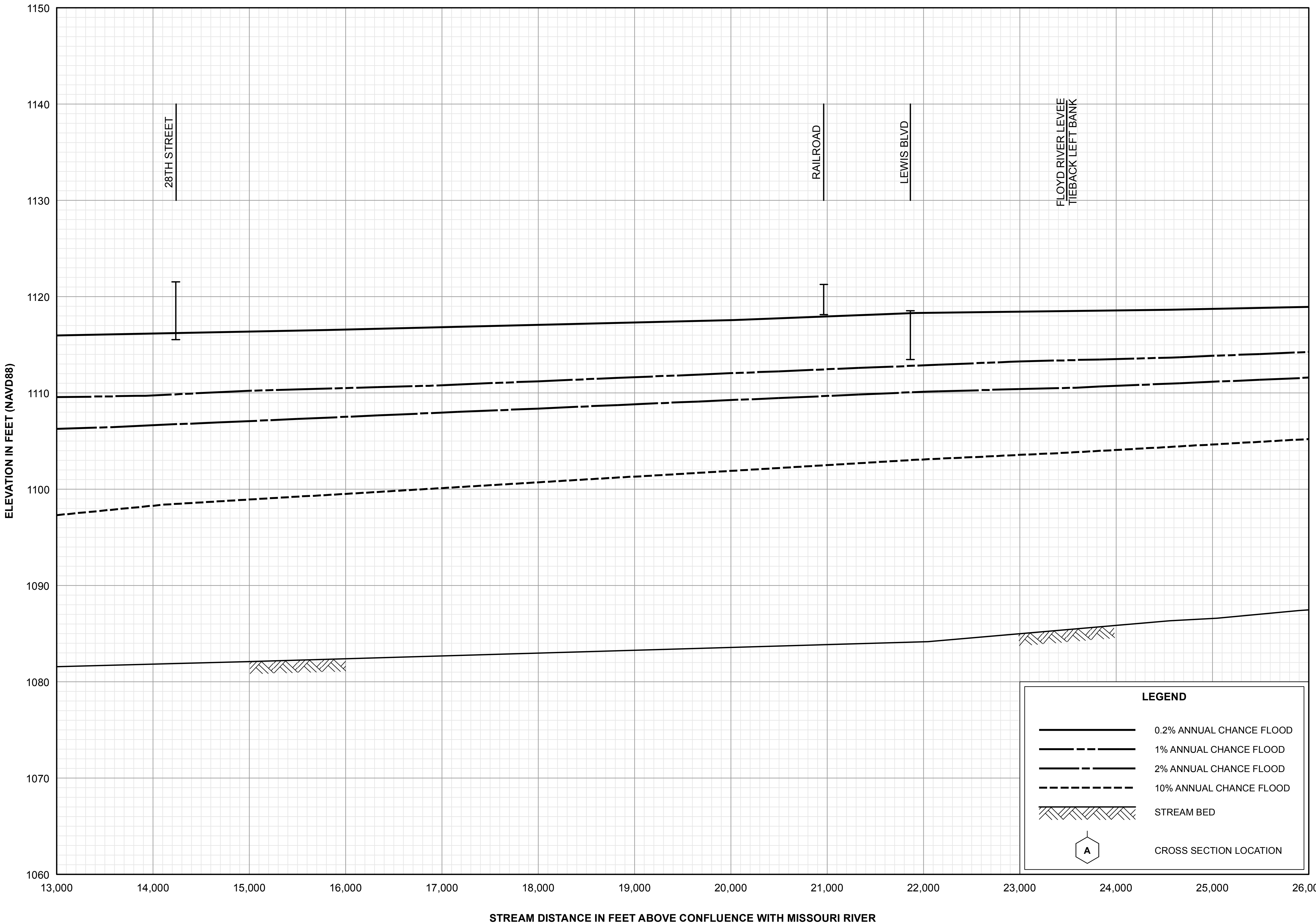
FLOOD PROFILES

FLOYD RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

06P



FLOOD PROFILES

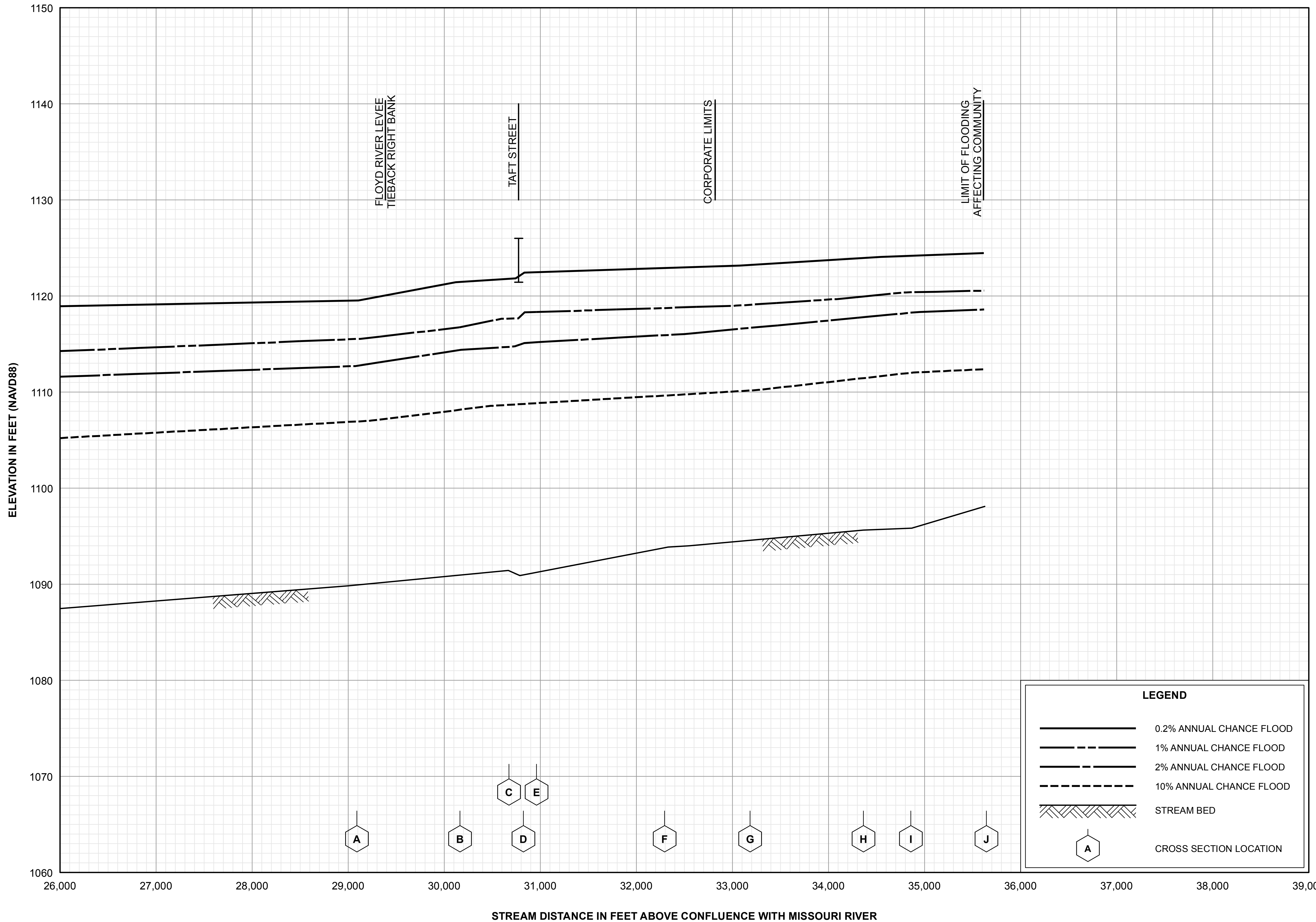
FLOYD RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS

