1984

Flood Insurance Study, City of Logan, Utah, Cache County

Federal Emergency Management Agency

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Logan, Cache County, Utah, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Logan to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

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. These criteria take precedence over the minmum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3. In such cases, however, it shall be understood that the State (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

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

The hydrologic and hydraulic analyses for this study were performed by Rollins, Brown and Gunnell, Inc., for FEMA under Contract No. H-4593. This study was completed in January 1982.

1.3 Coordination

Streams requiring detailed study were discussed at a meeting attended by representatives of FEMA, the study contractor, and the city on August 3, 1979. Results of the hydrologic analysis were sent to the U.S. Army Corps of Engineers (COE), the city, and FEMA for review and comment in June 1981. Copies of the work maps showing flood plain delineations were sent to FEMA and the city in February 1982, and a meeting with FEMA and the city was held on February 19, 1982, for discussion and review. The work maps were revised according to the results of the meeting. The final community coordination meeting was held on November 14, 1983, and was attended by representatives of FEMA, the study contractor, and the city. No significant problems were raised at the meeting.

The COE, the U.S. Soil Conservation Service (SCS), the U.S. Geological Survey (USGS), and the Utah Water Research Laboratory (UWRL) were contacted to obtain any information which would be helpful in flood plain delineation.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Logan, Cache County, Utah. The area of study is shown on the Vicinity Map (Figure 1).

Streams studied by detailed methods were: Logan River, from its emergence from Logan Canyon at State Dam to the Logan corporate limits at 1000 West Street; Spring Creek, from its confluence with Logan River upstream to the Logan corporate limits; and Blacksmith Fork, from its confluence with Logan River upstream to the Logan corporate limits.

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 through August 1984.

2.2 Community Description

The City of Logan has a population of approximately 27,000 and is situated in the central portion of Cache County in Cache Valley between the Bear River and the Wasatch Mountains, in northern Utah. The communities of Smithfield and North Logan lie to the north of the city, while River Heights and Providence lie to the south. North Logan and River Heights share common borders with Logan.

Cache Valley is part of the Bear River Basin, which in turn is located in the Great Salt Lake subbasin of the Great Basin. The three major streams in the study area are Spring Creek, Blacksmith Fork, and the Logan River. Spring Creek and Blacksmith Fork are tributaries to the Logan River, while the Logan River is a tributary to the Bear River. All three streams have their headwaters in the Bear River Mountain Range to the east. The streams originate from snowfed springs in the canyons before emerging into the valley area. Blacksmith Fork and Spring Creek have drainage areas of 287 and 19.9 square miles, respectively, at their confluences with the Logan River. The Logan River has a total drainage area of 524 square miles at the Mendon Road bridge.

Elevations of the watersheds range from above 9,000 feet in the mountains down to approximately 4,500 feet in the valley. Precipitation varies from 16 inches at Logan to 50 inches annually in the high elevations. Winter precipitation usually occurs as snow with the normal annual snowpack ranging from 6 to 8 feet in the mountains. Precipitation in the summer usually originates from high-intensity thunderstorms.

Vegetation in the area varies significantly with elevation, slope, and aspect. Subalpine vegetation can be found on the highest elevations, aspen and conifer forest in the high to middle elevations, and oak and sagebrush in the middle to lower elevations. On south-facing

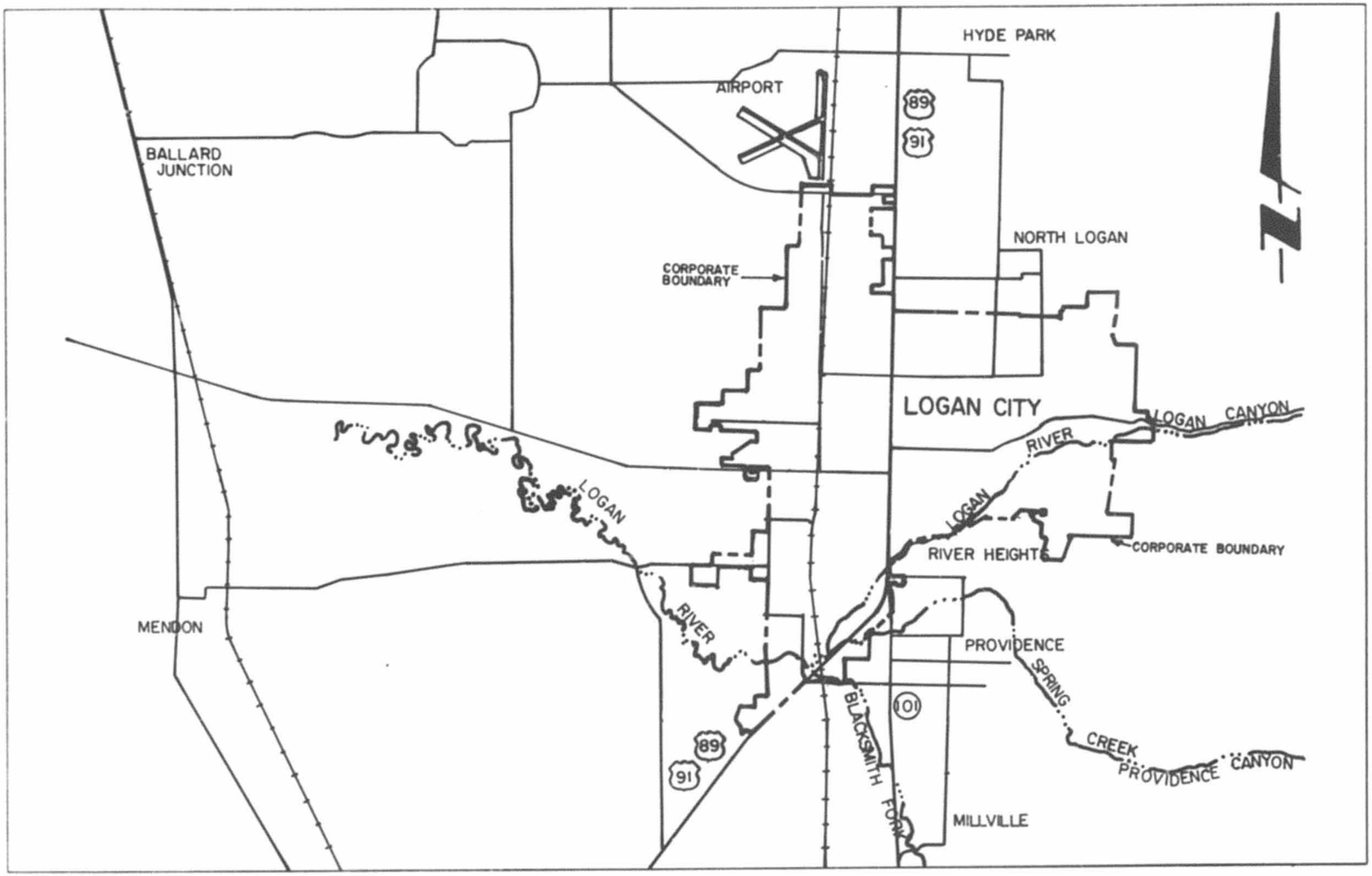


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

APPROXIMATE SCALE

0 8000 16000 24000 32000 FEET

VICINITY MAP

slopes, the oak brush may extend into the higher elevations, while on north-facing slopes, the aspen and conifers may extend into the lower elevations. Many of the south-facing slopes are semiarid, while the north-facing slopes support thick stands of timber and underbrush. Native vegetation in the valley area consists of sage and native grasses with stands of cottonwoods and willows along the stream courses.

Extensive residential development has occurred along the Logan River within the corporate limits of the city; there has been some encroachment on the flood plain, particularly in what is known locally as the Island area. Development along the lower reaches of the Logan River has been limited to farmland and pasture, with a few scattered homes near the river. Past development along Blacksmith Fork and Spring Creek has been limited primarily to farmland and pasture, with scattered farmhouses and barns; however, some development of land near the lower reaches of these streams has occurred recently.

2.3 Principal Flood Problems

Flooding in the Logan area can result from heavy spring snowmelt runoff, from rain falling on snow or frozen ground, or from summer cloudburst storms. All three types of flooding have been reported in the Cache Valley area in the past. The larger floods in this century on both the Logan River and Blacksmith Fork have resulted from spring snowmelt runoff. The largest recorded flood on both occurred in the spring of 1907. The Logan River had a recorded peak discharge of 2,480 cubic feet per second (cfs) at the mouth of Logan Canyon, while Blacksmith Fork had a recorded peak discharge of 1,900 cfs just upstream from its canyon mouth. The 1907 flood was equivalent to approximately the 100-year flood on both streams. A flood in the spring of 1971 on the Logan River flooded backyards of residences adjacent to the river; sandbagging was required. This flood had a recorded peak discharge of 1,680 cfs at the canyon mouth and 1,980 cfs at the Mendon Road bridge. The flood had an estimated return period of approximately 10 years. Flooding on Blacksmith Fork in 1971 was minor and caused little damage.

Spring Creek is an ungaged stream and information regarding past floods on this stream is very limited. The only flood which has been documented on this stream occurred on August 19, 1959, as a result of a heavy cloudburst. The USGS (Reference 1) estimated a peak discharge of 175 cfs at the canyon mouth, which is approximately equivalent to a 15-year flood. The storm caused flooding and damage in the City of Providence, but there were no reports of damage in the City of Logan.

Cloudbursts are an important source of flooding on Spring Creek at the canyon mouth; however, since these floods generally have a small volume, much of the floodwater dissipates before reaching the corporate limits of Logan. Snowmelt or rain-on-snow is felt to be the more critical cause of floods on Spring Creek within the corporate limits.

2.4 Flood Protection Measures

Three small diversion dams have been constructed on the Logan River above the study area. A fourth diversion structure, the Eighth Ward diversion dam, is located in the study area approximately 1.5 miles downstream from the mouth of the canyon and diverts water into the Little Logan River. This stream divides from the Logan River at this point, flows through the southern part of the city, and rejoins the river below the study area. Flow into the Little Logan River is used for irrigation purposes and is regulated by the Eighth Ward diversion structure. None of the above mentioned diversion structures have any significant effect upon the flooding potential of the Logan River. Also, two small irrigation diversion dams are located on Blacksmith Fork in Blacksmith Fork Canyon, but have little effect upon the flooding potential of the river.

Following the 1971 flood, the COE improved the channel of the Logan River from Main Street to 600 West Street. The carrying capacity of the channel was increased by removal of silt and gravel from the channel and forming low levees. These levees will contain the 100- and 500-year floods, but with a freeboard of less than one foot in some places. FEMA guidelines require three feet of freeboard for the 100-year flood for artificial levees; thus, the levees were assumed to be ineffective in the analysis.

A levee constructed along the channel of Blacksmith Fork immediately upstream of the Union Pacific Railroad bridge protects a recent subdivision from the floodwaters of Blacksmith Fork. This levee provides approximately 4 feet of freeboard above the 100-year flood elevation at the downstream end and approximately 3.5 feet of freeboard at the upstream end and is adequate according to FEMA guidelines.

There are no other flood control facilities affecting the city authorized or under investigation at the present time. However, nonstructural measures of flood protection are being utilized to aid in the prevention of future flood damage. These are in the form of land use regulations which control building within the 100-year flood plain.

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 intervals), 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 100-year flood (one percent chance of annual occurrence) in any 50 year period is about 40 percent (four in 10), and for any 90 year period, the risk increases to about 60 percent (six in ten). 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 in the community.

Both the Logan and Blacksmith Fork Rivers have adequate gaging records for flood-frequency analyses. Frequency analyses were conducted in accordance with the U.S. Water Resources Council Guidelines, Bulletin 17A (Reference 2). The log-Pearson Type III probability distribution was assumed and a regional skew of -0.2 was used in calculations. The Logan River above the State Dam streamgage is located at the upstream limit of the study area and has 85 years of record while the Logan River below Blacksmith Fork streamgage is located only a few miles downstream of the study area and has 17 years of record. Thus, frequency estimates for the Logan River could be obtained directly from streamgaging records. The 10-year flood discharge was found to be somewhat larger at the downstream streamgage; however, the 50-, 100-, and 500-year flood discharges were slightly less. This decrease in the flood peak is most likely due to the attenuating effect of the wide flood plain in the valley area.

