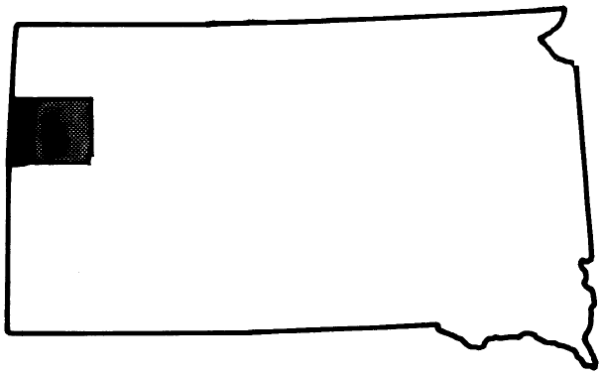
# FLOOD INSURANCE STUDY

# BUTTE COUNTY, SOUTH DAKOTA
## AND INCORPORATED AREAS

| Community Name | Community Number |
|---|---|
| BELLE FOURCHE, CITY OF | 460012 |
| BUTTE COUNTY UNINCORPORATED AREAS | 460236 |
| FRUITDALE, TOWN OF | 460312 |
| NEWELL, CITY OF | 460209 |
| NISLAND, CITY OF | 460245 |



January 6, 2012

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
46019CV000A

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

Initial FIS Report Effective Date: January 6, 2012 Butte County and Incorporated Areas

Selected Flood Insurance Rate Map panels for this 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(s) | New Zone |
|---|---|
| A1 through A30 | AE |
| V1 through V30 | VE |
| B | X |
| C | X |

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BUTTE COUNTY and INCORPORATED AREAS, SOUTH DAKOTA

# 1.0 INTRODUCTION

## 1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and supersedes the FIS reports and/or Flood Insurance Rate Maps (FIRMs) in the geographic area of Butte County, South Dakota, including the Cities of Belle Fourche, Newell, and Nisland, the Town of Fruitdale, and the unincorporated areas of Butte County (hereinafter referred to collectively as Butte County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This information will be used by Butte County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally supported studies are based. 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 Acknowledgements

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

The original City of Belle Fourche Flood Insurance Study was conducted by Black & Veatch at the request of the Federal Insurance Administration, U.S. Department of Housing and Urban Development. Authority and financing were contained in Contract No. H-3834 between Black & Veatch and the Federal Insurance Administration. The original FIS was published in December, 1976 (Reference 1).

ICON Engineering, Inc., as a sub-consultant to GG3 A Joint Venture, performed new hydrologic and hydraulic analyses for the Belle Fourche River and Willow Creek, as well as a new hydraulic analysis for Hay Creek for this countywide DFIRM and FIS report (References 2 and 3). The analyses were conducted for FEMA under Contract No. EMS-2001-CO-0070, task order 0026, entered into on April 21, 2007. The hydrologic study was completed in January 2009 and the hydraulic study was completed in July 2009.

The base map information shown in this study was compiled from State of South Dakota Geographic Information System (GIS) data as well as community GIS resources. Information on the latest State of South Dakota GIS data can be accessed via the internet at http://www.state.sd.us/gis/ or by telephone at 605-773-4750. The base map information updates the political boundaries and transportation lines throughout the county.

The base map information is current as of September 2006 at a scale of 1:24000. The base map data is based on NAD83 horizontal datum and projected to UTM Z13N.

### 1.3 Coordination

For the original City of Belle Fourche FIS, a search for basic data was made at all levels of government. Information was obtained from the City Auditor, the City Engineer, Brady Engineering Company, State Highway Department, the 6th District Council of Local Governments, and also with the State Planning Bureau.

Contact was also made with the U.S. Geological Survey, U.S. Army Corps of Engineers, Soil Conservation Service, U.S. Bureau of Reclamation, and the U.S. Department of Housing and Urban Development. The final consultation and coordination meeting was held on March 1, 1976.

For this countywide FIS, community base map selection and the identification of streams requiring detailed study were performed at the 2007 scoping meeting attended by personnel of the study contractor, FEMA, the State of South Dakota Office of Emergency Management and the affected communities.

A final community coordination meeting was held in Belle Fourche on July 8, 2010. The outcome of the meeting set the effective date for this study.

## 2.0 AREA STUDIED

### 2.1 Scope of Study

This Flood Insurance Study covers the unincorporated and incorporated areas of Butte County, South Dakota. This includes the Cities of Belle Fourche, Newell, and Nisland, and the Town of Fruitdale.

The Belle Fourche River which originates about half way between Casper and Gillette in east central Wyoming flows in a northeastern direction

before turning southeasterly to pass through the City of Belle Fourche. Hay Creek and Redwater River enter Belle Fourche from the southwest and southeast, respectively, and combine in Belle Fourche just a short distance above the confluence of the Belle Fourche River and Redwater River.

These three streams have been studied in detail, as was Willow Creek, a tributary to the Redwater River.

There are no incorporated areas excluded from this Butte County study.

## 2.2 Community Description

Belle Fourche, the County seat of Butte County, is located in the west central part of South Dakota, on the northern edge of the Black Hills, about 10 miles from the South Dakota-Wyoming State line.

Belle Fourche was founded in 1891. In July 2008, the populations of the City of Belle Fourche and Butte County were 4,979 and 9,593, respectively (Reference 4).

The City of Belle Fourche is served by the Chicago and North Western Railroad and Federal Highways 85 and 212. The three drainage areas that contribute to flow in the Belle Fourche River downstream of Belle Fourche represent a wide variety of topography, climate and vegetation. The mean basin elevations of the Belle Fourche River, Redwater River and Hay Creek are 4,590 feet, 4,800 feet and 3,700 feet above mean sea level, respectively.

Elevations in the vicinity vary from about 2,925 near Fruitdale to 7,140 on Crooks Tower in the Black Hills. Mean annual precipitation for the Belle Fourche, Redwater and Hay Creek basins are 16.4, 20.0 and 18.5 inches, respectively. The lower reading for the Belle Fourche River reflects the drier type environment of western Wyoming (Reference 1).

## 2.3 Principal Flood Problems

Flood records for the Belle Fourche River date back to 1924 when the largest flow on record was recorded. Since neither the levee in Belle Fourche nor Keyhole Reservoir on the Belle Fourche River had yet been constructed, there was extensive flooding. The largest flooding since these structures were built occurred on June 18, 1962 where there was flooding in the low area where the Belle Fourche and Redwater Rivers meet. Flooding in this area was increased by the high water in Redwater River which two days earlier recorded its largest flow since its river gage was established in 1946. Record’s analysis indicates that the flow recorded in

the Redwater River in mid-June 1962 approximated the flow that would be created by a 75-year flood (Reference 1).

Hay Creek, which many times is dry, recorded its largest flow on June 19, 1972. This flow also approximated a 75-year flood. Residential areas on 6th Avenue and 7th Avenue and between Lawrence and National Streets were flooded. Most damage occurred in this area. Ice jams during spring thaws often create flooding problems within the City (Reference 1).

## 2.4 Flood Protection Measures

The levee near the south bank of the Belle Fourche River in the central and western portion of the City of Belle Fourche was built by the U.S. Army Corps of Engineers in 1938 under the authority of the 1936 Flood Control Act. The levee has a design discharge of 24,000 cfs, and a recurrence interval of greater than 100 years. Since that time, the area behind the levee has not been flooded by flow from the Belle Fourche River. It should be noted that Belle Fourche River Levee connects with the embankment for the Chicago and Northwestern Railroad at the upstream end of the levee system. Through coordination with FEMA and the National Service Provider (NSP), the railroad embankment was identified as a "levee-like" structure and considered as such during the hydraulic analysis of the Belle Fourche River, presented in this FIS report.

The channel of Hay Creek has been improved and changed in some locations which has increased the creek's hydraulic properties and eliminated constrictions and other hindrances to flow.

Subsequent to March 1952, flow in the Belle Fourche River has been regulated by Keyhole Reservoir located in northeastern Wyoming. This reservoir has the effect of controlling approximately half of the drainage area of the Belle Fourche River and thus greatly decreases the chances for a large flood in the city of Belle Fourche (Reference 1).

Eight miles east of the City of Belle Fourche lies the Belle Fourche Reservoir. Normally, all the flow from the Belle Fourche River is diverted through 4, 10 foot tall gates into an inlet canal leading to the reservoir. This inlet canal begins at a diversion dam which is located about a mile northeast of the city of Belle Fourche. This structure, the U.S. Bureau of Reclamation Diversion Dam, was improved to its current configuration around 1990. The inlet canal has a capacity of 1,600 cfs. During periods when flow is in excess of this capacity, the excess flow will be released to the Belle Fourche River through 3 additional 20 foot tall gates or will flow over a 194 foot long, ogee-type spillway. The top of the spillway is at elevation 3,001.02 (NAVD)

## 3.0 ENGINEERING METHODS

For the flooding sources studied in detail 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 which are 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 flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent 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 short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 1% annual chance flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here 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 Analyses

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

The original City of Belle Fourche FIS referenced a U.S. Geological Survey report in its determination of frequency of floods (Reference 5). In this report, the Belle Fourche River downstream of the South Dakota-Wyoming State line is classified as a regulated stream. The report gives flood flow frequency data for the 2-, 5-, 10-, 25- and 50-year floods.

By using the log-Pearson Type III method of analysis as outlined by the Water Resources Council (Reference 6), peak flows for the 2-, 5-, 10-, 25-, 50-, 100- and 200-year recurrence interval were computed based on annual peak flows at the location and length of record stations (References 7 and 8). The Fruitdale and State Line gage stations have been in operation since 1946 and 1947 respectively. The annual peak flows used were those occurring since Keyhole Reservoir began regulating flow in the Belle Fourche River in 1952. Curves were developed using these data. By adjusting skew coefficients, these curves were modified to closely match the flood flow frequency data published in Reference 5. The equation for the closest fitted curve was then used to calculate the 100-year flows at these two gaging stations.

Because there is very little difference between the contributing drainage area at the diversion dam and at the Fruitdale gaging station, the flows listed for that station were used as a basis for determining the flows downstream of the confluence of Redwater River. The flow diverted to the Belle Fourche Reservoir through the inlet canal was added to these flows.

The flood flows upstream of the confluence with Redwater River were obtained by subtracting the Redwater River and Hay Creek drainage areas from the total drainage area and then obtaining the flow based on that drainage area using the U.S. Geological Survey report (Reference 5).

The flood flow frequency data used for Redwater River and Hay Creek was obtained from the log-Pearson Type III method of analysis as outlined by the Water Resources Council (Reference 6).

Twenty-nine years of record were used for Redwater River and 21 years of record were used for Hay Creek. The results were found to compare favorably with data published by the U.S. Geological Survey based on two less years of data.

Discharges for the 500-year floods of all streams studied in detail in the original FIS were determined by straight-line extrapolation of a single-log graph of flood discharges computed for frequencies up to 100-years.

For the current county-wide FIS, the hydrology of the Belle Fourche River was re-studied and an entirely new study was performed for Willow Creek (Reference 2). The discharges for Hay Creek were taken directly from the original City of Belle Fourche FIS.