07P



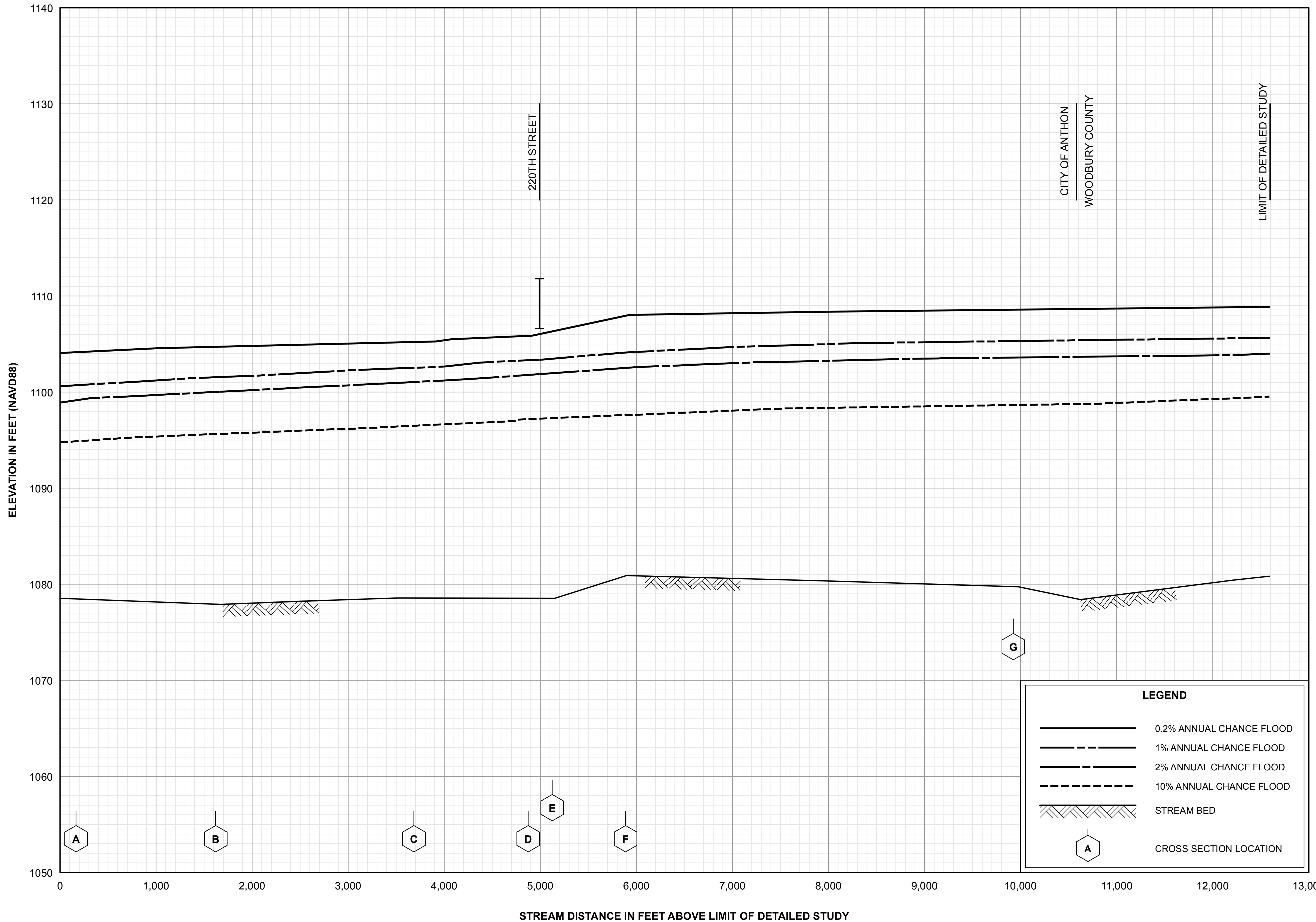
FLOOD PROFILES

FLOYD RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS



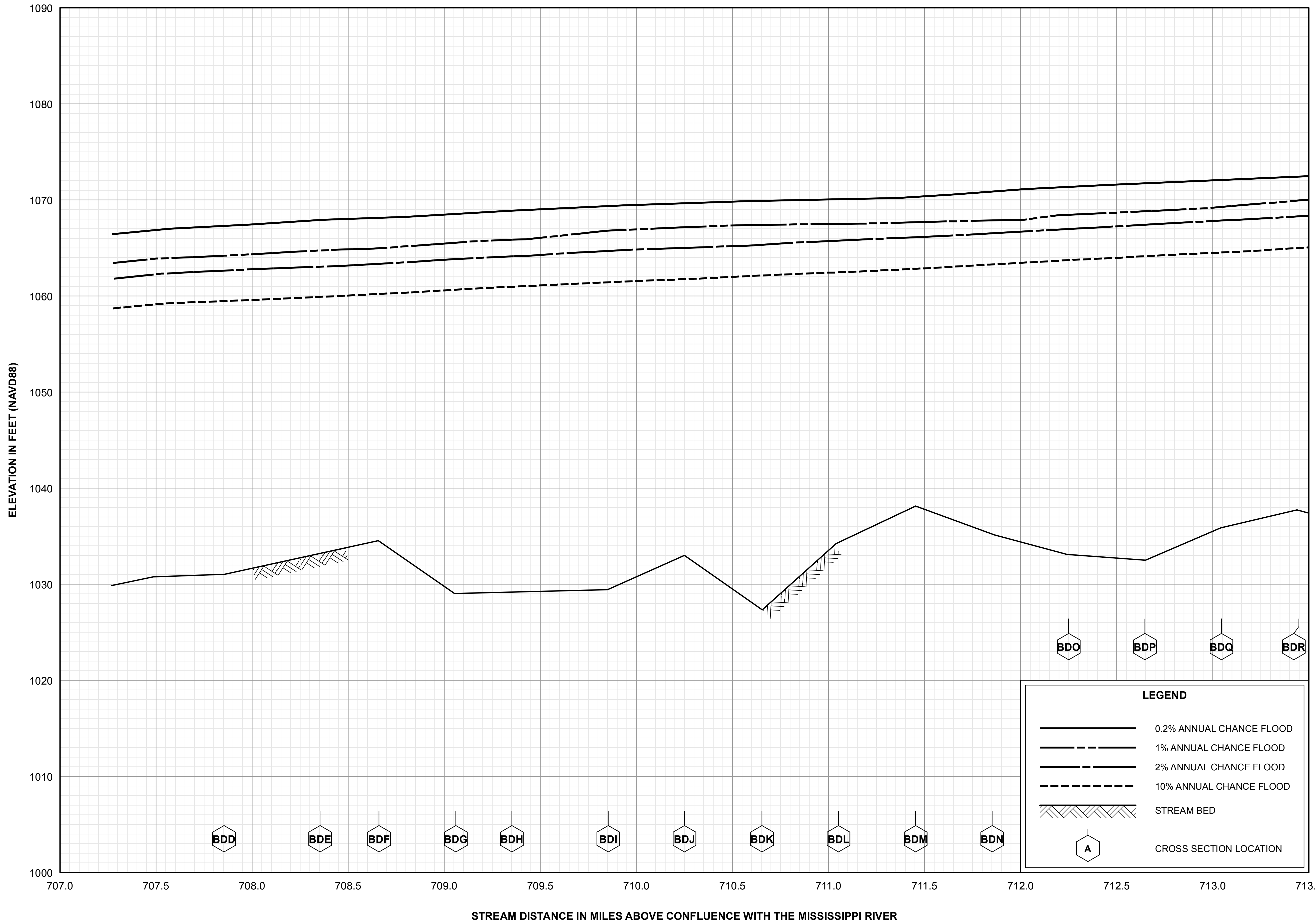
FLOOD PROFILES