The Blacksmith Fork above the Utah Power and Light Company dam streamgage has 67 years of record, but is located approximately 9 miles upstream from the study area. Therefore, it was necessary to transfer the flood-frequency estimates at the streamgage downstream to the study area. A 1971 USGS open file Report (Reference 3) which provides statistical regression equations relating watershed area and mean elevation to peak discharge for streams in Utah, was used for this transfer.

Spring Creek is the only ungaged stream in the study area. Three different methods for flood-frequency estimation on ungaged streams in the Logan Region were used to estimate the 10-year flood for Spring Creek. Two of these methods were developed by the USGS (References 3 and 4) using statistical regressions relating parameters such as area and mean elevation to peak discharge.

The third method used was recently adopted by the Federal Highway Administration (Reference 5) for the design of bridges and culverts. This method also employs statistical regression to relate parameters such as area, change in elevation, and rainfall with peak discharge.

All three regional methods result in adequate predictions of the 10-year flood and can be used to obtain estimates up to the 50-year flood. However, predictions of the 50-year flood vary to some extent between methods. The FHWA method is the only one which can be used to estimate floods greater than the 50-year flood. Estimates for the 10-, 25-, and 50-year floods as predicted by the three regional methods were plotted on log-normal probability paper along with a 100-year flood estimate obtained using only the FHWA method. A best fit curve was then drawn through the 10- and 25-year floods using the regional skew of -0.2 for extrapolation to the 50-, 100-, and 500-year floods. The best fit curve followed quite closely the estimates obtained from the FHWA method for the 50- and 100-year floods.

A summary of drainage area-peak discharge relationships for each stream studied is shown in Table 1.

TABLE 1
SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi.)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
LOGAN RIVER					
At State Dam	218	1,670	2,170	2,380	2,880
At Mendon Bridge	524	1,710	2,130	2,300	2,710
SPRING CREEK					
At U.S. Highway 89-91	19.9	160	260	300	420
BLACKSMITH FORK					
At Confluence With Logan River	287	1,070	1,700	2,000	2,750

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail in Logan were carried out to provide estimates of the elevations of floods of selected recurrence intervals along each of the flood sources.

Cross sections used for the backwater analyses of the streams studied were obtained by actual field survey. All bridges, dams, and culverts were field checked to obtain elevation data and structural geometry. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgement and based on field observations of the streams and flood plain areas. Roughness values for the main channels and flood plain areas of flood sources are listed in Table 2. Values shown apply to all floods.

TABLE 2
ROUGHNESS FACTORS

STREAM	ROUGHNESS FACTOR (MANNING'S "N") MAIN CHANNEL VALUES	FLOOD PLAIN VALUES
Logan River	0.033-0.045	0.035-0.080
Spring Creek	0.024-0.040	0.035-0.060
Blacksmith Fork	0.035-0.043	0.045-0.060

Water-surface elevations of floods of the selected recurrence intervals for the detailed study streams were computed by the use of the COE HEC-2 step-backwater computer program (Reference 6). Flood profiles for the selected recurrence intervals were drawn showing the computed water-surface elevation. Starting water-surface elevations for Spring Creek and the Logan River were determined by normal depth calculations. The starting water-surface elevation for Blacksmith Fork was assumed at critical depth since normal depth calculations were in the supercritical flow regime. All elevations in this study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

Since the freeboard for the levees located between the Union Pacific Railroad and the Main Street bridge along the Logan River and immediately upstream of the Union Pacific Railroad along Blacksmith Fork do not meet FEMA standards, it was necessary to evaluate the effect of the levees on water-surface elevations for two opposing conditions. First, it was assumed that the levee would hold during a major flood and water-surface elevations were computed accordingly. Second, it was assumed the levee would not hold and water-surface elevations were computed as if the levee did not exist. Both analyses were used in mapping the flood plain in these areas. For Blacksmith Fork, the two conditions produced nearly identical water surface elevations; whereas, for the Logan River water-surface elevations computed for the first condition were signficantly higher than those computed for the second condition.

The hydraulic analyses for this study were based on unobstructed flow with two exceptions. A culvert on Spring Creek at a field driveway located approximately 400 feet upstream from U.S. 89-91 was assumed to be 50 percent obstructed. This culvert was obstructed at the time of the field survey and is likely to be obstructed at the time of a major flood. The second exception to the assumption of unobstructed flow was at the Union Pacific Railroad bridge over the Logan River approximately 0.3 mile upstream from 600 West Street. This bridge was assumed to be 30 percent obstructed since it is prone to the collection of debris against its piers. The flood elevations shown on the profiles are thus considered valid only if the hydraulic structures, and other than those listed above, remain unobstructed, operate properly, and do not fail.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by FEMA as the base flood for purposes of flood plain management measures. The 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 the 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 a scale of 1:1,200 with a contour interval of 2 feet (Reference 7). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year boundary has been shown.

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map. Small areas within the flood boundaries may lie above the flood elevations, and therefore, may not be subject to flooding. Owing to limitations of the map scale and/or lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 3).

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE (FEET)
LOGAN RIVER								
A[2]	28	61	439	5.2	4,427.5	4,427.5	4,428.5	1.0
B[2]	1,440	364	843	2.7	4,429.3	4,429.3	4,429.7	0.4
C[2]	3,040	68	372	6.2	4,431.8	4,431.8	4,432.1	0.3
D[2]	4,190	78	491	4.7	4,433.7	4,433.7	4,434.5	0.8
E[2]	6,490	110	488	4.7	4,437.9	4,437.9	4,438.2	0.3
F[2]	8,490	60	347	6.6	4,442.7	4,442.7	4,443.1	0.4
G[2]	12,440	145	629	3.7	4,451.0	4,451.0	4,452.0	1.0
H[2]	13,440	87	460	5.0	4,453.3	4,453.3	4,453.8	0.5
I[2]	15,240	95	440	5.2	4,457.4	4,457.4	4,457.6	0.2
J[2]	15,340	130	617	3.7	4,457.9	4,457.9	4,458.2	0.3
K[2]	15,390	130	623	3.7	4,457.9	4,457.9	4,458.2	0.3
L	15,510	102	600	3.8	4,458.1	4,458.1	4,458.3	0.2
M	17,890	55	307	7.5	4,461.9	4,461.9	4,462.7	0.8
N	18,070	99	452	5.1	4,463.9	4,463.9	4,464.0	0.1
O	19,620	115	471	5.1	4,468.1	4,468.1	4,469.1	1.0
P	19,740	200	1,414	1.7	4,471.5	4,471.5	4,472.3	0.8
Q	23,040	88	361	6.6	4,484.1	4,484.1	4,484.1	0.0
R	24,990	68	219	10.9	4,492.6	4,492.6	4,492.6	0.0
S	27,240	52	318	7.5	4,506.9	4,506.9	4,506.9	0.0
T[2]	27,540	52	251	9.5	4,507.8	4,507.8	4,507.9	0.1
U	28,230	80[3]	316	7.5	4,512.9	4,512.9	4,512.9	0.0
V	28,400	53[3]	263	9.1	4,514.5	4,514.5	4,514.5	0.0

[1] Stream Distance in Feet Above Mendon Road.

[2] Cross Section is Outside of Corporate Limits and is not Shown on the Flood Boundary and Floodway Map.

[3] This Width Extends Beyond Corporate Limits.

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT

(CACHE CO.)

FLOODWAY DATA

LOGAN RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE (FEET)
LOGAN RIVER (continued)								
W	30,565	67[2]	309	7.7	4,528.1	4,528.1	4,528.3	0.2
X	30,720	114[2]	419	5.7	4,529.1	4,529.1	4,529.3	0.2
Y	31,570	71[2]	290	8.2	4,533.4	4,533.4	4,533.4	0.0
Z	31,716	55[2]	377	6.3	4,536.3	4,536.3	4,536.3	0.0
AA	33,540	55	199	11.9	4,548.6	4,548.6	4,548.6	0.0
AB	33,720	55	285	8.4	4,553.5	4,553.5	4,553.5	0.0
AC	34,480	54	317	7.5	4,558.2	4,558.2	4,558.2	0.0
AD	34,640	88	256	9.3	4,559.3	4,559.3	4,559.3	0.0
AE	35,600	51	249	9.6	4,568.9	4,568.9	4,568.9	0.0
AF	35,763	80	337	7.1	4,573.0	4,573.0	4,573.0	0.0
AG	36,723	57	295	8.1	4,578.3	4,578.3	4,578.4	0.1
AH	36,773	66	516	4.6	4,586.9	4,586.9	4,587.9	1.0
AI	36,913	71	536	4.4	4,587.1	4,587.1	4,588.1	1.0
AJ	38,790	98	246	9.7	4,597.7	4,597.7	4,597.7	0.0
AK	40,300	67	307	7.8	4,615.6	4,615.6	4,615.6	0.0
AL	42,730	68	198	12.0	4,641.5	4,641.5	4,641.5	0.0
AM	42,900	75	517	4.6	4,645.8	4,645.8	4,645.8	0.0
LOGAN RIVER without consideration of levee								
Q	23,040	483	866	2.7	4,481.8	4,481.8	4,482.8	1.0

[1]Stream Distance in Feet Above Mendon Road.
[2]This Width Extends Beyond Corporate Limits.

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

FLOODWAY DATA

LOGAN RIVER, LOGAN RIVER WITHOUT CONSIDERATION OF LEVEE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE (FEET)
BLACKSMITH FORK								
A	765	56	261	7.7	4,467.6	4,467.6	4,467.9	0.3
B[2]	3,525	43	103	9.3	4,472.9	4,472.9	4,473.8	0.9
C[2]	3,640	59	188	5.1	4,476.1	4,476.1	4,476.7	0.6
D[2]	7,690	127	252	3.8	4,487.6	4,487.6	4,488.6	1.0
E[2]	8,890	94	149	6.4	4,494.3	4,494.3	4,494.8	0.5
F[2]	11,390	60	210	4.5	4,507.4	4,507.4	4,507.8	0.4
G[2]	11,474	809	415	4.8	4,508.6	4,508.6	4,509.6	1.0
H[2]	11,490	1,326	1,700	1.2	4,509.0	4,509.0	4,510.0	1.0
I[2]	11,590	1,388	2,916	0.7	4,509.2	4,509.2	4,510.0	0.8
J[2]	12,590	47	182	11.0	4,514.2	4,514.2	4,514.2	0.0
K[2]	12,635	32	158	12.7	4,515.4	4,515.4	4,515.4	0.0
L[2]	12,684	32	228	8.8	4,517.5	4,517.5	4,517.5	0.0
M[2]	12,744	375	1,946	1.0	4,519.1	4,519.1	4,519.1	0.0

[1] Stream Distance in Feet Above Mouth.

[2] Cross Section is Outside of Corporate Limits and is not Shown on the Flood Boundary and Floodway Map.

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

FLOODWAY DATA

BLACKSMITH FORK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE (FEET)
SPRING CREEK								
A	900	42	94	3.2	4,474.4	4,474.4	4,475.4	1.0
B	2,680	438[3]	84	3.6	4,482.2	4,482.2	4,482.8	0.6
C	2,817	139[3]	211	1.4	4,484.4	4,484.4	4,485.3	0.9
D[2]	3,035	118	338	0.9	4,487.9	4,487.9	4,487.9	0.0
E[2]	4,135	33	49	6.1	4,488.5	4,488.5	4,488.5	0.0
F[2]	4,365	31	103	2.9	4,494.7	4,494.7	4,494.7	0.0
G[2]	6,495	28	48	6.2	4,501.3	4,501.3	4,501.3	0.0
H[2]	6,855	159	306	1.0	4,504.5	4,504.5	4,504.5	0.0
I[2]	7,355	18	41	7.4	4,506.7	4,506.7	4,506.7	0.0
J[2]	9,655	62	101	3.0	4,524.7	4,524.7	4,524.8	0.1
K[2]	9,955	94	669	0.4	4,534.4	4,534.4	4,534.4	0.0

[1]Stream Distance in Feet Above Mouth.

[2]Cross Section is Outside of Corporate Limits and is not Shown on the Flood Boundary and Floodway Map.

[3]This Width Extends Beyond Corporate Limits.