The discharge-frequency data for the Belle Fourche River re-study was developed from a regional frequency analysis of peak flows at several USGS gage stations. Using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) (Reference 9), the 10-, 2-, 1-, and 0.2%-annual-chance discharges were calculated at the Stateline Gage, as well as downstream of the confluence with the Redwater River, and at the United States Bureau of Reclamation diversion structure. In order to compute a discharge for the Belle Fourche River upstream of the confluence with the Redwater River, the approach for determining peak flows for an ungaged site near a gage station, as presented in *Techniques for Estimating Peak-Flow Magnitude and Frequency Relations for South Dakota Streams* (Reference 10), was utilized from an adjustment of the Stateline gage.

The 1%-annual-chance peak flow value for Willow Creek has been determined utilizing the regional regression equation as provided in the

Techniques for Estimating Peak-Flow Magnitude and Frequency Relations for South Dakota Streams (Reference 10).

Peak discharge-drainage area relationships for the Butte County and Incorporated Areas flood sources studied by detailed methods are shown in Table 1.

TABLE 1– SUMMARY OF DISCHARGES

| Flooding Source and Location | Drainage Area (sq. Miles) | Peak Discharges (Cubic Feet per Second) 10-Percent-Annual-Chance | 2-Percent-Annual-Chance | 1-Percent-Annual-Chance | 0.2-Percent-Annual-Chance |
|---|---|---|---|---|---|
| Belle Fourche River | | | | | |
| Upstream of Confluence with Redwater River | 3,318 | 3,537 | 6,089 | 7,281 | 10,247 |
| Downstream of Confluence with Redwater River | 4,262 | 5,972 | 13,454 | 18,069 | 33,258 |
| Hay Creek | | | | | |
| City of Belle Fourche | 119 | - | - | 1,140 | - |
| Redwater River | | | | | |
| Upstream of City of Belle Fourche | 920 | - | - | 20,600 | - |
| Willow Creek | | | | | |
| City of Belle Fourche | 10.5 | - | - | 345 | - |

## 3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in the county 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 Flood Insurance Rate Map (FIRM) represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data table 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 the FIS report in conjunction with the data shown on the FIRM.

The analysis of the Redwater River was preserved from the original City of Belle Fourche FIS. Water-surface elevations of floods of the selected recurrence intervals were computed through use of the U.S. Corps of Engineers HEC-2 step-backwater computer program (Reference 11).

Cross sections for the backwater analyses of the stream were field-surveyed and were located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of these structures.

For this county-wide FIS, the Belle Fourche River was re-studied and Willow Creek was studied for the first time. A new hydraulic study was performed for Hay Creek upstream of 7th Avenue in the City of Belle Fourche.

Cross sections for the backwater analyses were obtained from topographic maps compiled from aerial photographs (Reference 16). Below water sections were obtained by field surveys. All bridges and culverts were surveyed to obtain elevation data and structural geometry. Survey elevations were also collected along the top of the existing levee system adjacent to the Belle Fourche River.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed, selected cross section locations are also shown on the FIRM.

Water Surface elevations for floods of the selected recurrence intervals were computed through use of the USACE HEC-RAS step backwater computer program, version 4.0.0 (Reference 12). Starting water surface elevations for the Belle Fourche River were developed from a backwater analysis of the Belle Fourche River, reflecting the current conditions of the U.S. Bureau of Reclamation Diversion Dam, located approximately 1-mile downstream of the study limits. The starting water surface elevation for Willow Creek was determined using normal depth.

Channel and overbank roughness factors (Manning's "n" values) used in the hydraulic computations were chosen by engineering judgment and were based on field observations and aerial photography of the stream and floodplain areas. Table 2 presents a range of values used for Manning's "n":

TABLE 2– MANNING'S "n" VALUES

| | Channel | Overbanks |
|---|---|---|
| Belle Fourche River | 0.028 to 0.070 | 0.045 to 0.100 |
| Hay Creek | 0.045 to 0.085 | 0.050 to 0.010 |
| Redwater River | 0.030 to 0.035 | 0.030 to 0.070 |
| Willow Creek | 0.050 to 0.070 | 0.050 to 0.070 |

An existing levee system is located along the south bank of the Belle Fourche River. At the upstream end, this levee system connects with an embankment for the Chicago and Northwestern Railroad. Through coordination with FEMA and the National Service Provider (NSP), the railroad embankment was identified as a "levee-like" structure and considered as such during the hydraulic analysis of the Belle Fourche River. The hydraulic analysis for the Belle Fourche River was evaluated under three hydraulic conditions. The first considered that the levee system would remain in-place and hold floodwater during the 1%-annual chance flooding event. The second condition considered the failure of the levee with floodwater conveyance to the south of the levee system. The final condition considered the failure of the Chicago and Northwestern Railroad embankment at the upstream end of the levee system. The failure of this embankment results in a backwater condition from the Belle Fourche River to the north of the railroad embankment.

Flood elevations in the city of Belle Fourche are often raised by ice jams during spring thaws. The hydraulic analysis for this study was based on open channel conditions free of debris and ice. The flood elevations shown on the profiles are, thus, considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail. The conditions shown would be of a minimum flooding situation that could occur under these conditions. Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

## 3.3 Vertical Datum

All FISs 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 in use for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the finalization of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are being prepared using NAVD88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in base flood elevations across the corporate limits between communities.

As noted above, the elevations shown in the FIS report and on the FIRM for Butte County and Incorporated Areas are referenced to NAVD88.

Ground, structure, and flood elevations may be compared and/or referenced to NGVD29 by applying a standard conversion factor.

The conversion from NGVD29 to NAVD88 ranged between 1.52 to 1.76 feet for this county. According to Appendix B of the FEMA Guidelines and Specifications, due to the range in conversion factors, an average conversion factor was established for the entire county. The elevations shown in the FIS report and on the FIRM were, therefore, converted to NAVD88 using a countywide approach in which an average conversion was established for the county. The conversion factor for NGVD 29 to NAVD 88 of 1.6 feet was used for each flooding source in the community that was not re-studied in NAVD 88.

The BFEs shown in the FIRM represent whole-foot rounded values. For example, a BFE of 1202.4 will appear as 1202 on the FIRM and 1202.6 will appear as 1203. Therefore, users who wish to convert the elevations in this FIS to NGVD29 should apply the stated conversion factor to elevations shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

| COMMUNITY NAME | INITIAL IDENTIFICATION | FLOOD HAZARD BOUNDARY MAP REVISION DATE(S) | FLOOD INSURANCE RATE MAP EFFECTIVE DATE | FLOOD INSURANCE RATE MAP REVISION DATE(S) |
|---|---|---|---|---|
| City of Belle Fourche | 11/02/1973 | 10/3/1975 | 06/01/1977 | 01/19/1982 |
| Butte County Unincorporated Areas | 12/20/1977 | none | 1/6/2012 | none |
| Town of Fruitdale | 1/6/2012 | none | 1/6/2012 | none |
| City of Newell | 1/6/2012 | none | 1/6/2012 | none |
| City of Nisland | 1/6/2012 | none | 1/6/2012 | none |

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

**BUTTE COUNTY, SD AND INCORPORATED AREAS**

**COMMUNITY MAP HISTORY**

For more information on NAVD88, see the publication entitled, *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988* (FEMA Publication FIA-20/June 1992), or contact the Vertical Network Branch, National Geodetic Survey, Coast and Geodetic Survey, National Oceanic and Atmospheric Administration, Rockville, Maryland 20910 (Internet address http://www.ngs.noaa.gov).

Qualifying bench marks within a given jurisdiction that are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Bench marks catalogued by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)

- Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutments)

- Stability C: Monuments which may be affected by surface ground movements (e.g., concrete monument below frost line)

- Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line or steel witness post)

To obtain up-to-date elevation information on NGS bench marks shown on the FIRM, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov. Map users should seek verification of non-NGS monument elevations when using these elevations for construction or floodplain management purposes.

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 this FIS report and FIRM for this community. Interested individuals may contact FEMA to access this data.

## 4.0 FLOOD MANAGEMENT APPLICATIONS

The NFIP encourages state and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 1%

annual chance flood elevations and delineations of the 100- and 500-year floodplain boundaries and 1% annual chance floodway to assist communities in developing sound flood plain management measures.

## 4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for purposes of flood plain management measures. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:2,400, with a contour interval of 2 feet. For the Redwater River and the portions of Hay Creek and the Belle Fourche River not restudied, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 10 feet (Reference 13) and field surveys.

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 1% annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones AE, A, and X); and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 1% 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.

## 4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces the flood-carrying capacity, increases the 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% annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of the stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1% annual chance 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

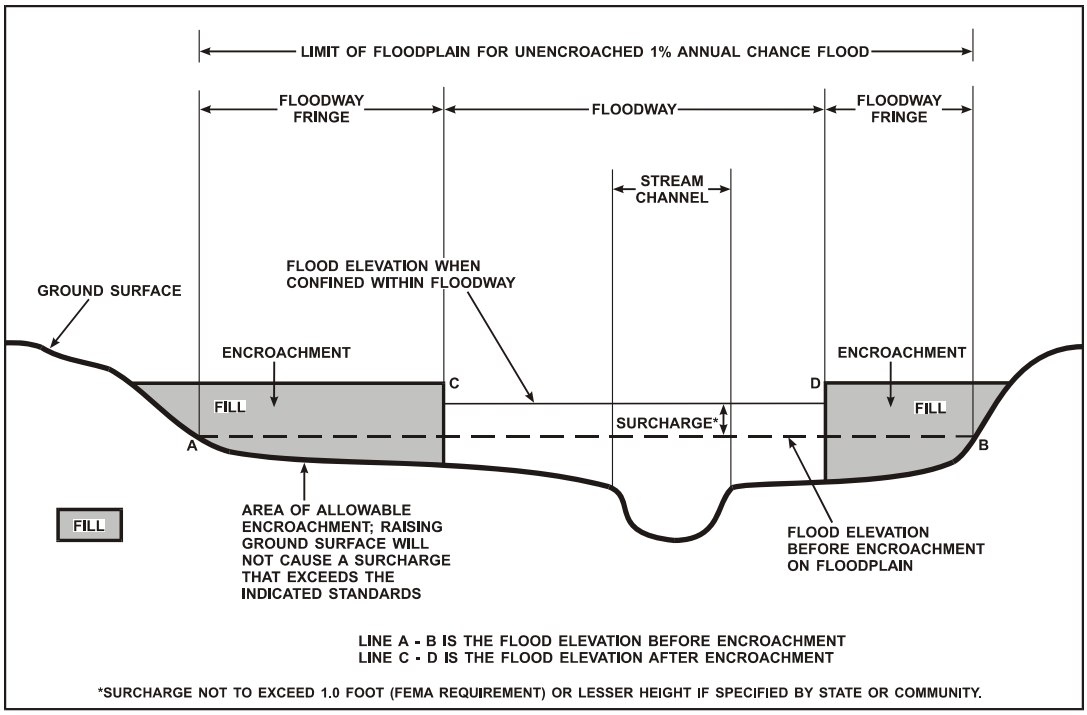
produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the flood plain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated at selected cross sections (Table 4). In cases where the floodway and the 1% annual chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

This method was followed throughout each stream except in reaches where there is an existing levee. In these areas it was assumed that no encroachment would be made between the levee and the stream channel. Therefore, in these reaches the flood way width was the same as the width of the 100-year flood.