LITTLE SIOUX RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS



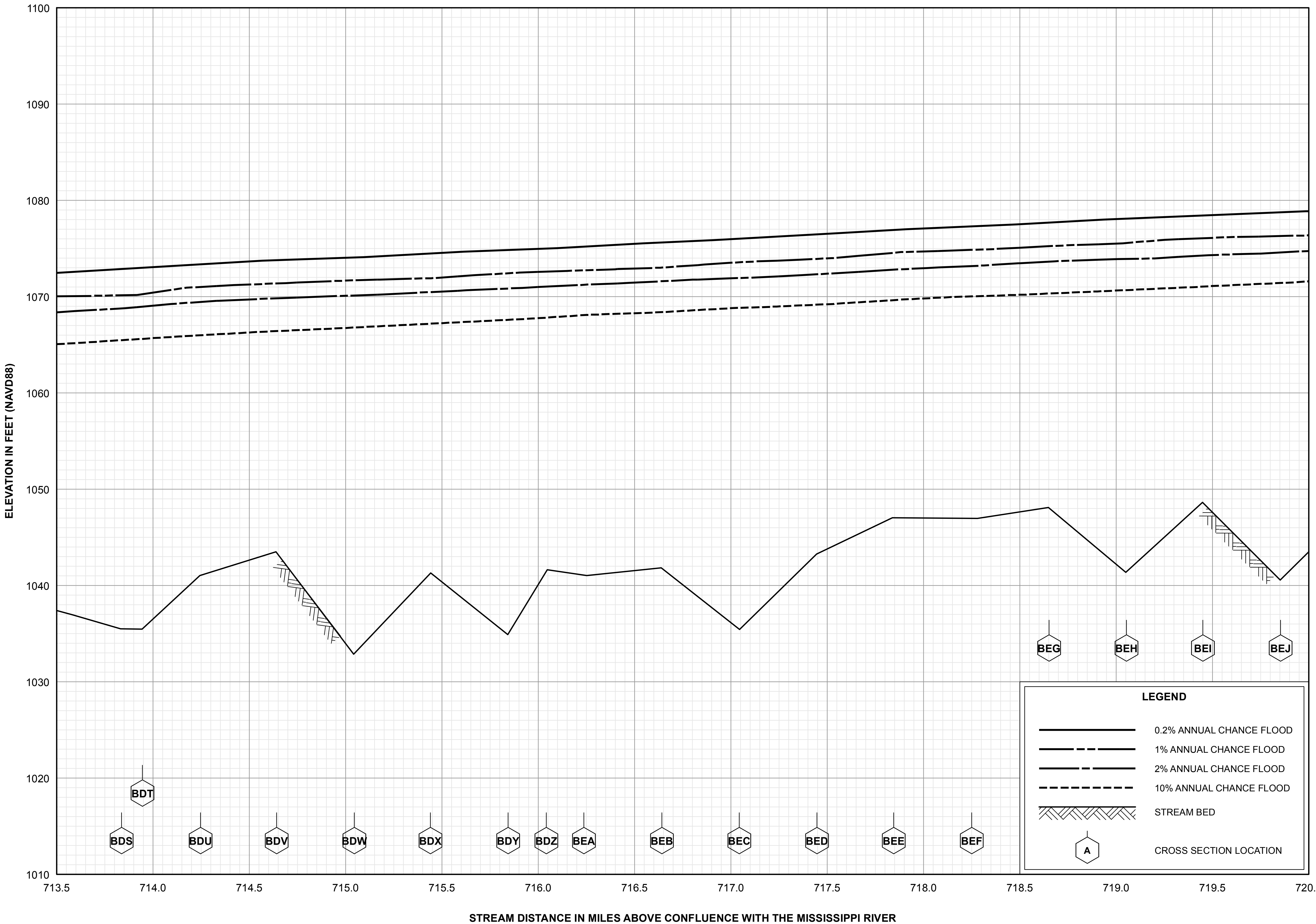
FLOOD PROFILES

MISSOURI RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

10P

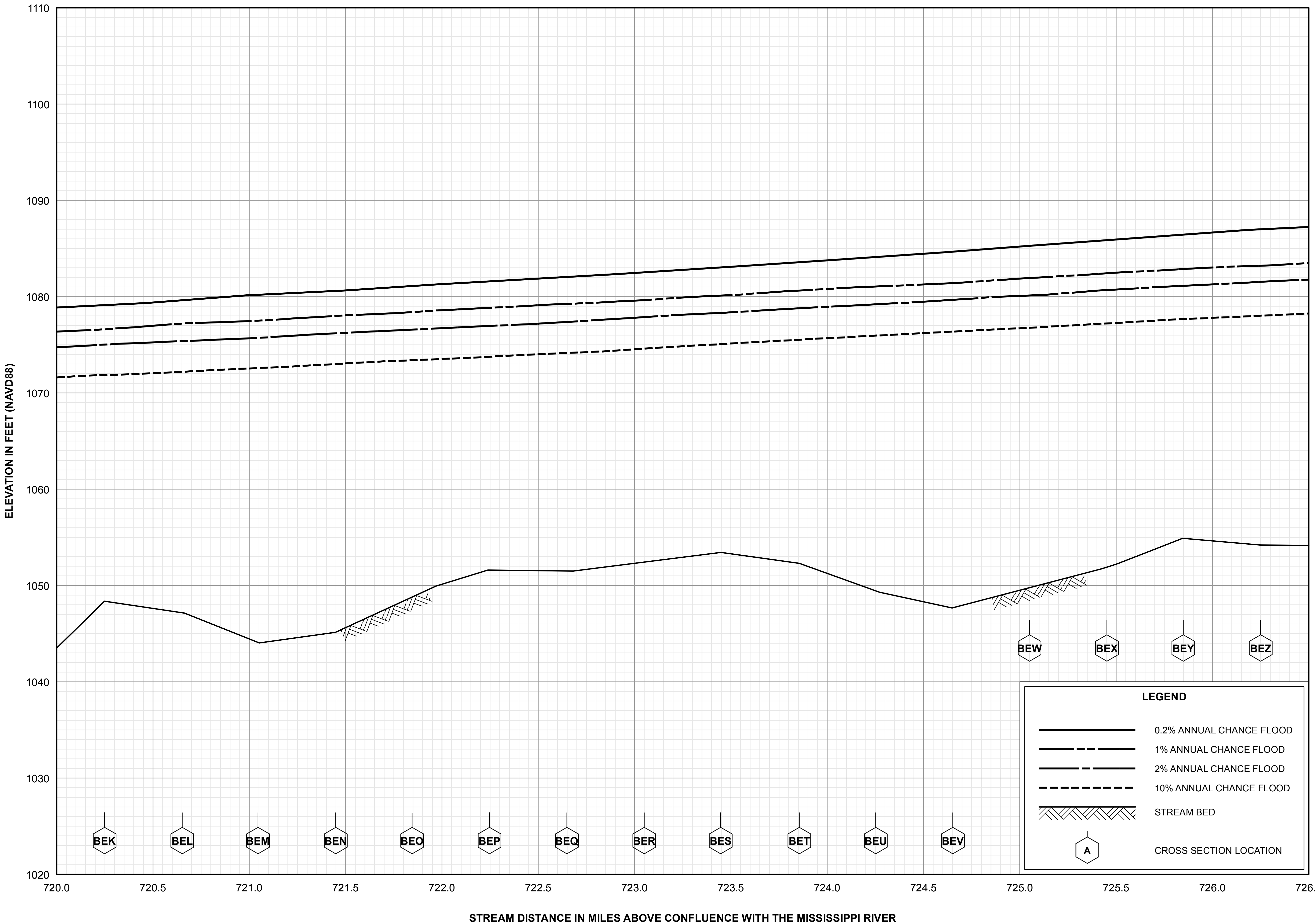