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

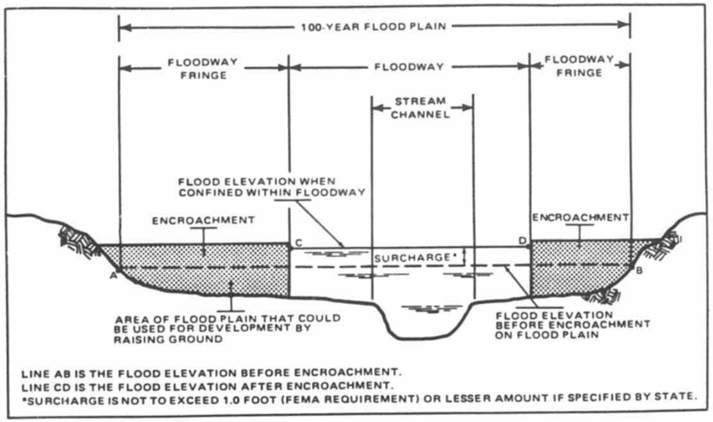
CITY OF LOGAN, UT
(CACHE CO.)

FLOODWAY DATA

SPRING CREEK

As shown on the Flood Boundary and Floodway Map, the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year 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 2.



5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FEMA has

developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source affecting the City of Logan.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot

Three reaches meeting the above criteria were required for the flooding sources of Logan. These include one reach on the Logan River, one on Blacksmith Fork, and one reach on Spring Creek. The locations of the reaches are shown on the Flood Profiles.

5.2 Flood Hazard Factor

The Flood Hazard Factor is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their assigned FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100- year flood water-surface elevations expressed to the nearest one-half foot and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, the accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of Logan was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zones A1 and A2: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones assigned according to FHFs.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; or, areas subject to 100-year flooding from sources with drainage areas of less than one square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Logan is, for insurance purposes, the principal result of the Flood Insurance Study. 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 (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

6.0 OTHER STUDIES

No previous Flood Insurance Studies have been conducted for the City of Logan. However, a Flood Hazard Boundary Map (Reference 8) was prepared by the Federal Insurance Administration and published in 1977. This map is superseded by the present study. The COE completed a Flood Plain Information report for the Logan River in 1973 (Reference 9) and a Flood Plain Information report for Blacksmith Fork and Spring Creek in 1976 (Reference 10). These investigations included mapping of the flood plains along the various streams for the intermediate regional and standard

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND 10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)	HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
Logan River Reach 1	0005,0006 0007,0008	-0.9	-0.2	0.5	010	A2	Varies-See Map
Blacksmith Fork Reach 1	0008	-1.0	-0.2	0.4	010	A2	Varies-See Map
Spring Creek Reach 1	0008	-0.3	-0.1	0.1	005	A1	Varies-See Map

[1]Flood Insurance Rate Map Panel

[2]Weighted Average

[3]Rounded to Nearest Foot

BEST COPY AVAILABLE

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

FLOOD INSURANCE ZONE DATA

LOGAN RIVER, BLACKSMITH FORK, SPRING CREEK project floods.[1]

Significant differences were found between the water-surface elevations and flood plain boundaries computed by the COE for the intermediate regional flood and those computed in this Flood Insurance Study for the 100-year flood on the Logan River, Blacksmith Fork, and Spring Creek. Water-surface elevations computed in this study were generally lower than those computed by the COE.

The differences may be attributed mainly to the different hydrologic and hydraulic methodologies used. The peak flood discharges used in hydraulic computations for this study differed significantly from that of the COE for the Logan Rliver below its confluence with Blacksmith Fork, for Blacksmith Fork, and Spring Creek. A report was prepared (Reference 11) outlining the rationale and computations employed to obtain the peak discharges used in this study and was submitted to the COE for review and comments. The COE indicated that the flood discharge estimates used in this study are reasonable since they were based upon more recent information than was available at the time of their studies.

More improved mapping was available for this Flood Insurance Study than was available to the COE at the time of their study. Aerial photographic maps at a scale of 1:1,200 with a contour interval of 2 feet were used for the Logan River above 1000 West Street, Blacksmith Fork below 1700 South Street, and Spring Creek below State Road 165, whereas, the COE was obliged to use USGS Quadrangle Maps at a scale of 1:24,000 with a contour interval of 10 feet.

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(1) The COE defines the intermediate regional and standard project floods as follows:

Intermediate Regional Flood. A flood having an average frequency of occurence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally approximately 40 to 60 percent of the Probable Maximum Floods for the same basins. As used by the COE. Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

One specific point where the 100-year flood profile of this study differs significantly from that of the COE study is at the Union Pacific Railroad bridge over the Logan River just above the confluence of Blacksmith Fork. The difference is due to the assumption of 30 percent blockage by debris in computations made for this study, whereas the COE assumed no debris blockage. This resulted in a higher water-surface elevation upstream of bridge.

There are no other studies past or present which will significantly affect the results of this study. Flood discharges, elevations, and boundaries as computed in the Flood Insurance Study were adopted for use since it was determined that they best represent current hydrologic and hydraulic procedures and existing physical and topographic conditions.

7.0 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, Building 710, Denver Federal Center, Lakewood, Colorado 80225.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Department of the Interior, Geological Survey, Cloudburst Floods and Mud Rock Flows Between Providence and Millville Canyons, Office Memorandum, Salt Lake City, Utah, 1959.

2. U.S. Water Resources Council, "Guidelines for Determining Flood Flow Frequency", Bulletin 17A, 1977.

3. U.S. Department of the Interior, Geological Survey, Open-File Report, Floods of Utah, Magnitude and Frequency Characteristics through 1969, E. Butler and R.W. Cruff, 1971.

4. U.S. Department of the Interior, Geological Survey, Water-Supply Paper 1684, Magnitude and Frequency of Floods in the United States, Part 10, The Great Basin, E. Butler, J.K. Reid, and V.K. Berwick, 1966.

5. U.S. Department of Transportation, Federal Highway Administration, Runoff Estimates for Small Rural Watersheds and Development of a Sound Design Method, Volumes I and II, Prepared by Utah Water Research Laboratory, Utah State University, 1977.

6. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, Computer Program 723-X6-L202A HEC-2 Water-Surface Profiles, Davis, California, November 1976 with updates.

7. City of Logan, Utah, Aerial Topographic Maps, Scale: 1:1,200, contour interval: 2 feet.

8. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, City of Logan, Utah, 1977 revised.

9. U.S. Department of the Army, Corps of Engineers, Sacramento District, Logan River, Logan, Utah, Floodplain Information Report, 1973.

10. U.S. Department of the Army, Corps of Engineers, Blacksmith Fork and Spring Creek, Millville, Utah, Flood Plain Information Report, 1976.

11. Rollins, Brown and Gunnell, Inc. Hydrology Report of Flood Insurance Studies for Logan, Utah and Adjacent Areas, 1981.

Dawdy, David R., Flood Frequency Estimates on Alluvial Fans, Journal of the Hydraulics Division, ASCE., November, 1979, HY11, pp. 1407-1413.

Magura, Lawrence M. and Darrel E. Wood, Flood Hazard Identification and Flood Plain Management on Alluvial Fans, Water Resources Bulletin, American Water Resources Association, February 1980, pp. 56-62.

McCuen, Richard H., Map Skew???, Journal of the Water Resources Planning and Management Division, ASCE, 1979, WR2, pp. 269-27?.

Powell, Roy F. and L. Douglas James, Approximate Method for Quick Flood Plain Mapping, Journal of the Water Resources Planning and Management Division ASCE, WR1, March 1980, pp. 103-122.

U.S. Department of Agriculture, Agricultural Research Service, Flood Flow Frequency for Ungaged Watersheds; A Literature Evaluation, Richard H. McCuen, 1977.

U.S. Department of Agriculture, Soil Conservation Service, Forest Service, and Economic Research Service, Bear River Basin Cooperative Study, Idaho, Utah, Wyoming, Floods Working Paper, 1977.

U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.

U.S. Department of Agriculture, Soil Conservation Service, Soil Survey of Cache Valley Area, Utah, Parts of Cache and Box Elder Counties, 1974.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Precipitaion-Frequency Atlas of the Western United States, Volume VI-Utah, 1973.

U.S. Department of the Interior, Bureau of Reclamation, Flood Frequency Study for Blacksmith Fork Diversion Damsite-Bear River Project, Utah-Idaho, 1967.

U.S. Department of the Interior, Bureau of Reclamation, Flood Frequency Study for Logan River Diversion Dam - Bear River Project, Utah Idaho, 1966.

U.S. Department of the Interior, Geological Survey, Utah Division of Water Resources Cooperative Investigations, Report No. 11, Developing a State Water Plan, Cloudburst Floods in Utah 1939-1969, Elmer Butler, 1972.

U.S. Department of the Interior, Geological Survey, Water Resources Data for Utah, 1961-1978.

U.S. Department of the Interior, Geological Survey, Water Resources, Estimating Streamflow Characteristics for Streams in Utah Using Selected Channel - Geometry Parameters, Fred K. Fields, 1975.

U.S. Department of the Interior, Geological Survey, Water-Supply Paper 994, Cloudburst Floods in Utah, 1850-1938, 1946.

Utah State University, Department of Soils and Biometeorology, Estimated Return Periods for Short-Duration Precipitation in Utah, E. Arlo Richardson, 1971.

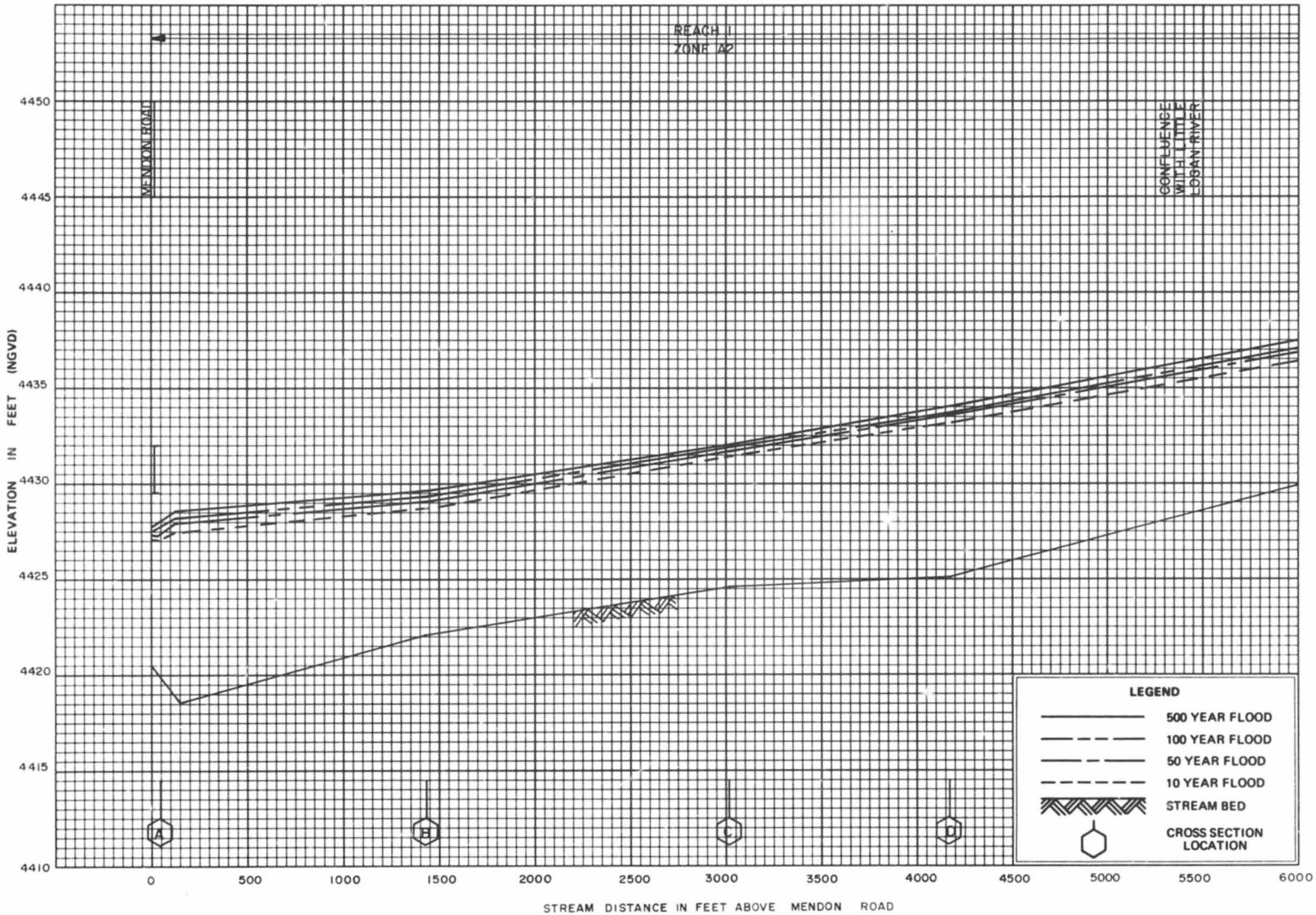
U.S. Water Resources Council, Pacific Southwest Interagency Committee, Great Basin Region Comprehensive Frame Work Study, Appendix IX, Flood Control, 1971

Utah Water Research Laboratory, Flood Damage Mitigation in Utah, Terrence L. Glover, Daniel H. Hoggan, L. Douglas James, Dean T. Larsen, 1980.