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

Figure 1 - Floodway Schematic



| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD) | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| BELLE FOURCHE RIVER | | | | | | | | |
| A | 5,387 | 390 | 3097 | 5.8 | 3,009.8 | 3,009.8 | 3,010.3 | 0.5 |
| B | 6,955 | 960 | 7516 | 2.4 | 3,011.9 | 3,011.9 | 3,012.4 | 0.5 |
| C | 8,053 | 1031 | 6871 | 2.6 | 3,012.2 | 3,012.2 | 3,012.7 | 0.5 |
| D | 9,069 | 671 | 4564 | 1.6 | 3,012.6 | 3,012.6 | 3,013.3 | 0.7 |
| E | 9,640 | 663 | 4272 | 1.7 | 3,012.7 | 3,012.7 | 3,013.4 | 0.7 |
| F | 9,892 | 565 | 3522 | 2.1 | 3,012.7 | 3,012.7 | 3,013.5 | 0.8 |
| G | 10,434 | 134 | 1484 | 4.9 | 3,012.8 | 3,012.8 | 3,013.5 | 0.7 |
| H | 11,460 | 349 | 2801 | 2.6 | 3,013.6 | 3,013.6 | 3,014.4 | 0.8 |
| I | 11,643 | 349 | 2606 | 2.8 | 3,013.8 | 3,013.8 | 3,014.5 | 0.7 |
| J | 12,401 | 453 | 3219 | 2.3 | 3,014.0 | 3,014.0 | 3,014.9 | 0.9 |
| K | 13,717 | 248 | 2003 | 3.6 | 3,014.4 | 3,014.4 | 3,015.2 | 0.8 |
| L | 13,779 | 263 | 2192 | 3.3 | 3,014.7 | 3,014.7 | 3,015.5 | 0.8 |
| M | 16,615 | 423 | 2632 | 3.8 | 3,015.9 | 3,015.9 | 3,016.8 | 0.9 |
| N | 16,716 | 423 | 2534 | 3.4 | 3,016.5 | 3,016.5 | 3,017.2 | 0.7 |
| O | 18,269 | 569 | 3313 | 2.2 | 3,017.3 | 3,017.3 | 3,018.1 | 0.7 |
| P | 18,908 | 458 | 2588 | 2.8 | 3,017.9 | 3,017.9 | 3,018.6 | 0.7 |
| Q | 20,502 | 987 | 4355 | 1.7 | 3,019.1 | 3,019.1 | 3,020.1 | 1.0 |

[1] Feet Above Diversion Structure

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

**BUTTE COUNTY, SD AND INCORPORATED AREAS**

**FLOODWAY DATA**

**BELLE FOURCHE RIVER**

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD) | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| HAY CREEK | | | | | | | | |
| A | 1,050 | 100 | 742 | 1.5 | 3,016.0 | 3,016.0 | 3,017.0 | 1.0 |
| B | 1,300 | 110 | 680 | 1.6 | 3,016.0 | 3,016.0 | 3,017.0 | 1.0 |
| C | 1,400 | 98 | 738 | 1.5 | 3,016.3 | 3,016.3 | 3,017.2 | 0.9 |
| D | 1,630 | 82 | 342 | 3.9 | 3,016.3 | 3,016.3 | 3,017.1 | 0.8 |
| E | 1,970 | 83 | 411 | 2.8 | 3,016.6 | 3,016.6 | 3,017.5 | 0.9 |
| F | 2,050 | 153 | 633 | 1.8 | 3,016.8 | 3,016.8 | 3,017.8 | 1.0 |
| G | 2,460 | 57 | 239 | 4.8 | 3,017.2 | 3,017.2 | 3,017.9 | 0.7 |
| H | 3,335 | 57 | 232 | 4.9 | 3,020.7 | 3,020.7 | 3,020.8 | 0.1 |
| I | 3,385 | 41 | 222 | 5.1 | 3,020.7 | 3,020.7 | 3,020.9 | 0.2 |
| J | 3,435 | 43 | 276 | 4.1 | 3,021.2 | 3,021.2 | 3,022.2 | 1.0 |
| K | 3,800 | 59 | 327 | 3.5 | 3,022.1 | 3,022.1 | 3,022.8 | 0.7 |
| L | 4,200 | 28 | 103 | 5.6 | 3,023.7 | 3,023.7 | 3,023.7 | 0.0 |
| M | 4,920 | 59 | 245 | 4.6 | 3,027.8 | 3,027.8 | 3,028.4 | 0.6 |
| N | 5,670 | 66 | 213 | 5.3 | 3,029.9 | 3,029.9 | 3,030.7 | 0.8 |
| O | 6,350 | 65 | 201 | 5.7 | 3,034.2 | 3,034.2 | 3,034.4 | 0.2 |
| P | 6,400 | 45 | 121 | 9.4 | 3,035.1 | 3,035.1 | 3,035.1 | 0.0 |
| Q | 6,435 | 47 | 186 | 6.1 | 3,035.5 | 3,035.5 | 3,036.5 | 1.0 |
| R | 7,210 | 190 | 959 | 1.2 | 3,036.8 | 3,036.8 | 3,037.3 | 0.5 |
| S | 8,275 | 210 | 564 | 2.9 | 3,041.2 | 3,041.2 | 3,041.6 | 0.4 |

[1] Feet Above Confluence of Redwater River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

**BUTTE COUNTY, SD AND INCORPORATED AREAS**

**FLOODWAY DATA**

**HAY CREEK**

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD) | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| REDWATER RIVER | | | | | | | | |
| A | 720 | 1,390 [2] | 6,609 | 5.2 | 3,014.1 | 3,014.1 | 3,014.4 | 0.3 |
| B | 1,670 | 817 [2] | 5,097 | 3.4 | 3,015.0 | 3,015.0 | 3,015.5 | 0.5 |
| C | 2,675 | 662 [2] | 2,795 | 8.5 | 3,017.2 | 3,017.2 | 3,017.6 | 0.4 |
| D | 3,265 | 286 [2] | 1,900 | 10.8 | 3,019.8 | 3,019.8 | 3,020.8 | 1.0 |
| E | 3,340 | 756 [2] | 4,744 | 4.3 | 3,019.8 | 3,019.8 | 3,020.8 | 1.0 |
| F | 3,415 | 394 [2] | 2,418 | 6.1 | 3,020.0 | 3,020.0 | 3,020.6 | 0.6 |
| G | 3,465 | 716 [2] | 4,441 | 5.6 | 3,022.4 | 3,022.4 | 3,022.4 | 0.0 |

[1] Feet Above Confluence of Belle Fourche River
[2] Part of floodway is outside Corporate Limits

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

**BUTTE COUNTY, SD AND INCORPORATED AREAS**

**FLOODWAY DATA**

**REDWATER RIVER**

## 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% annual chance floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 1% annual chance flooding where average depth are less than 1 foot, areas of the 1% annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1% annual chance flood by levees. No base flood elevations or depths are shown within this zone.

## 6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map 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% annual chance floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations 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 100- and 500-year floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

## 7.0 OTHER STUDIES

A Flood Insurance Study (FIS) and Flood Boundary and Floodway Maps (FBFMs) were previously prepared for the City of Belle Fourche (References 1 and 14). Flood Hazard Boundary Maps (FHBMs) were also prepared for the unincorporated areas of Butte County (Reference 15). This Flood Insurance Study is more detailed and comprehensive, and therefore, supersedes the previous FIS, FBFMs, and FHBMs.

This study is authoritative for the purposes of the Flood Insurance Program; data presented herein either superseded or are compatible with all previous determinations.

## 8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Denver Federal Center, Building 710, Box 25267, Denver, Colorado 80225-0267.

## 9.0 BIBLIOGRAPHY AND REFERENCES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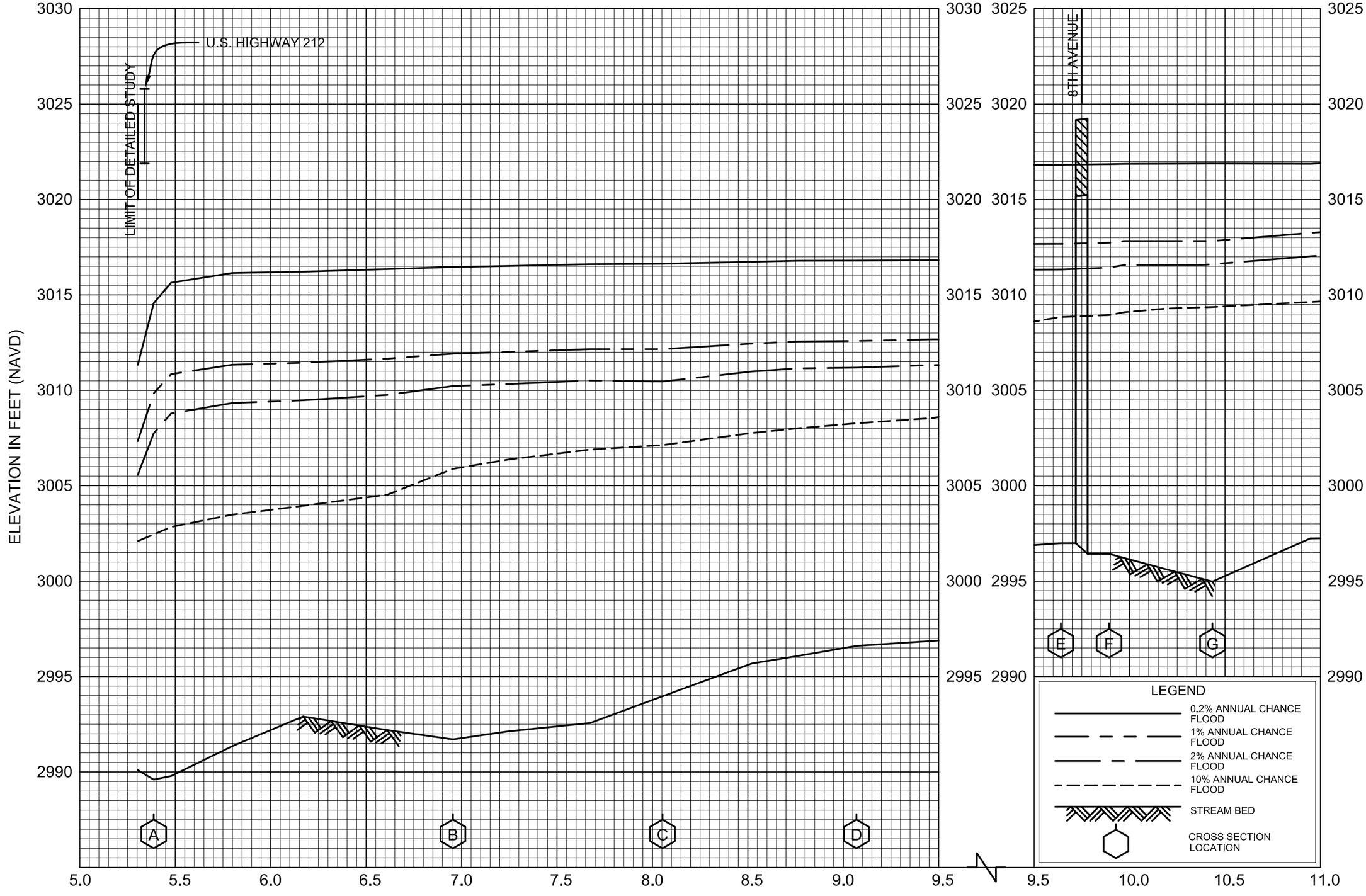