FLOOD PROFILES

MISSOURI RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS



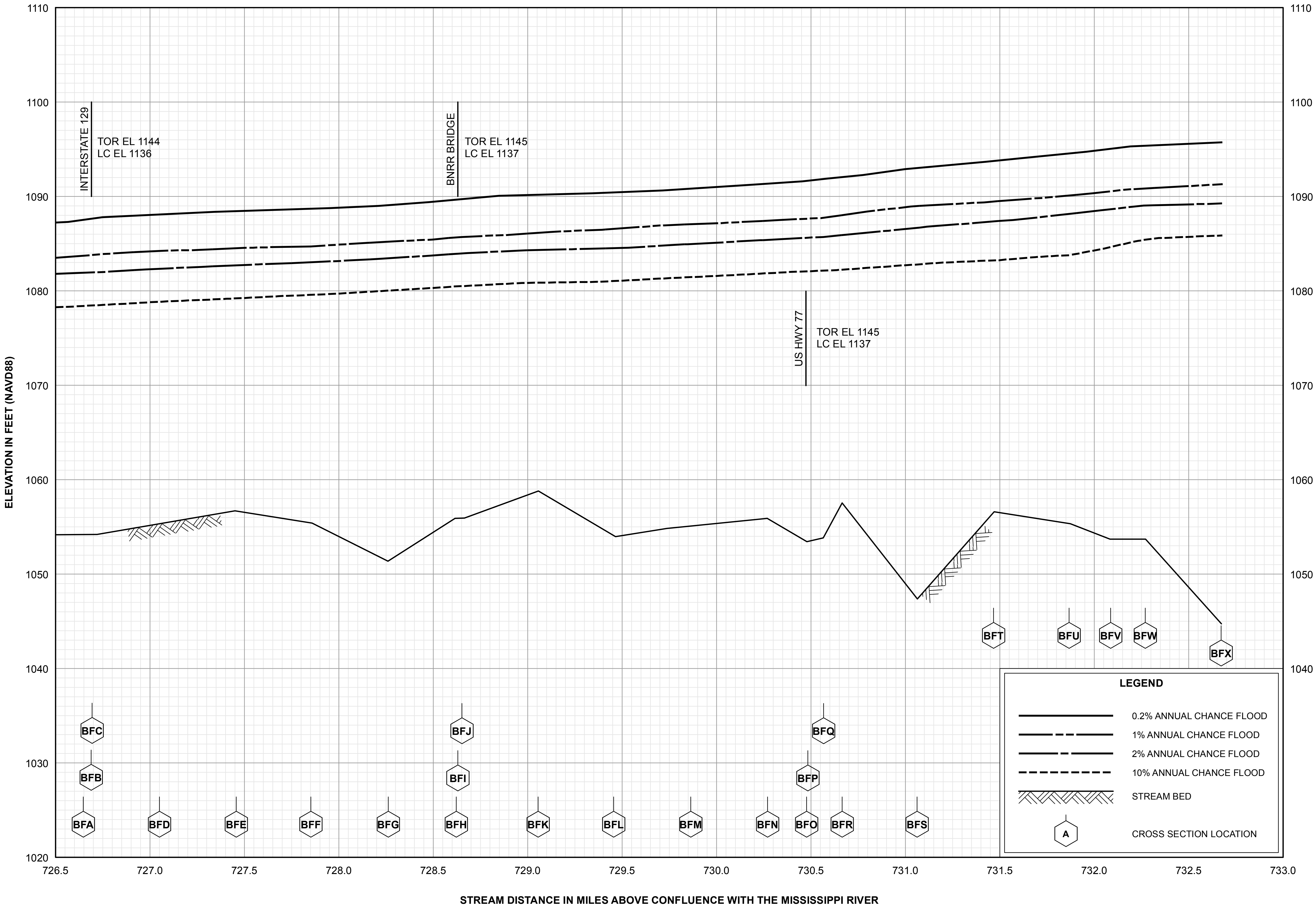
FLOOD PROFILES

MISSOURI RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

12P