Utah Water Research Laboratory, Hydrologic Atlas of Utah, R.W. Jeppson, et.al., 1968.

Utah Water Research Laboratory, Hydrologic Inventory of the Bear River Study Unit, Frank W. Haws and Trevor C. Hughes, Logan, Utah, 1973.

Whitaker, G.L., Summary of Maximum Discharges in Utah Streams, State of Utah Technical Publication No. 21, 1969.



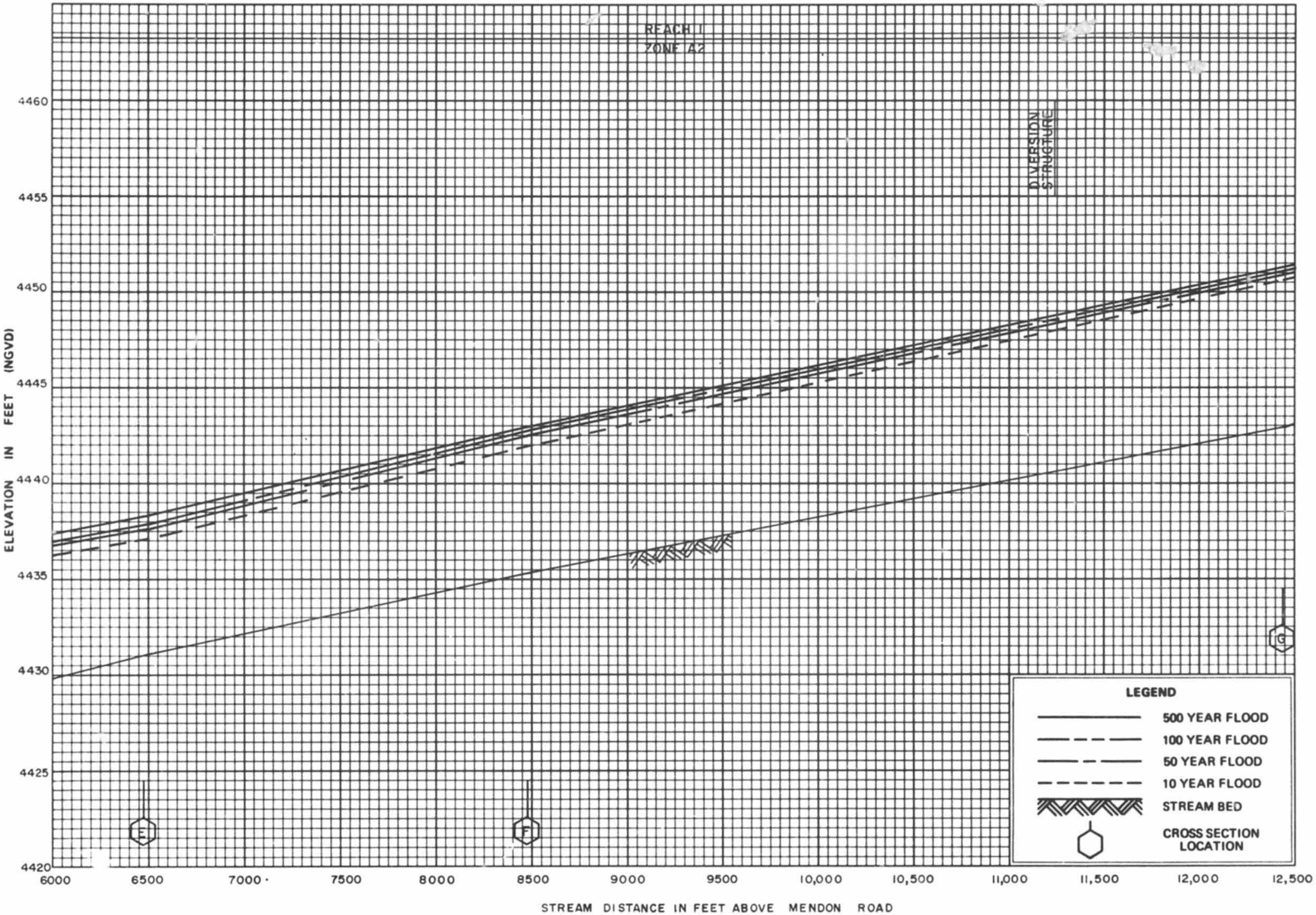
FLOOD PROFILES

LOGAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

01P



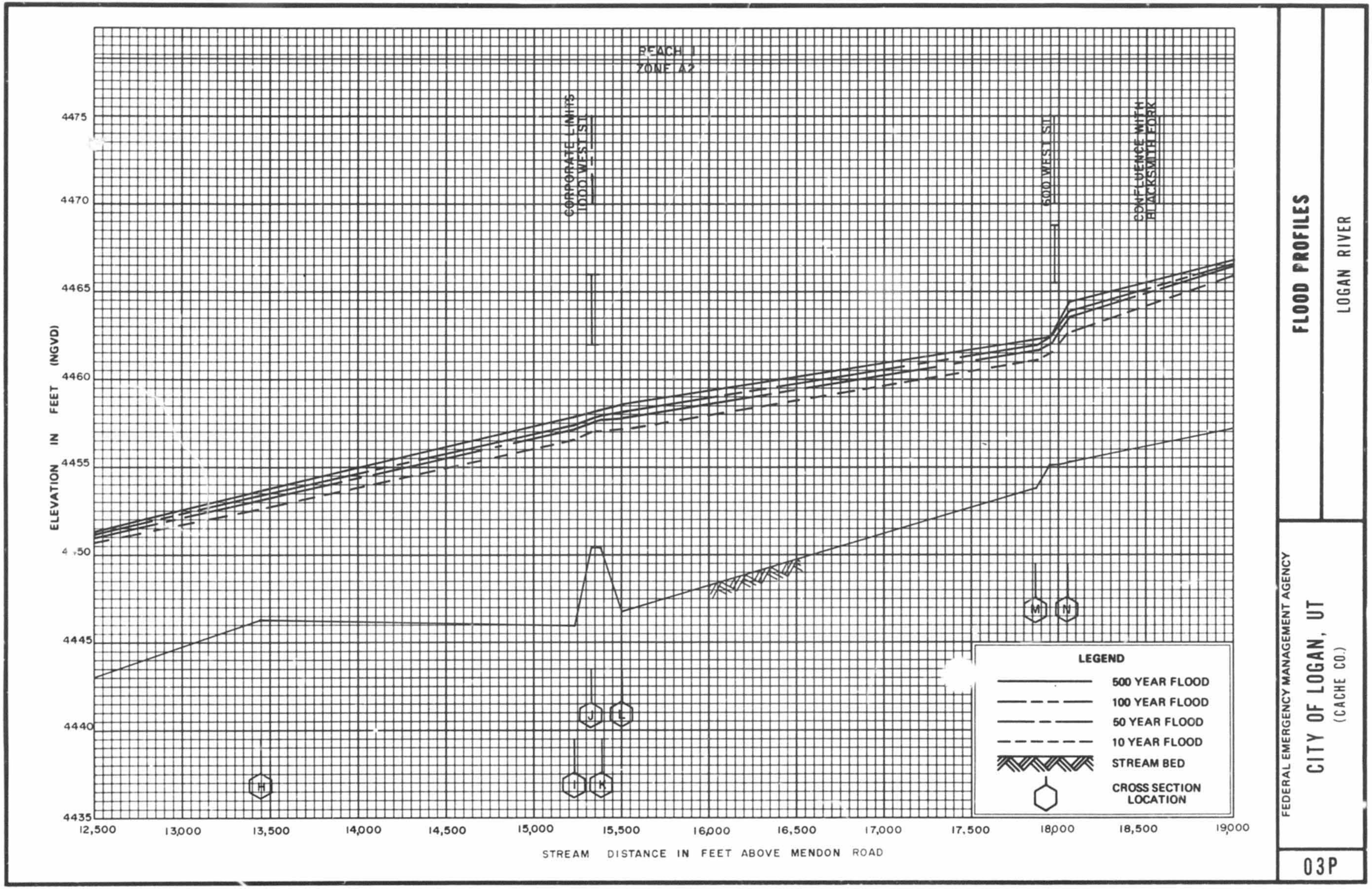
FLOOD PROFILES

LOGAN RIVER

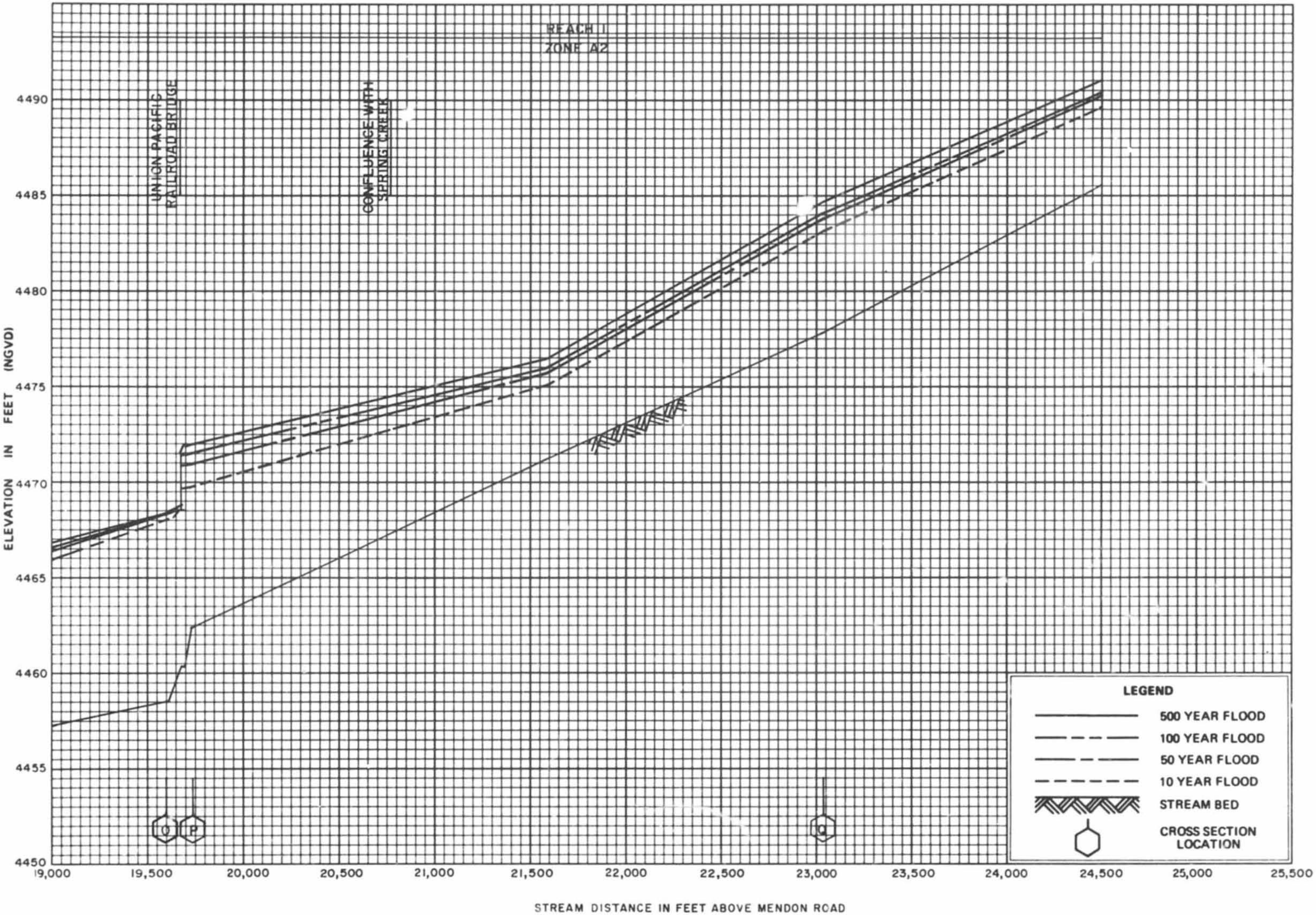
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