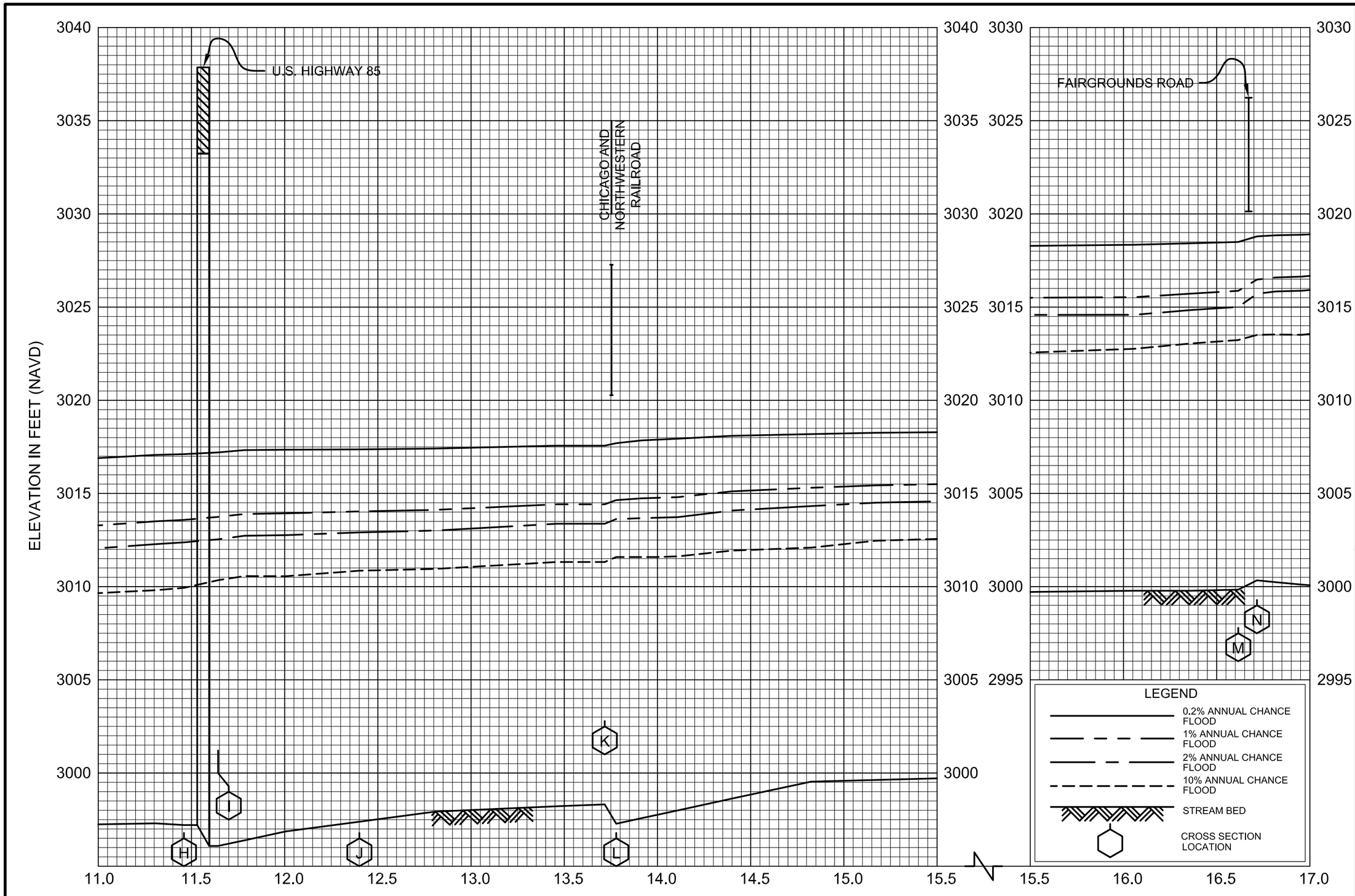

FLOOD PROFILES

BELLE FOURCHE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

01P




FLOOD PROFILES

BELLE FOURCHE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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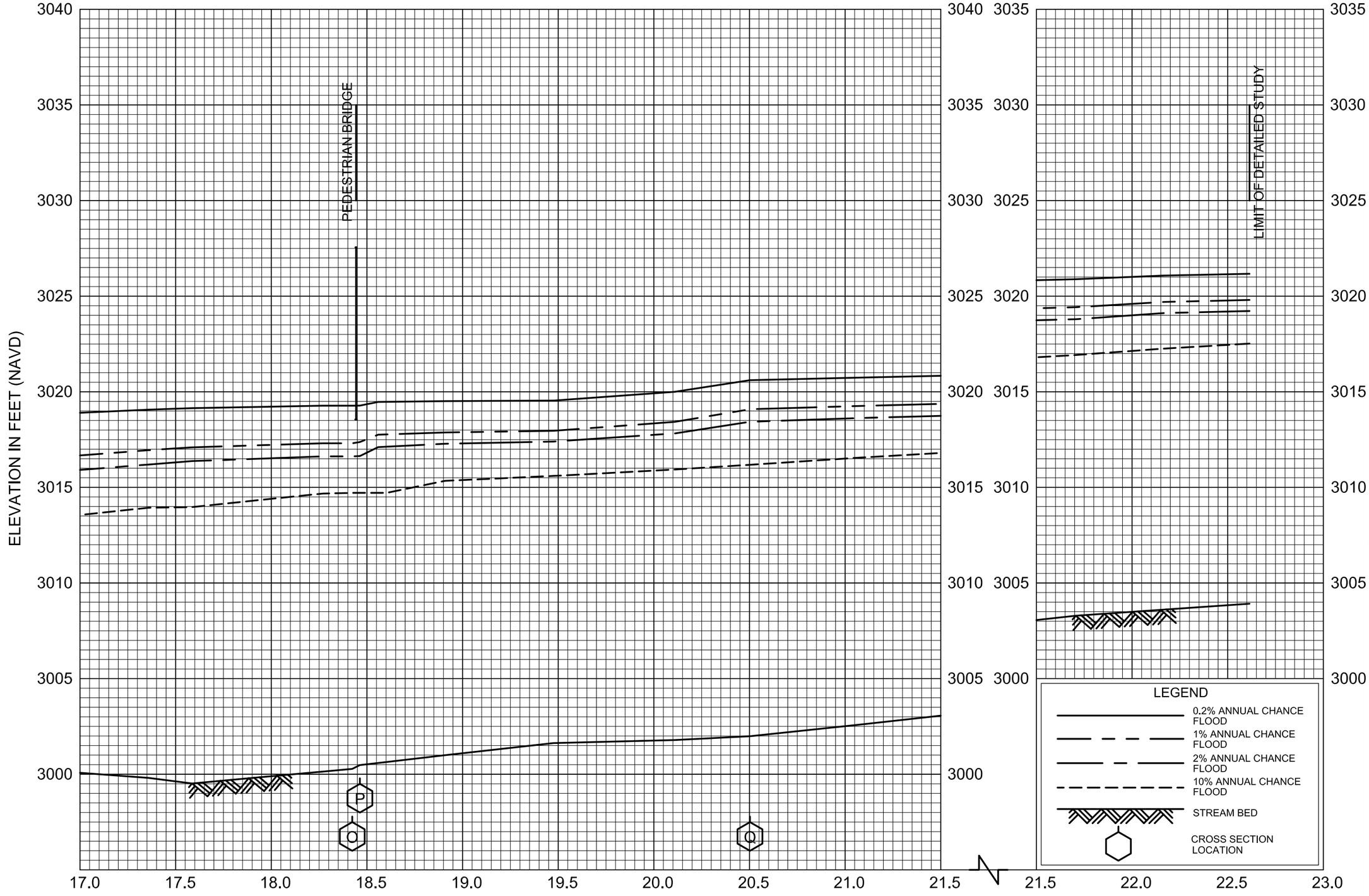