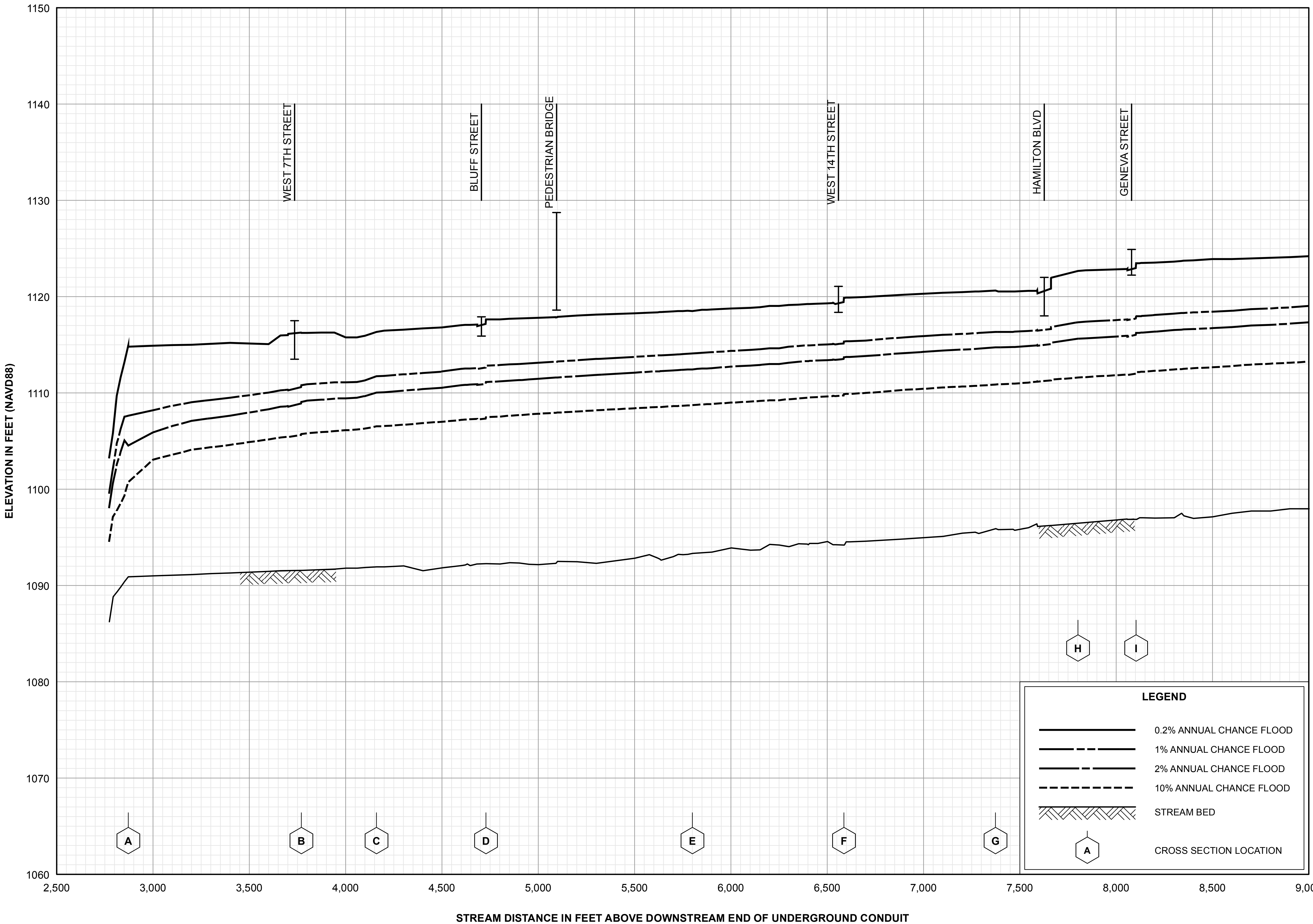


FLOOD PROFILES

MISSOURI RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS



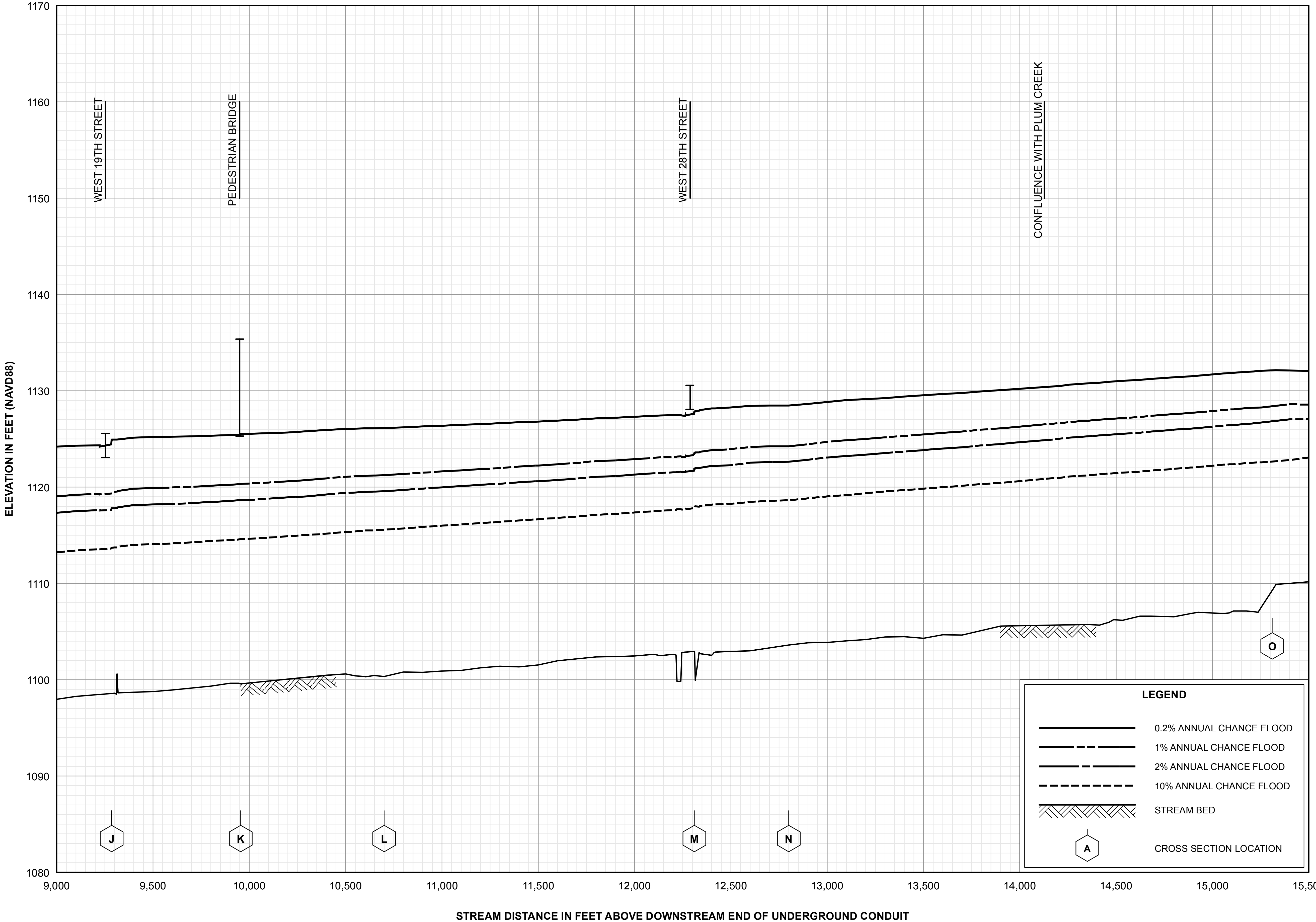
FLOOD PROFILES

PERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