02P



REACH I
ZONE A2
CORPORATE LIMITS
1000 WEST ST.
600 WEST ST.
CONFLUENCE WITH BLACKSMITH FORK
ELEVATION IN FEET (NGVD)
4475
4470
4465
4460
4455
4450
4445
4440
4435
12,500
13,000
13,500
14,000
14,500
15,000
15,500
16,000
16,500
17,000
17,500
18,000
18,500
19,000
STREAM DISTANCE IN FEET ABOVE MENDON ROAD
H
I
J
K
L
M
N
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
LOGAN RIVER
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
03P



FLOOD PROFILES

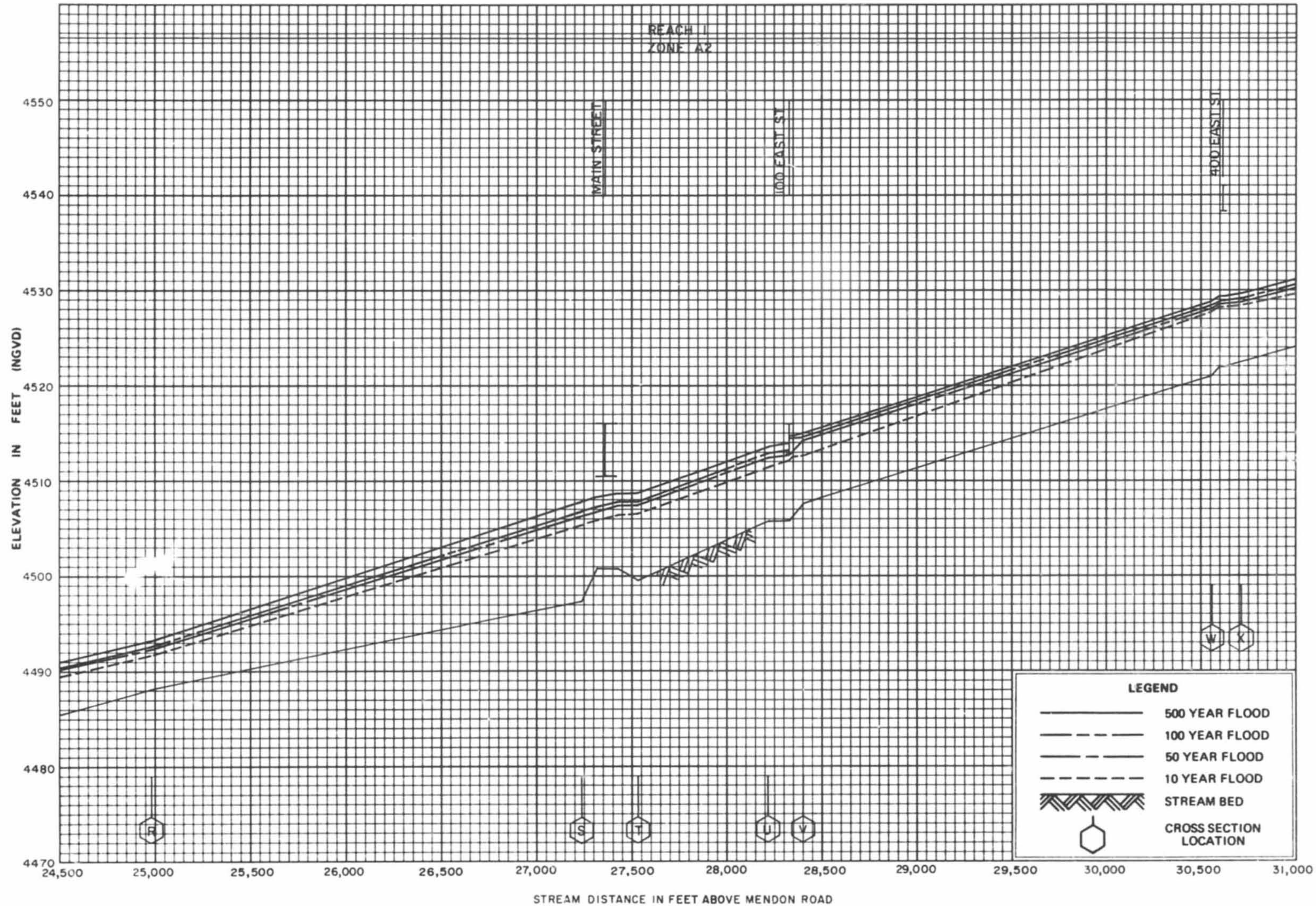
LOGAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT

(CACHE CO.)

04P



FLOOD PROFILES

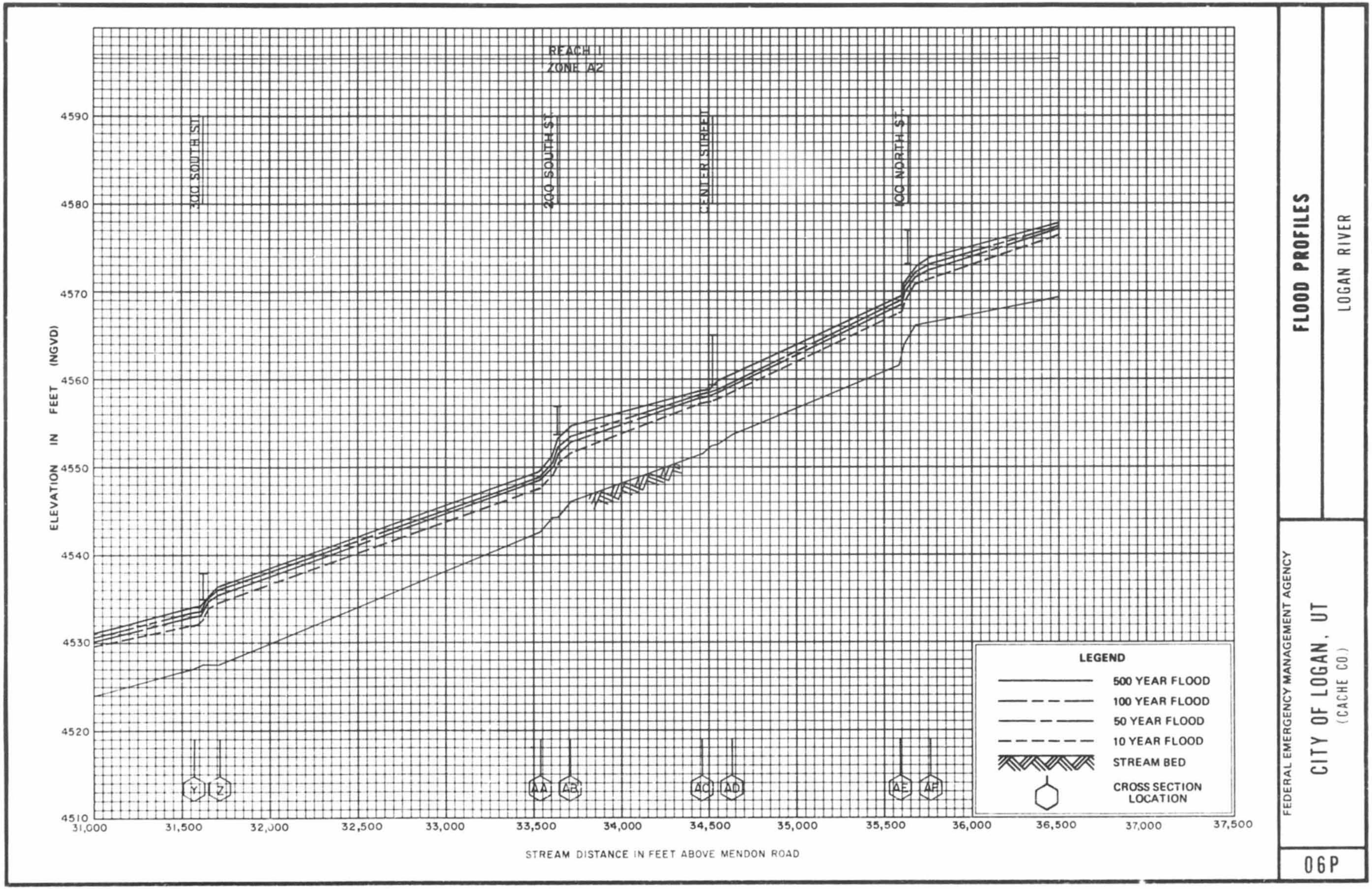
LOGAN RIVER

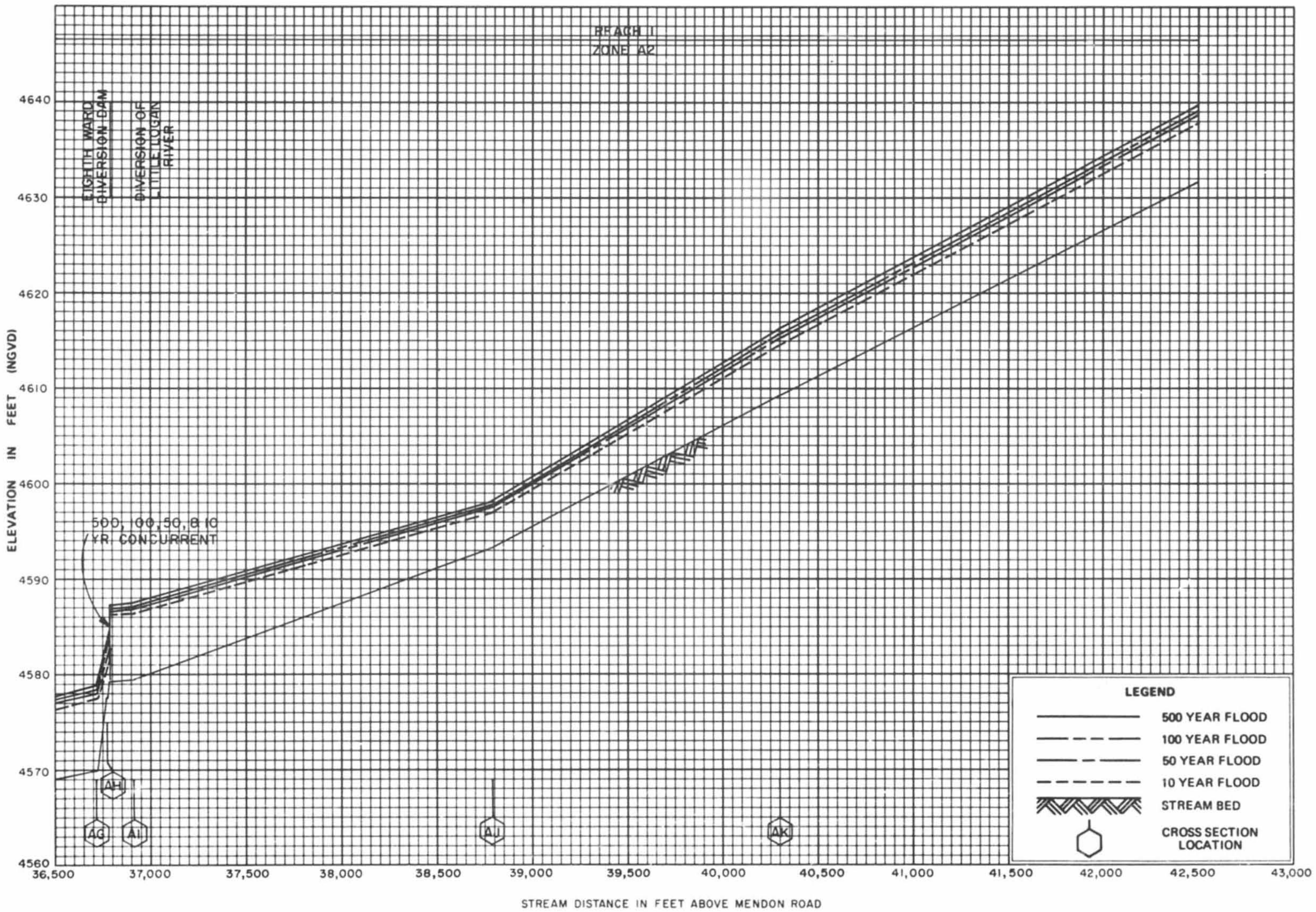
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT

(CACHE CO.)