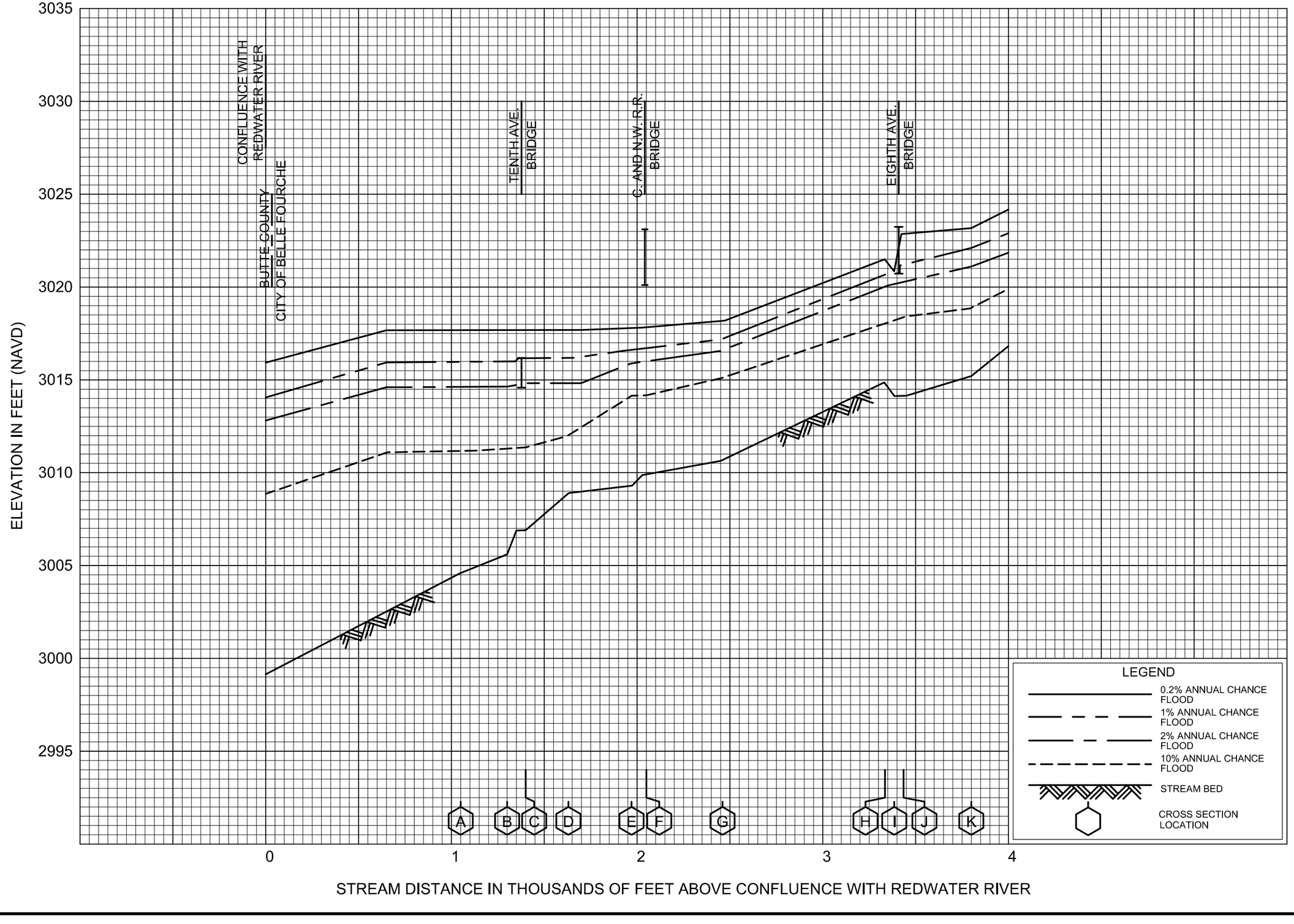

FLOOD PROFILES

BELLE FOURCHE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

03P



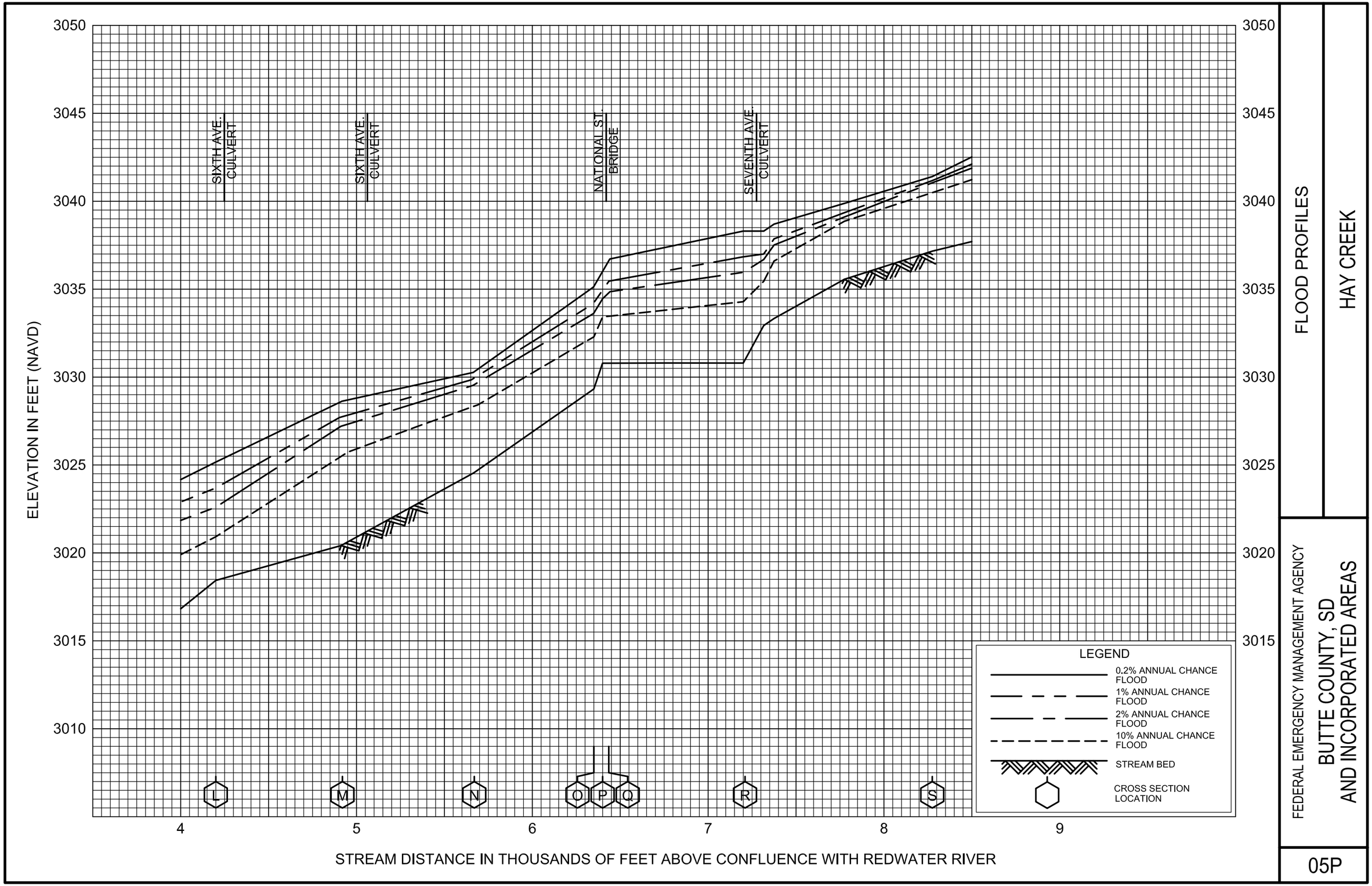

FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

04P




FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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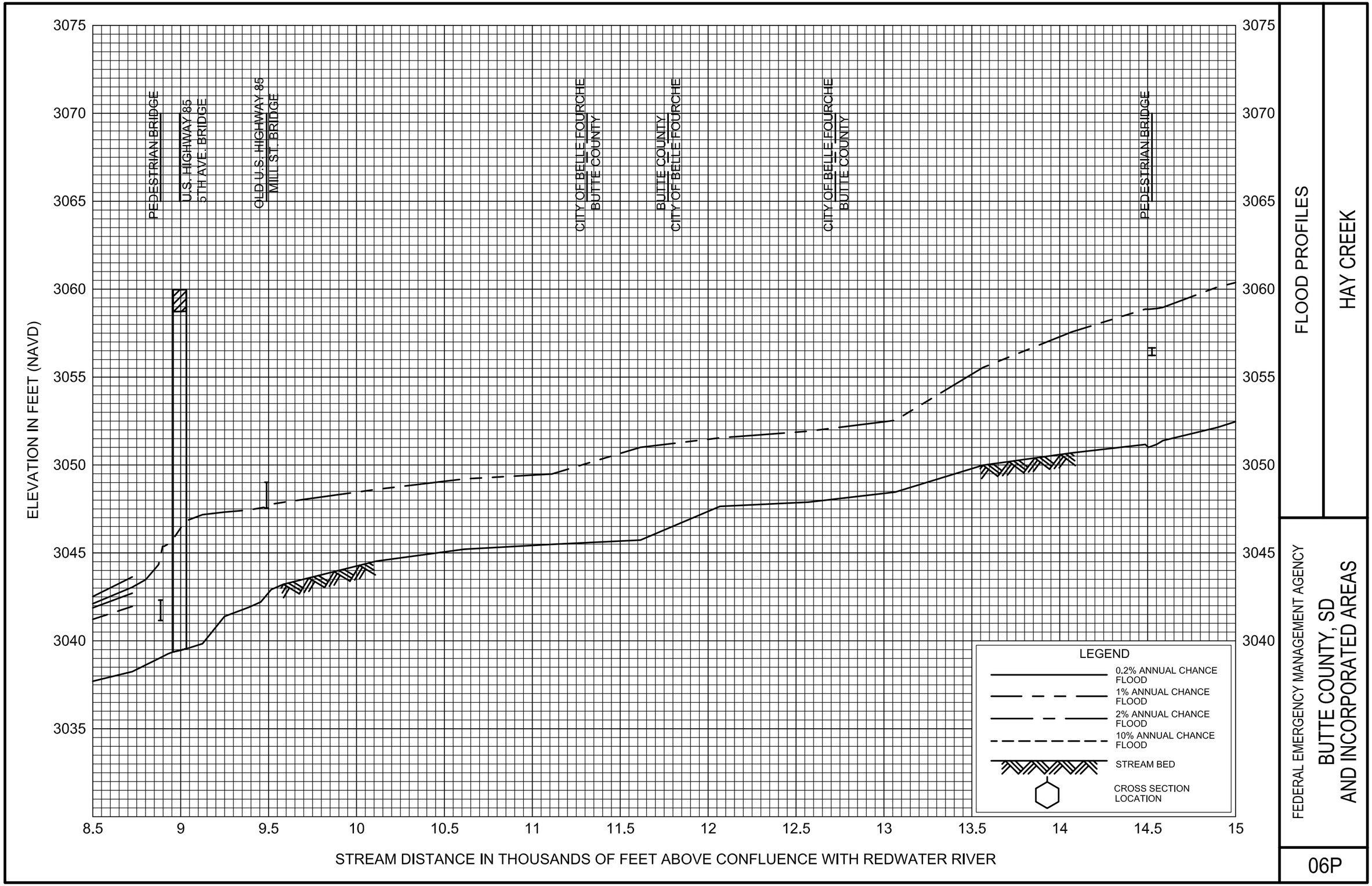


FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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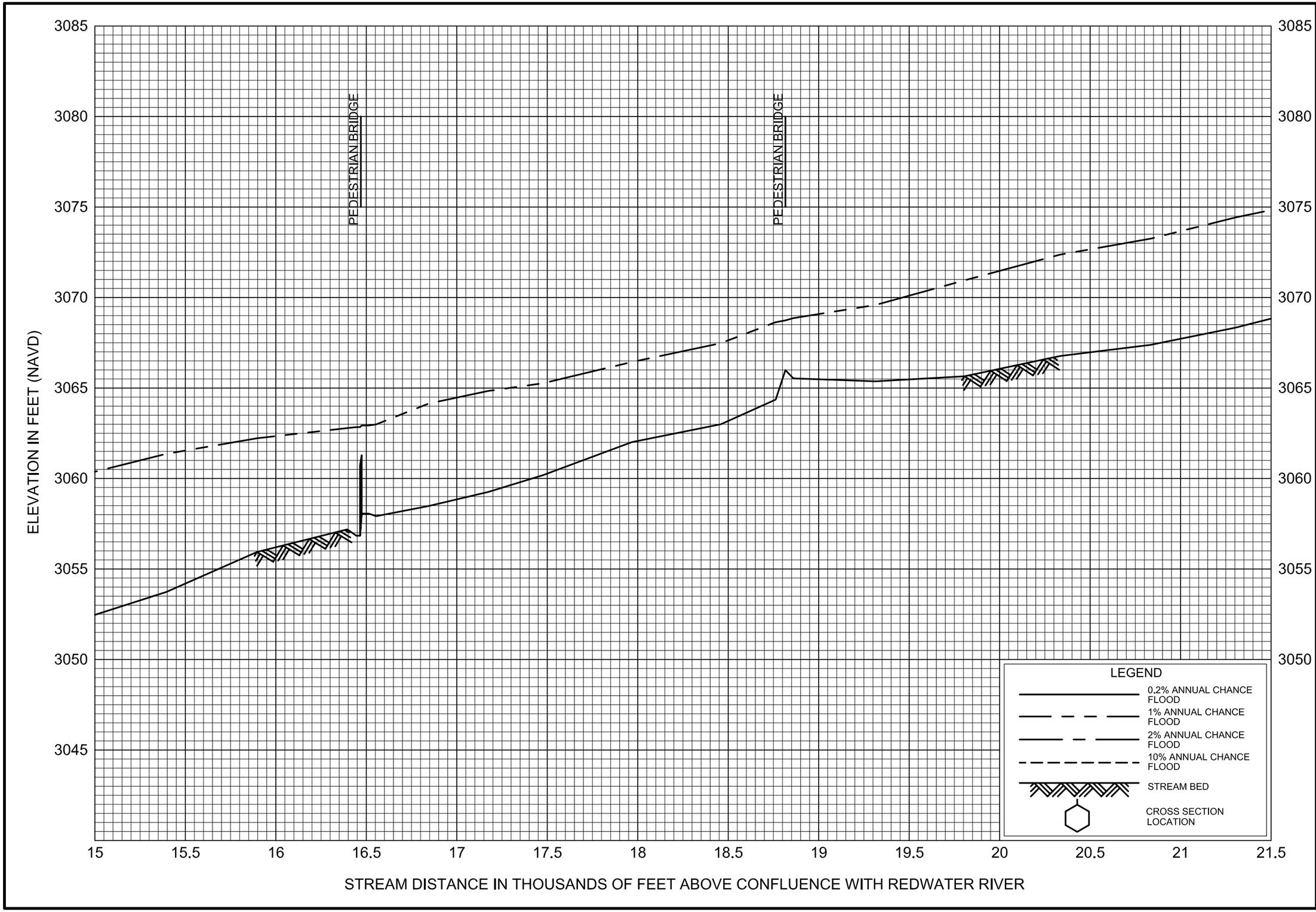