14P



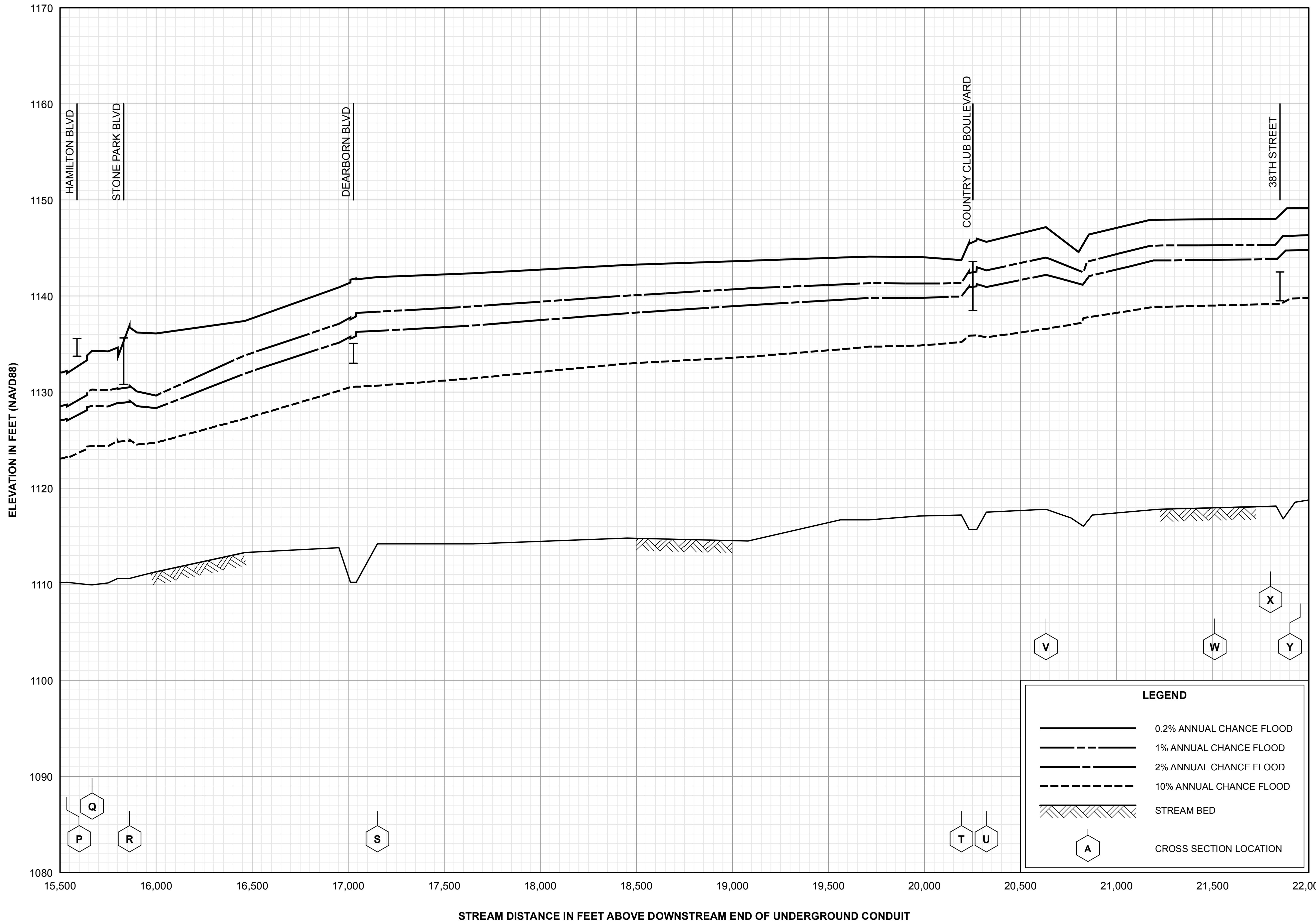
FLOOD PROFILES

PERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

15P

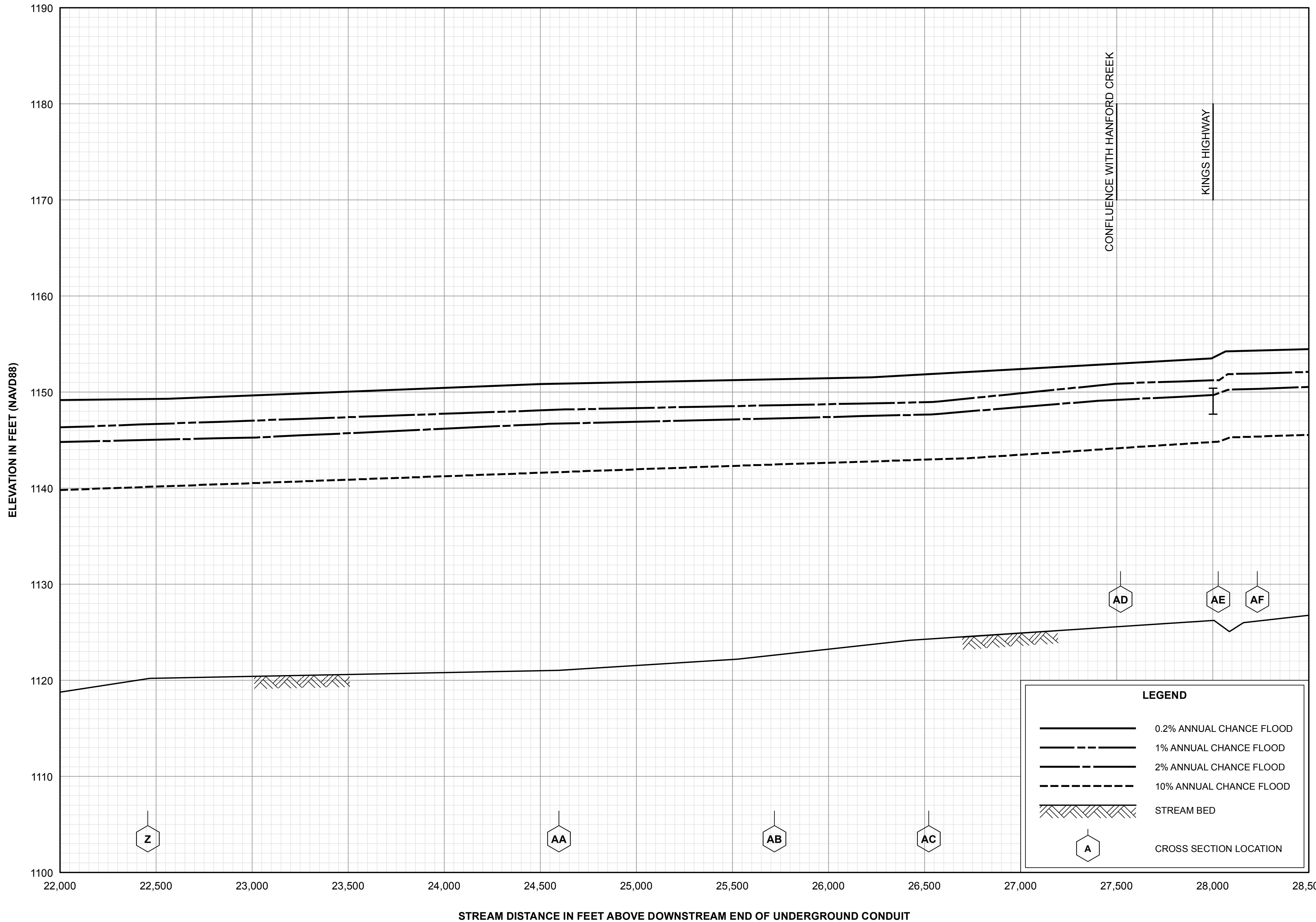


FLOOD PROFILES

PERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS



FLOOD PROFILES

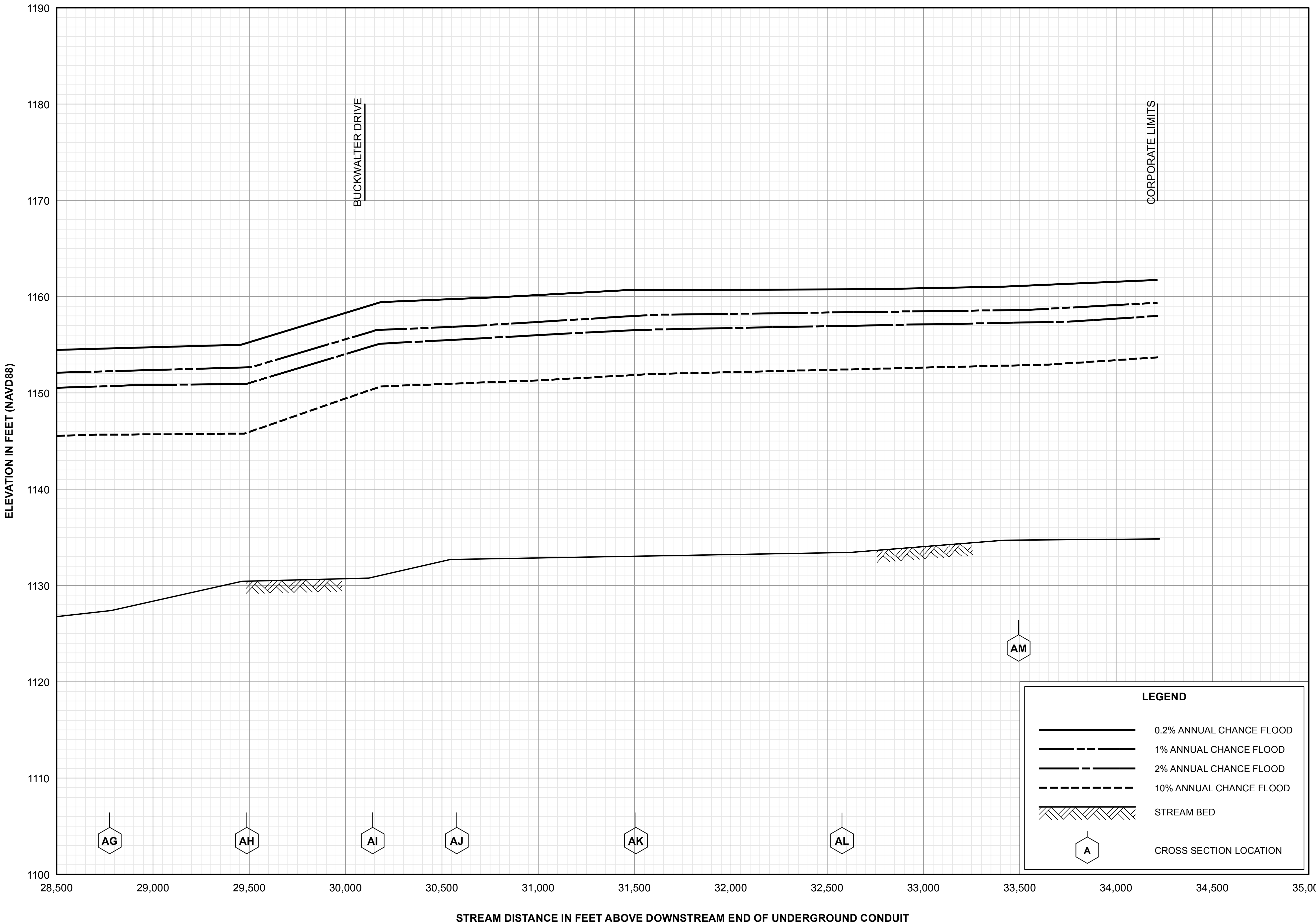
PERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA

AND INCORPORATED AREAS

17P

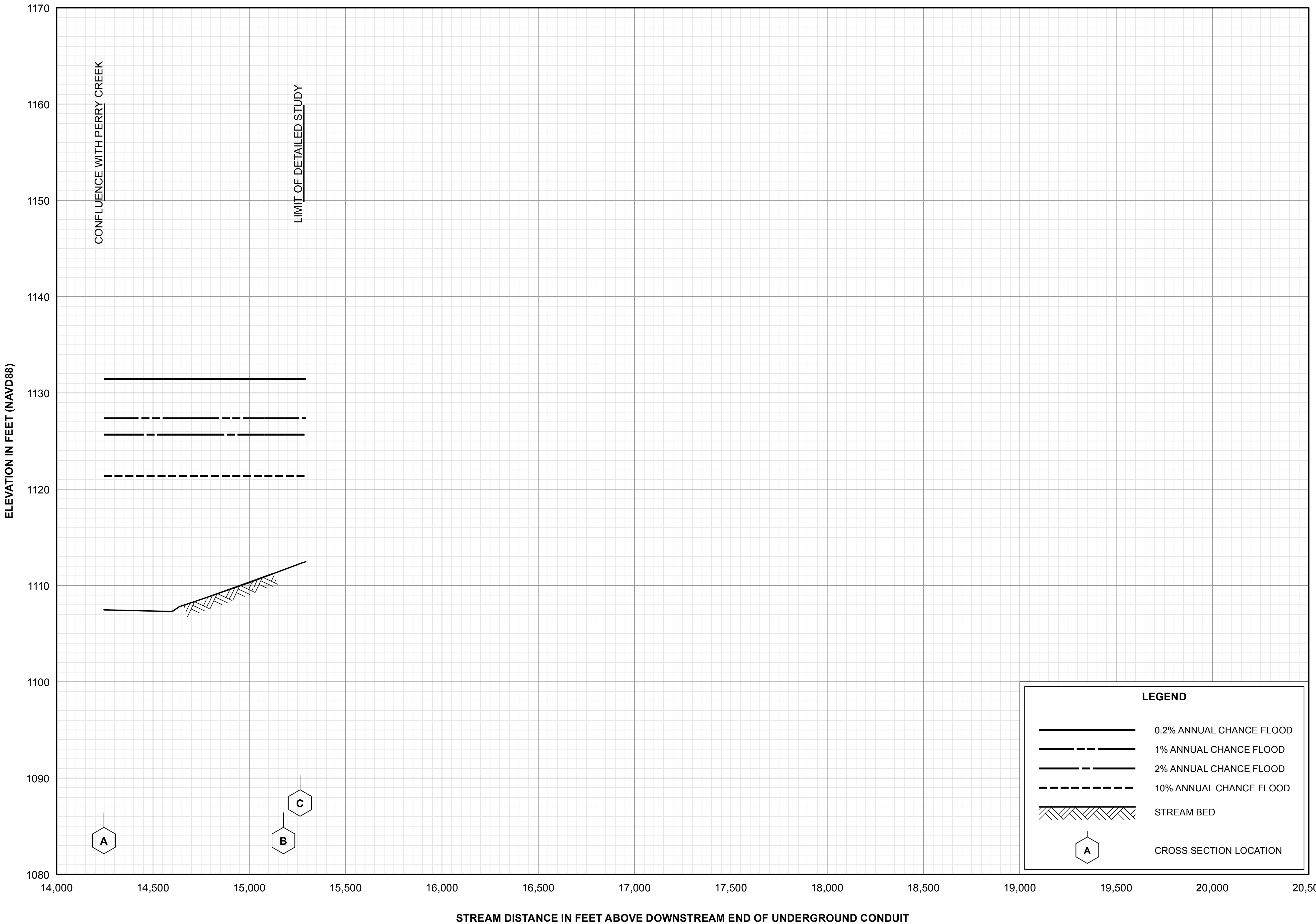


FLOOD PROFILES

PERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS



FLOOD PROFILES

PLUM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

WOODBURY COUNTY, IA
AND INCORPORATED AREAS

19P