05P


REACH I
ZONE A2
300 SOUTH ST.
200 SOUTH ST.
CENTER STREET
100 NORTH ST.
ELEVATION IN FEET (NGVD)
4510
4520
4530
4540
4550
4560
4570
4580
4590
31,000
31,500
32,000
32,500
33,000
33,500
34,000
34,500
35,000
35,500
36,000
36,500
37,000
37,500
STREAM DISTANCE IN FEET ABOVE MENDON ROAD
Y
Z
AA
AB
AC
AD
AE
AF
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
LOGAN RIVER
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
06P



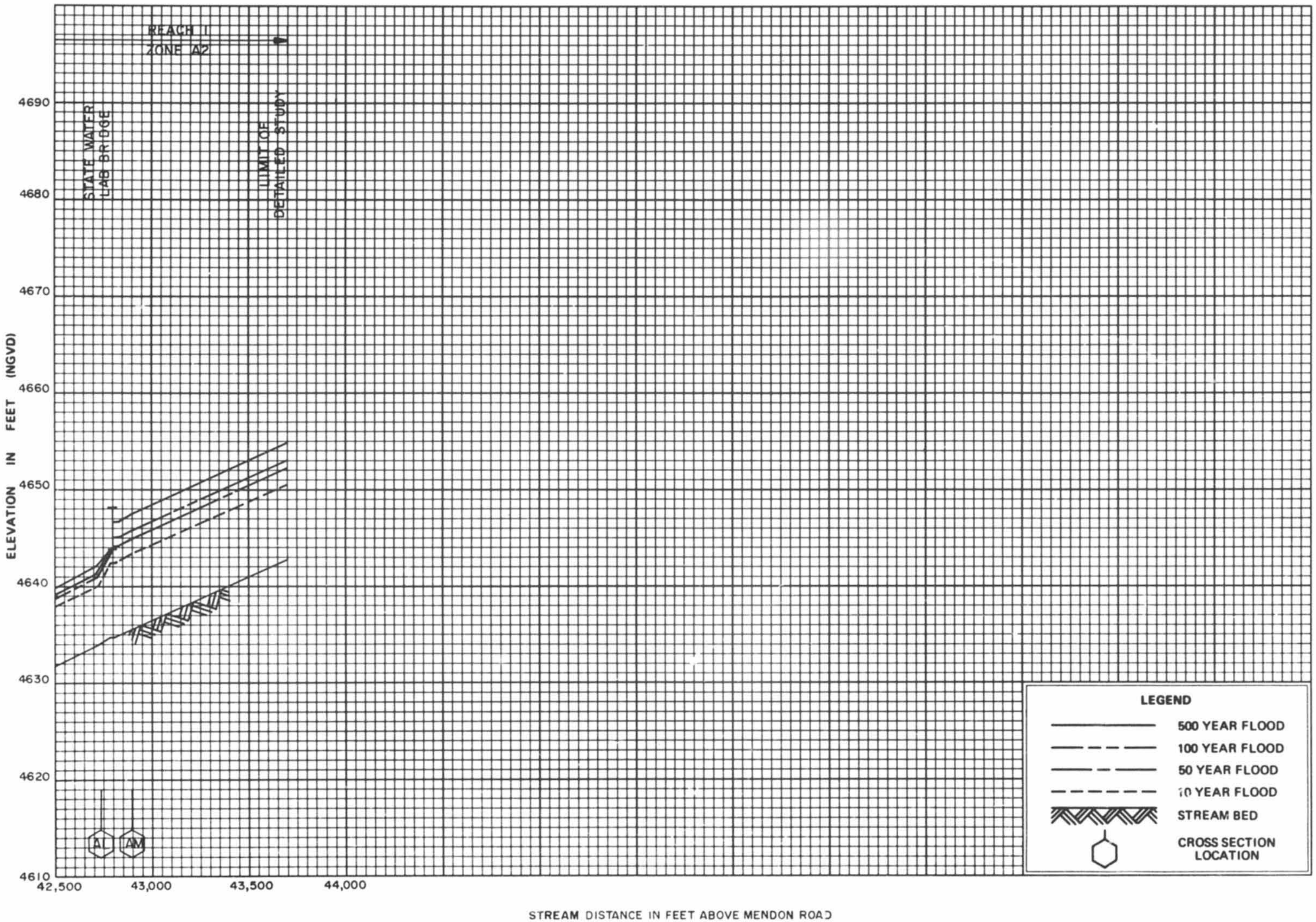
FLOOD PROFILES

LOGAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

07P



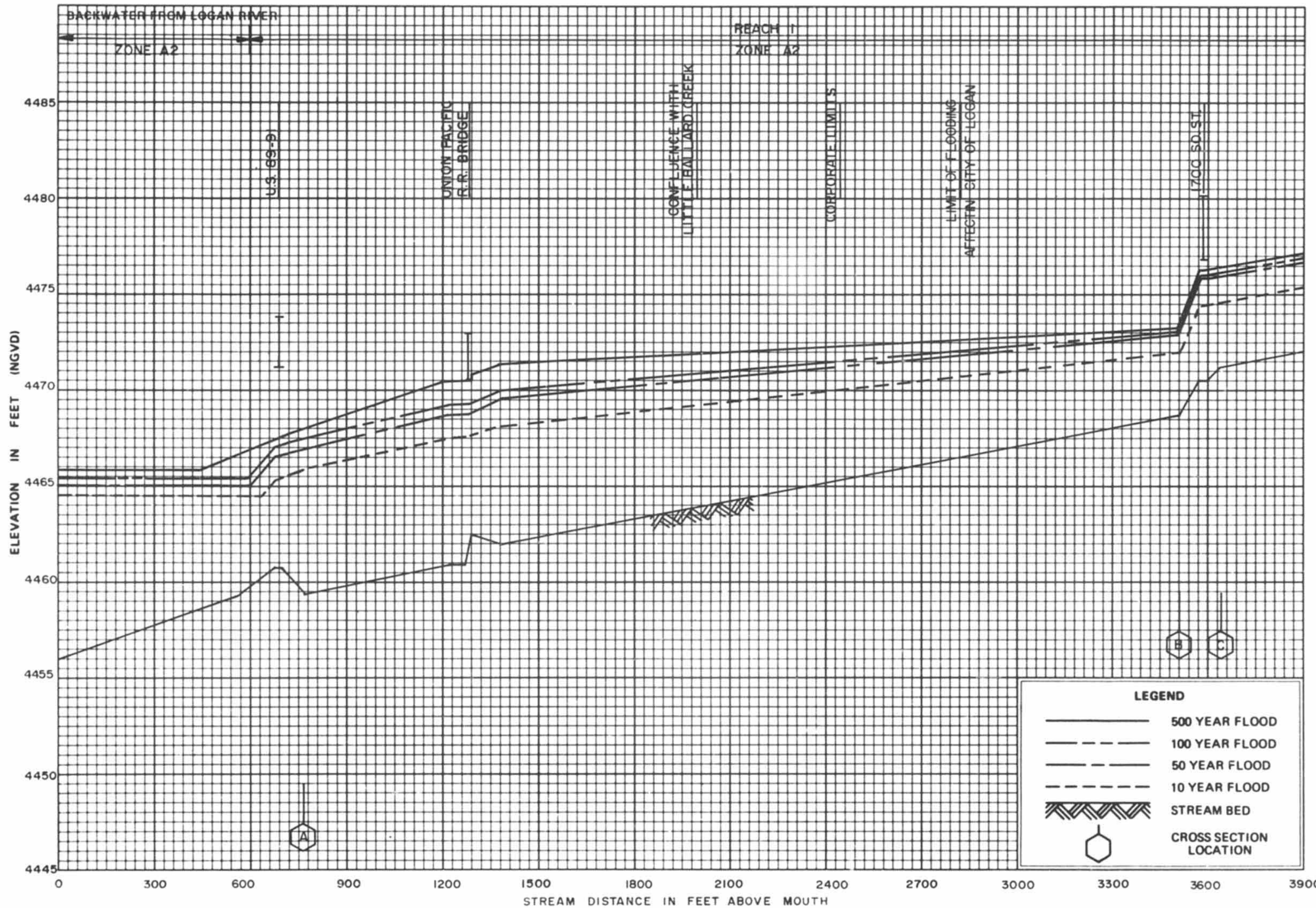
FLOOD PROFILES

LOGAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

08P



FLOOD PROFILES

BLACKSMITH FORK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT

(CACHE CO.)

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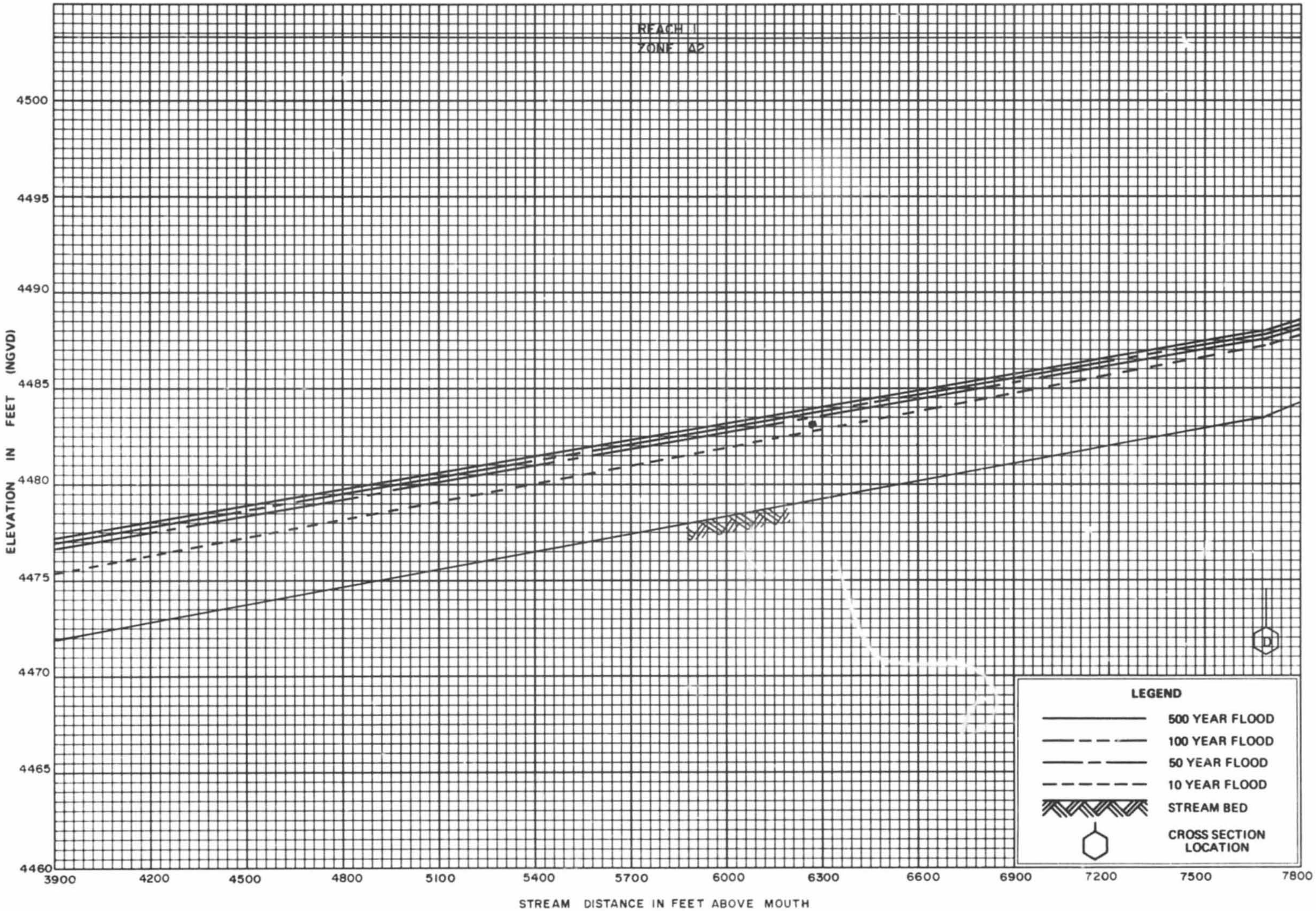