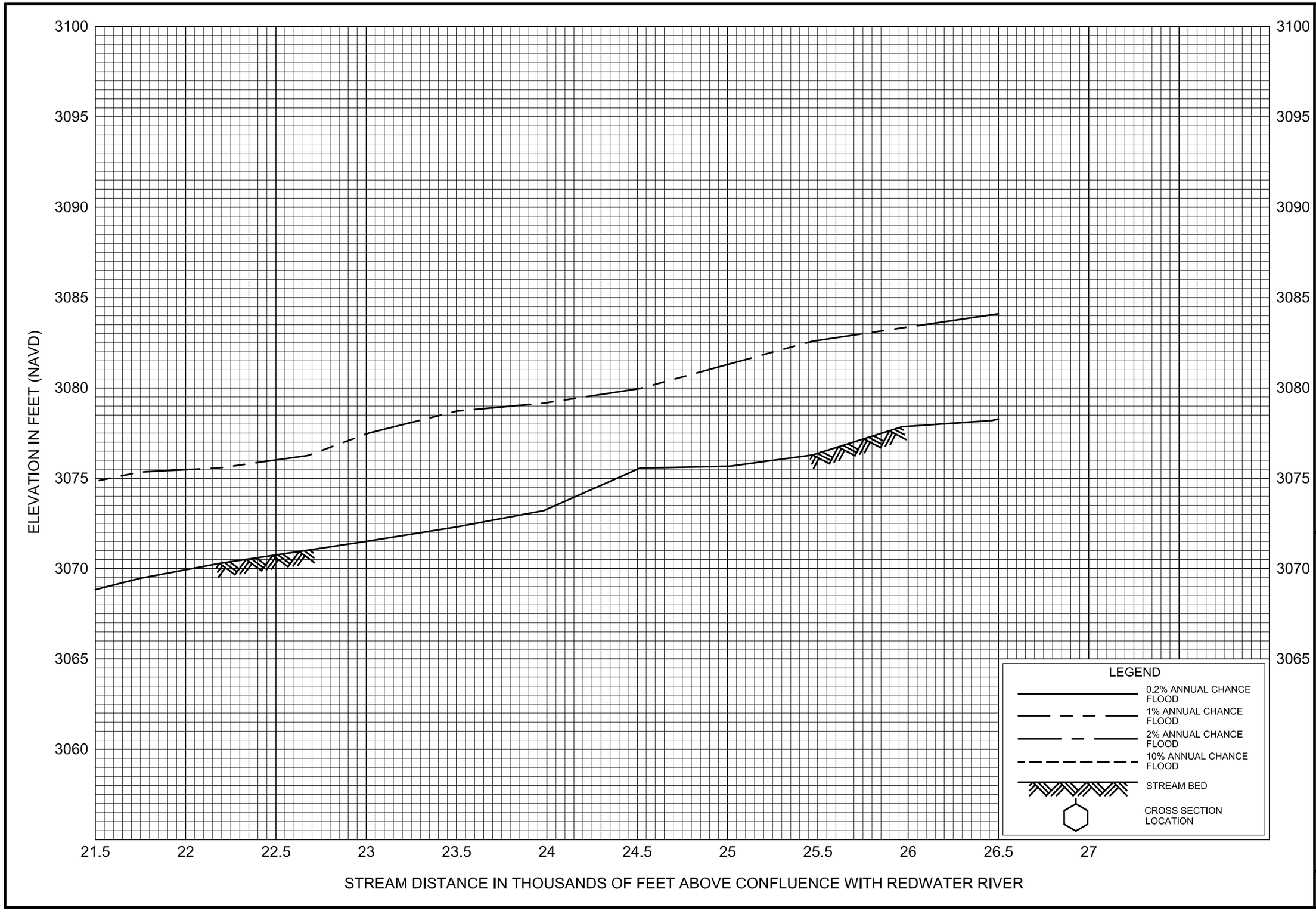

FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

07P



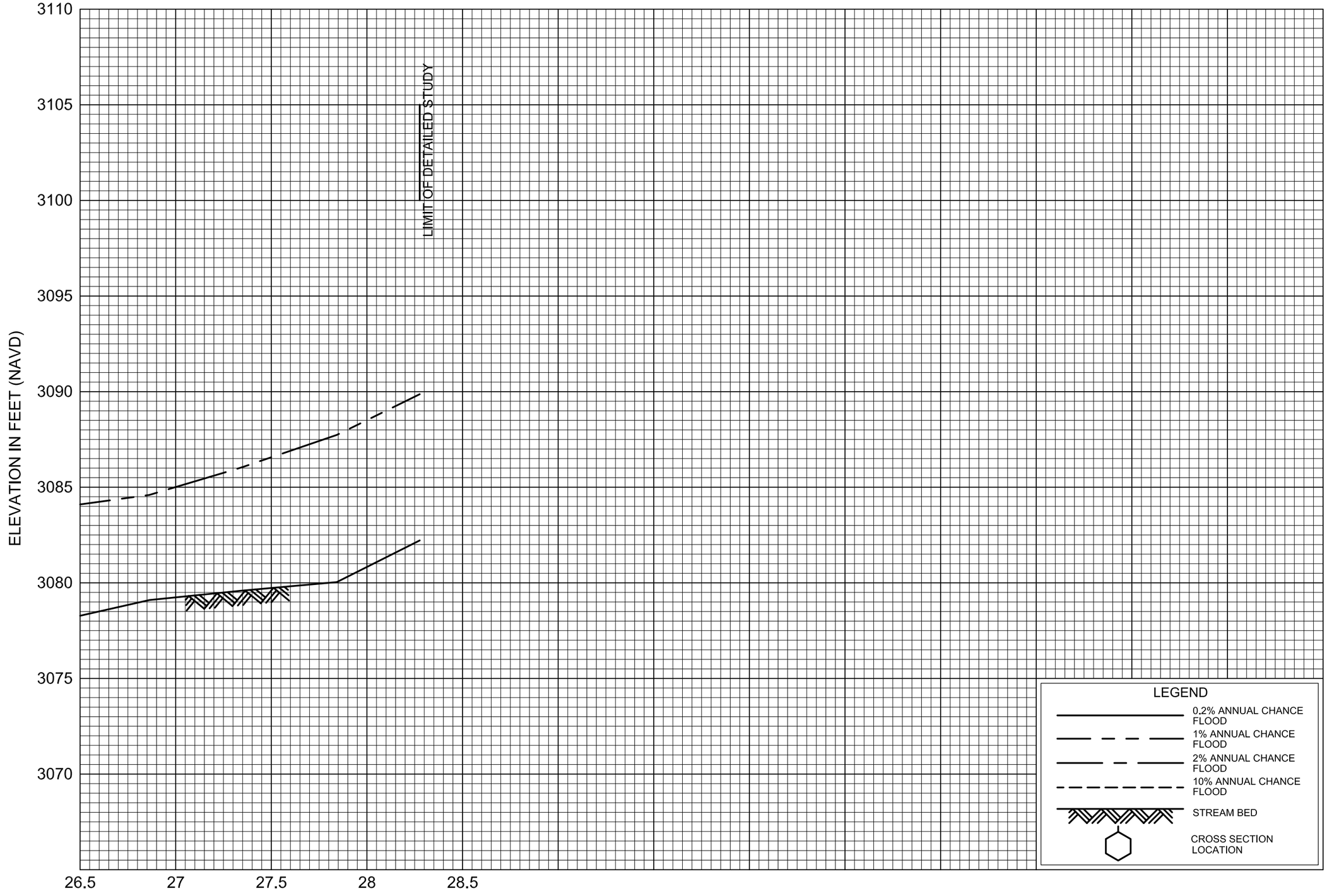

FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

08P




FLOOD PROFILES

HAY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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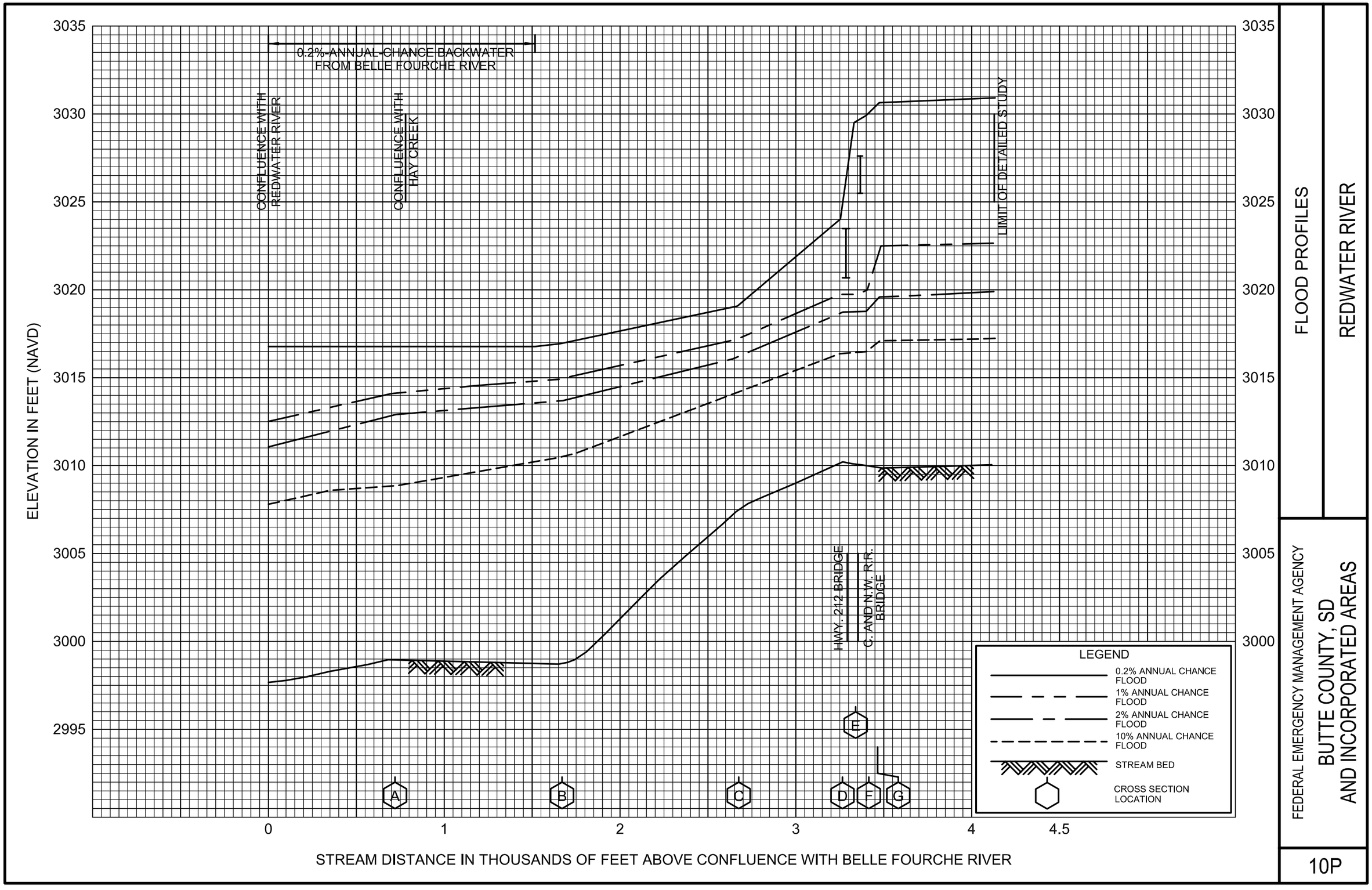


FLOOD PROFILES

REDWATER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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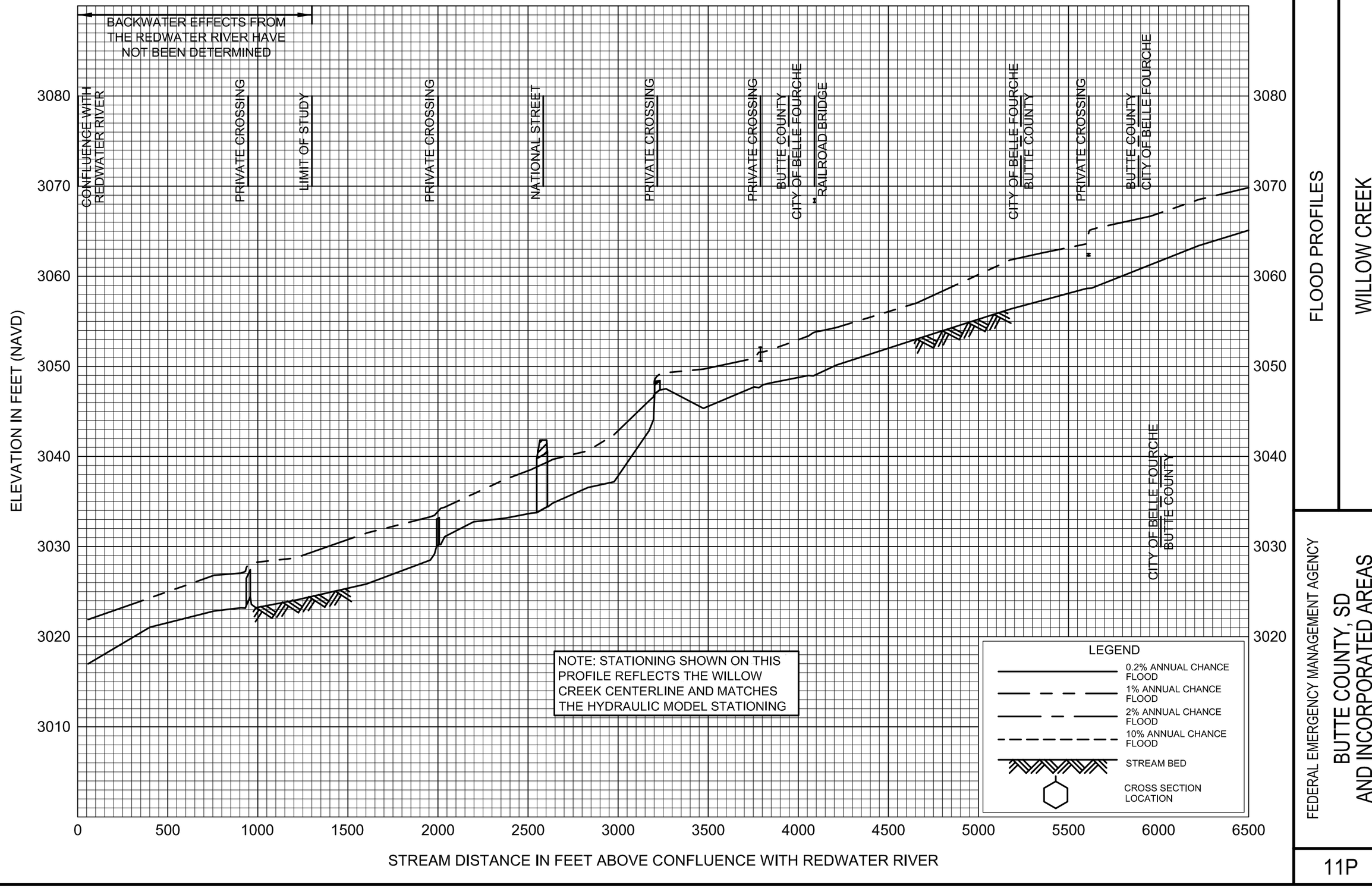
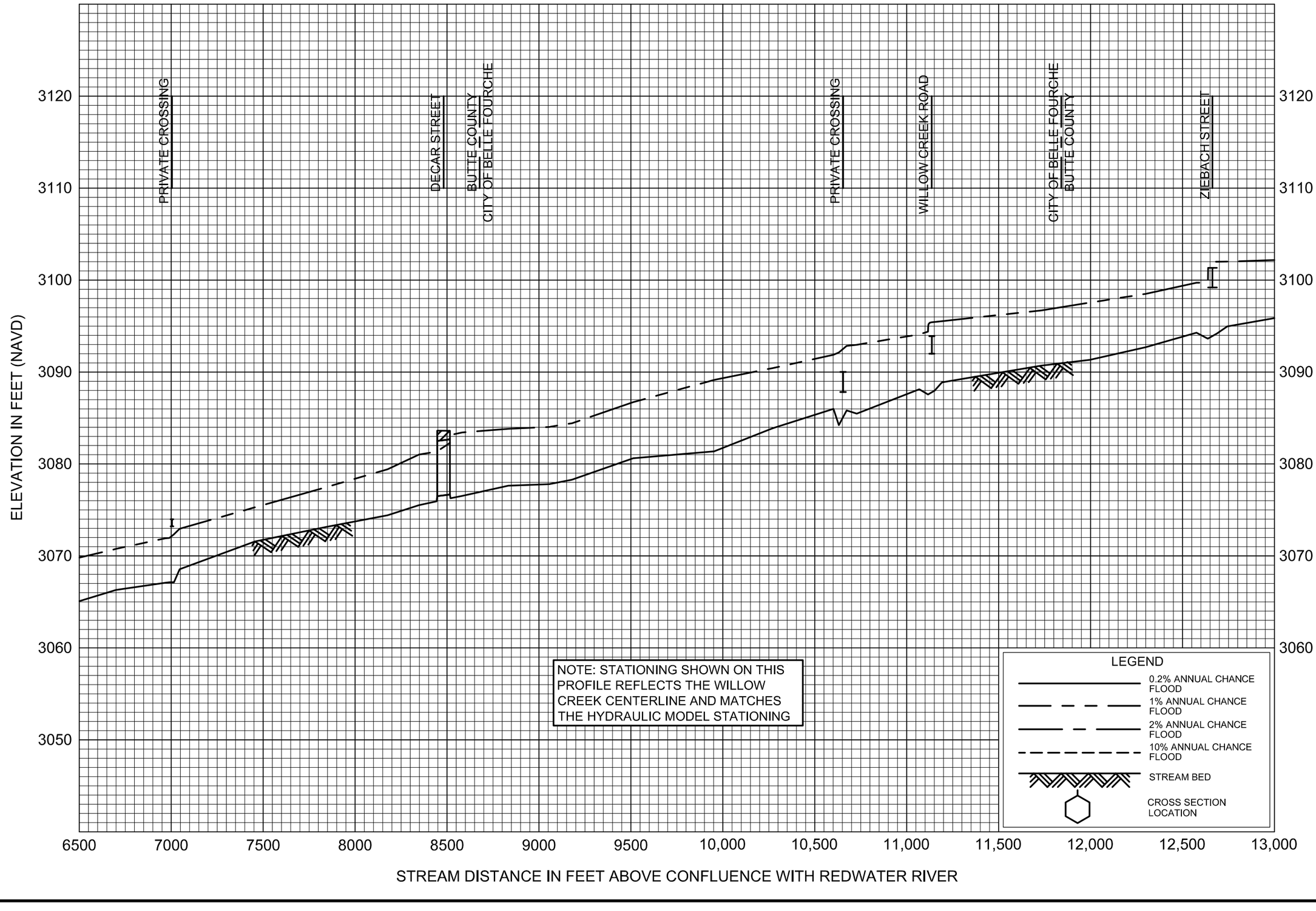