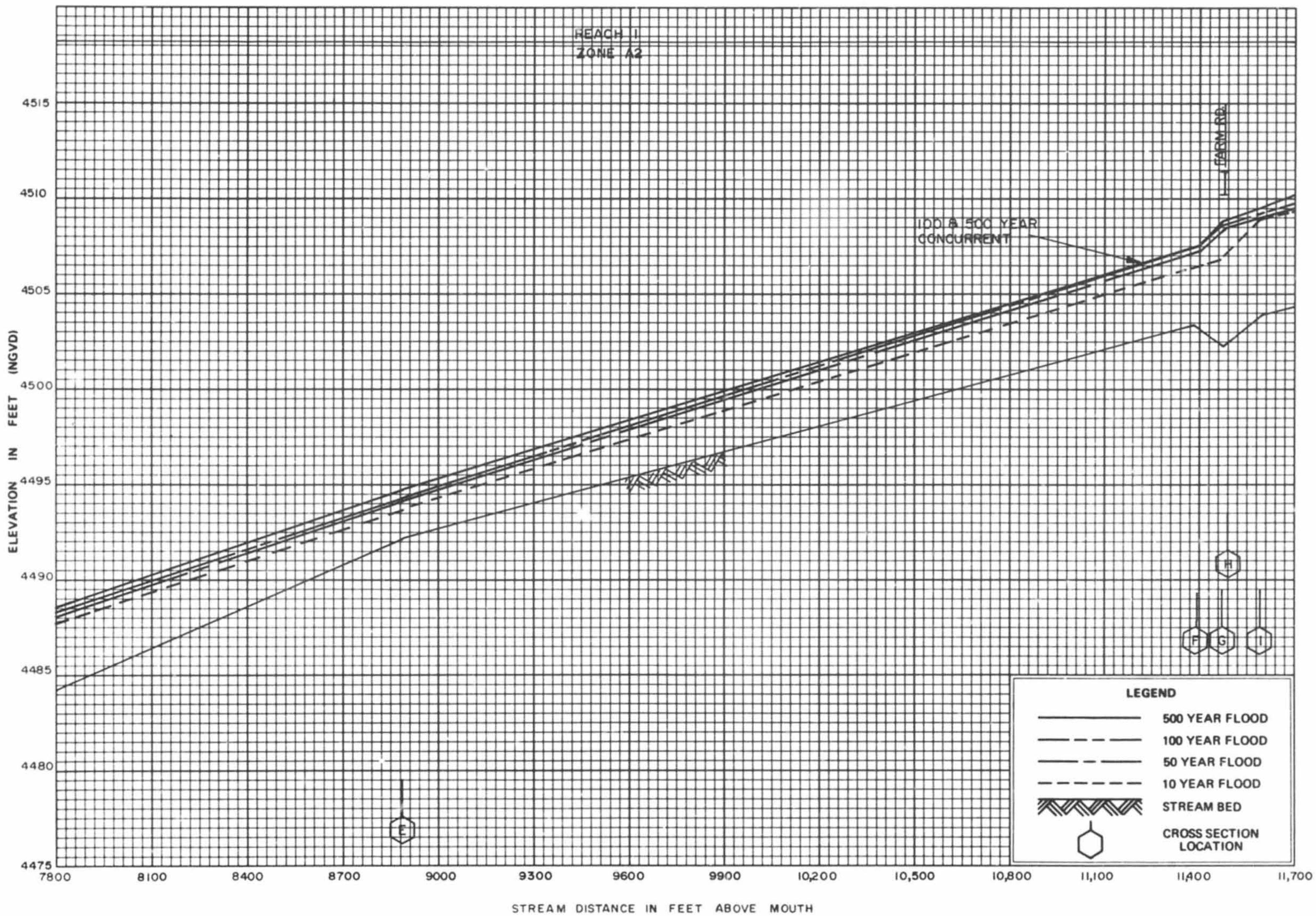
FLOOD PROFILES

BLACKSMITH FORK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

10P



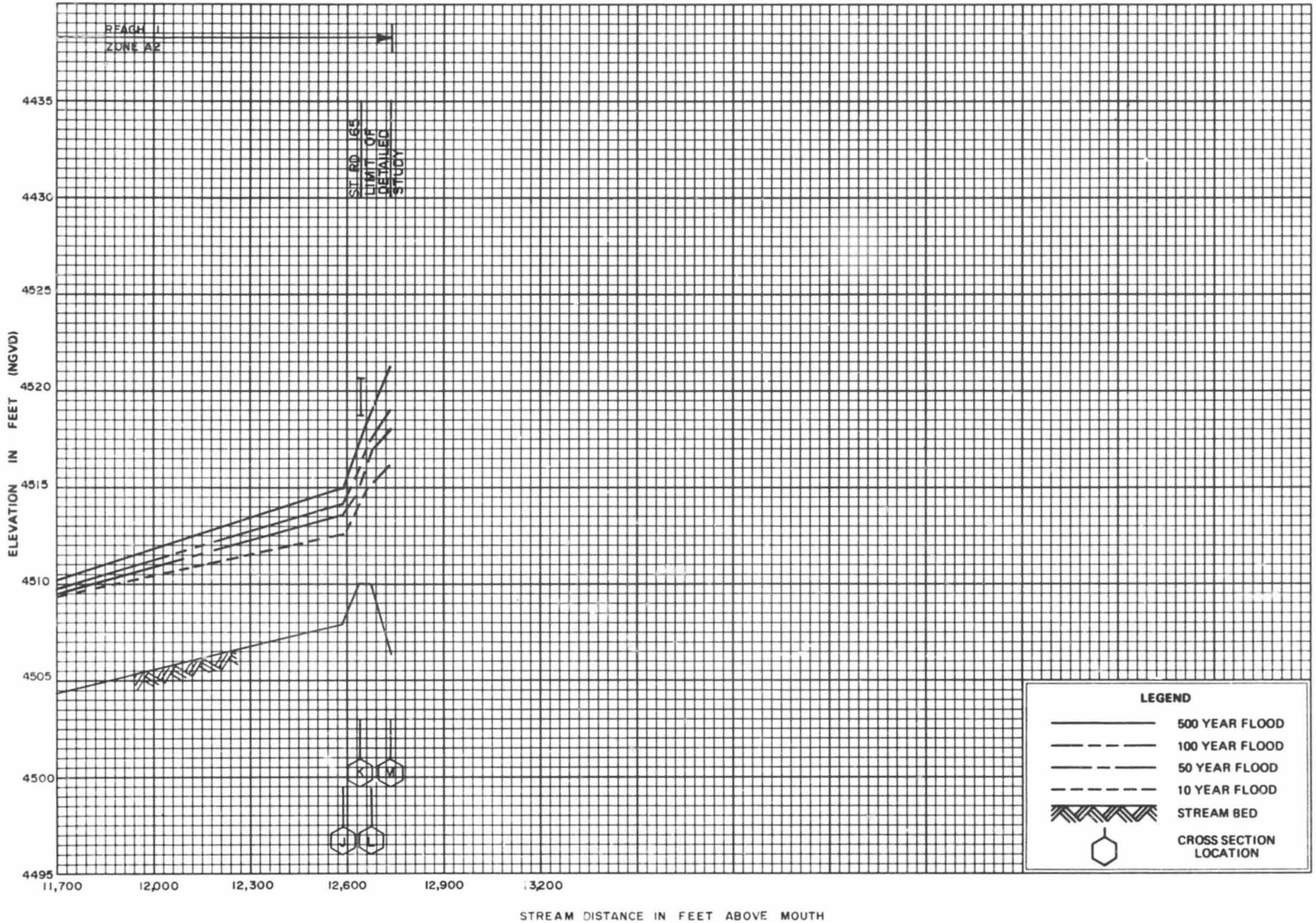
FLOOD PROFILES

BLACKSMITH FORK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

11P



FLOOD PROFILES

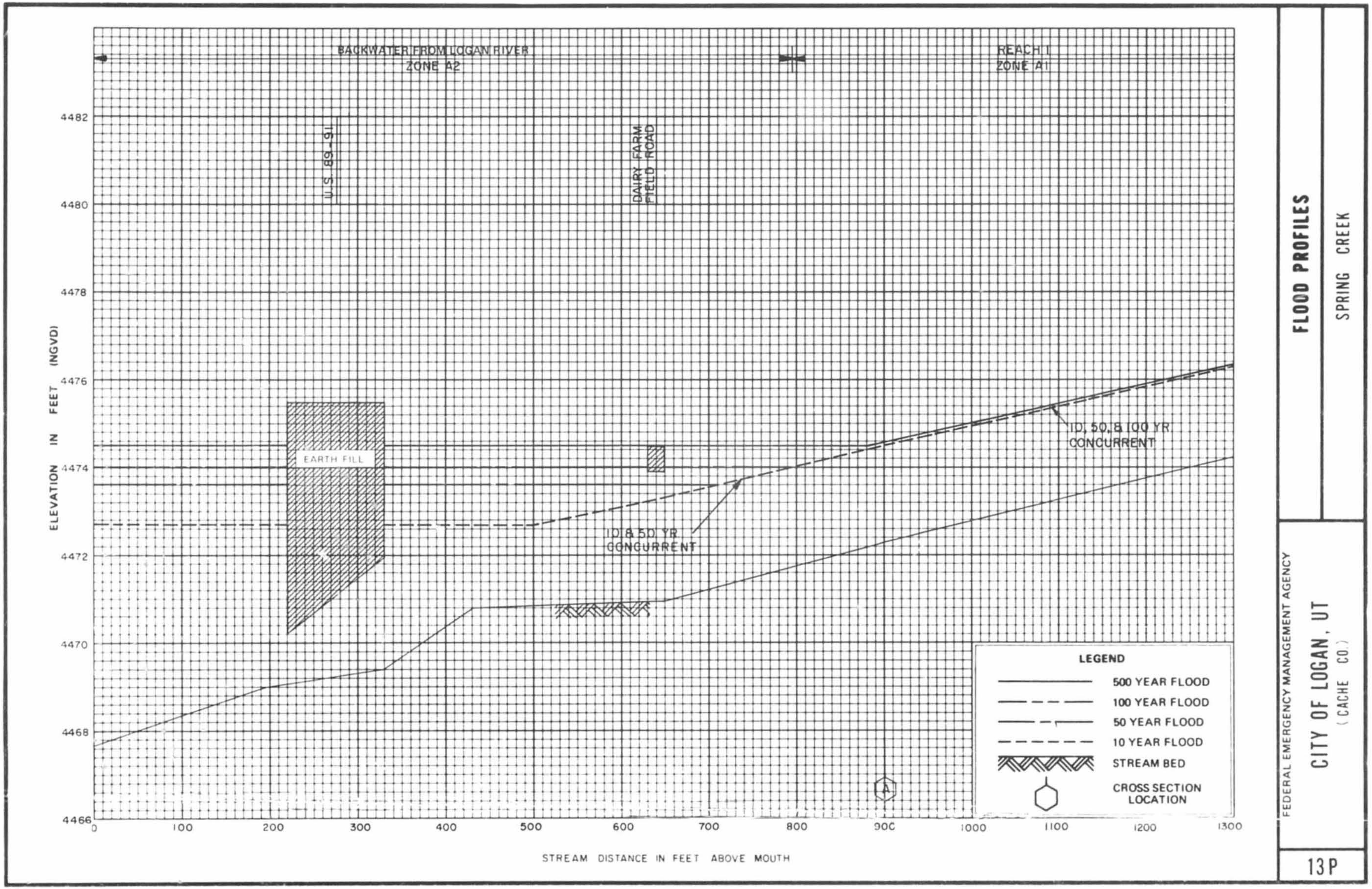
BLACKSMITH FORK

FEDERAL EMERGENCY MANAGEMENT AGENCY

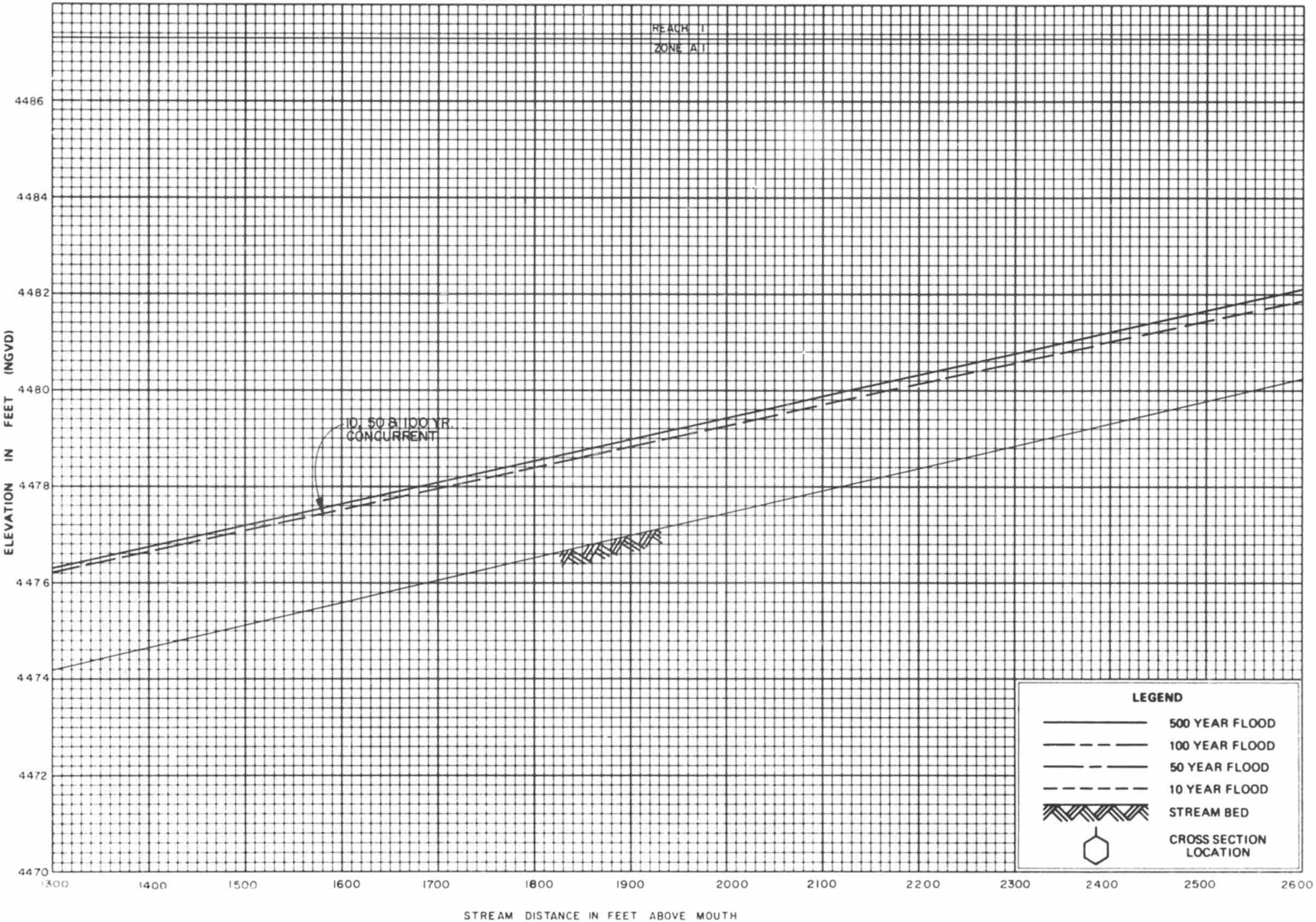
CITY OF LOGAN, UT

(CACHE CO.)

12P


BACKWATER FROM LOGAN RIVER
ZONE A2