FLOOD PROFILES

WILLOW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS




FLOOD PROFILES

WILLOW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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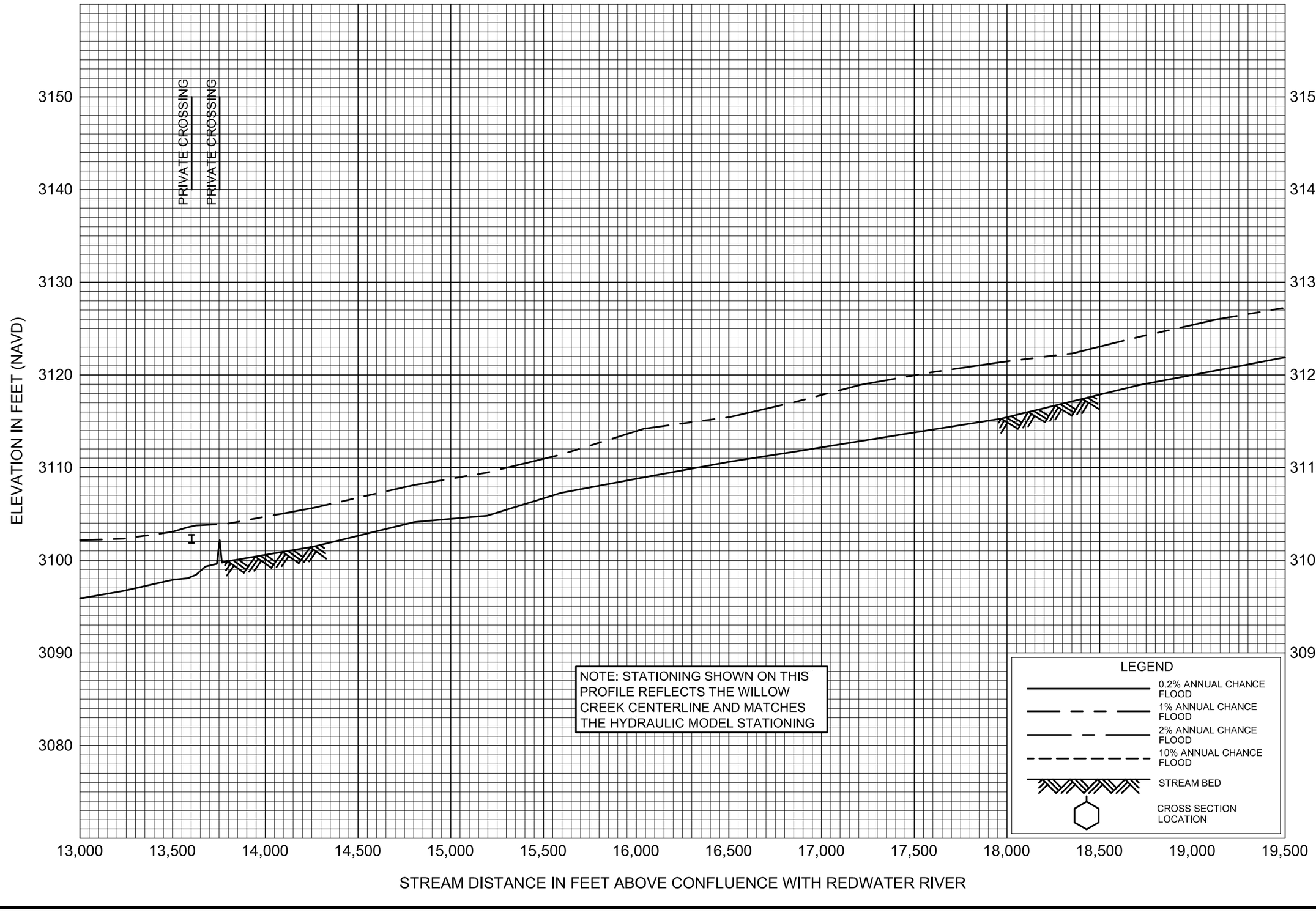


FLOOD PROFILES

WILLOW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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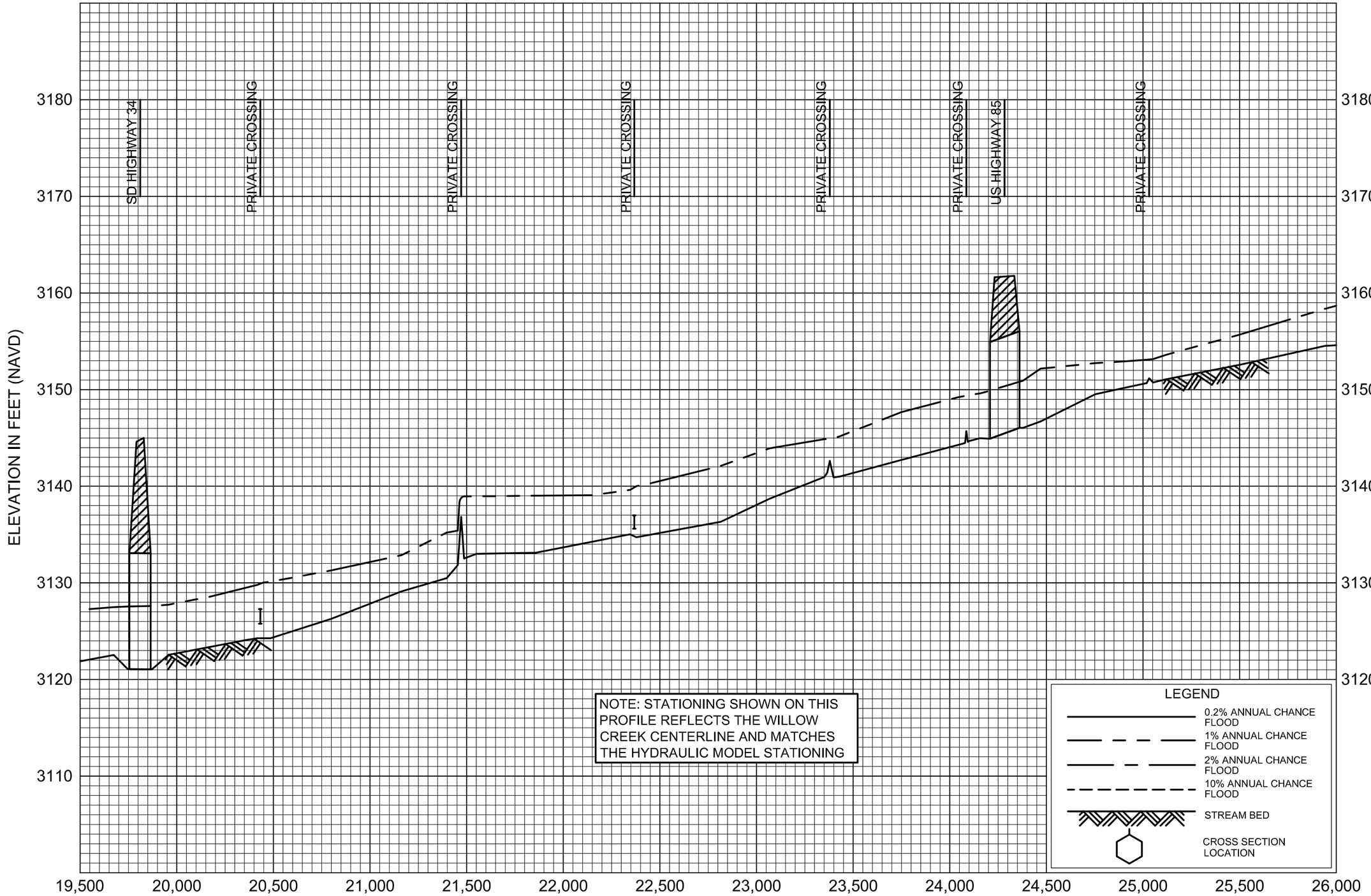


FLOOD PROFILES

WILLOW CREEK

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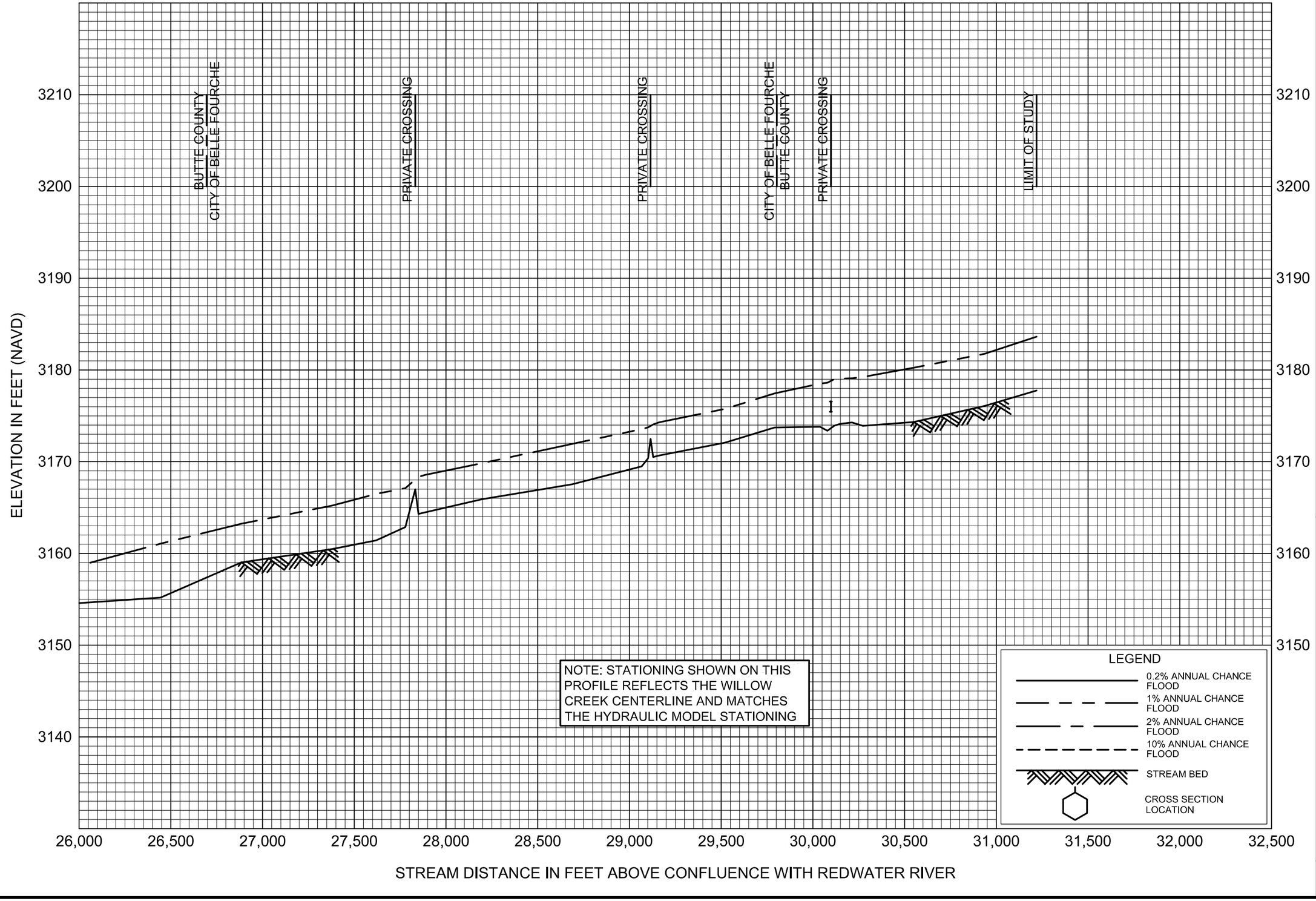


FLOOD PROFILES

WILLOW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, SD
AND INCORPORATED AREAS

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