REACH 1
ZONE A1
U.S. 89-91
DAIRY FARM FIELD ROAD
EARTH FILL
10, 50, & 100 YR CONCURRENT
10 & 50 YR CONCURRENT
ELEVATION IN FEET (NGVD)
4482
4480
4478
4476
4474
4472
4470
4468
4466
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
STREAM DISTANCE IN FEET ABOVE MOUTH
A
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
13P

31



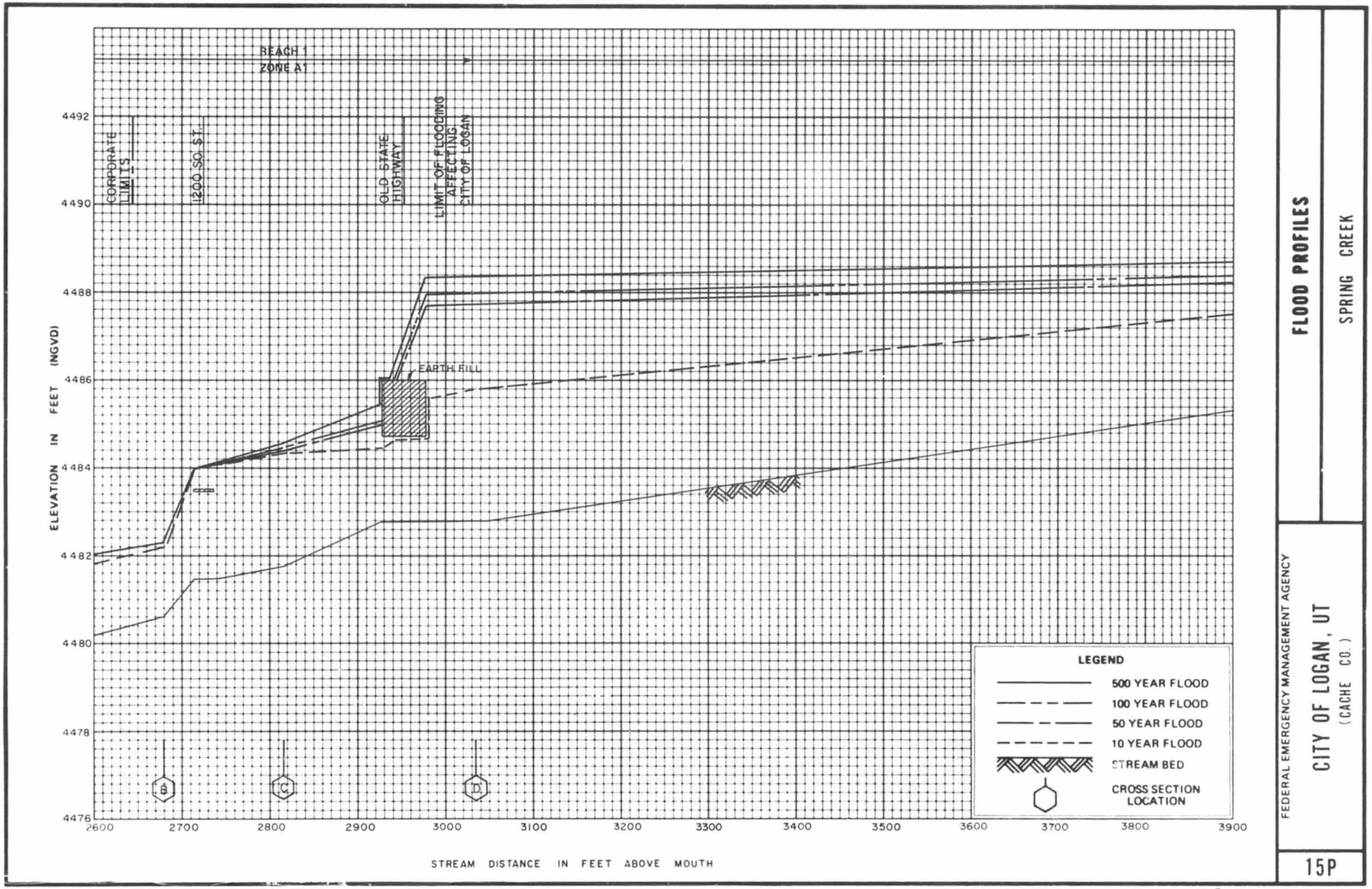
FLOOD PROFILES

SPRING CREEK

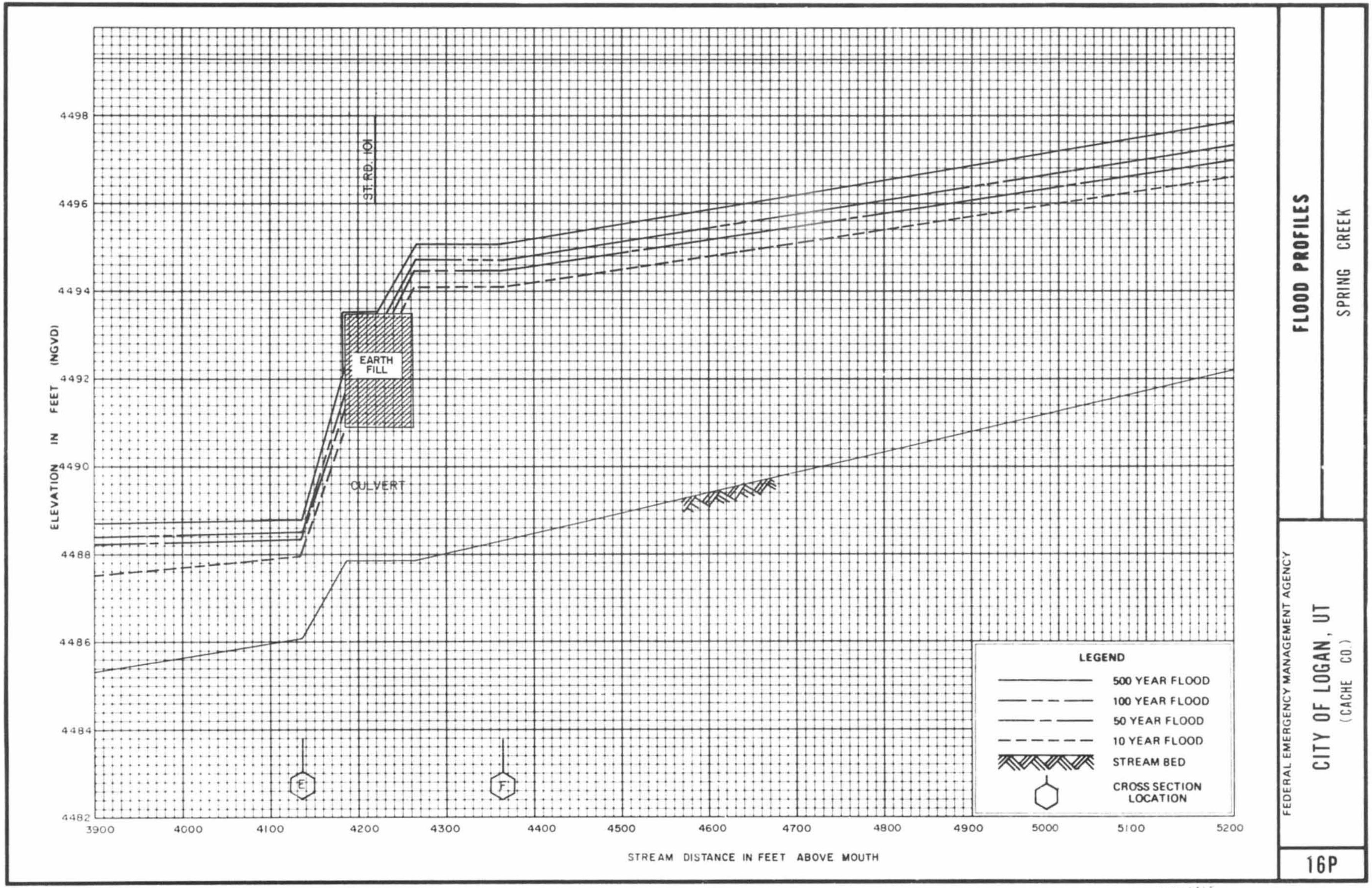
FEDERAL EMERGENCY MANAGEMENT AGENCY

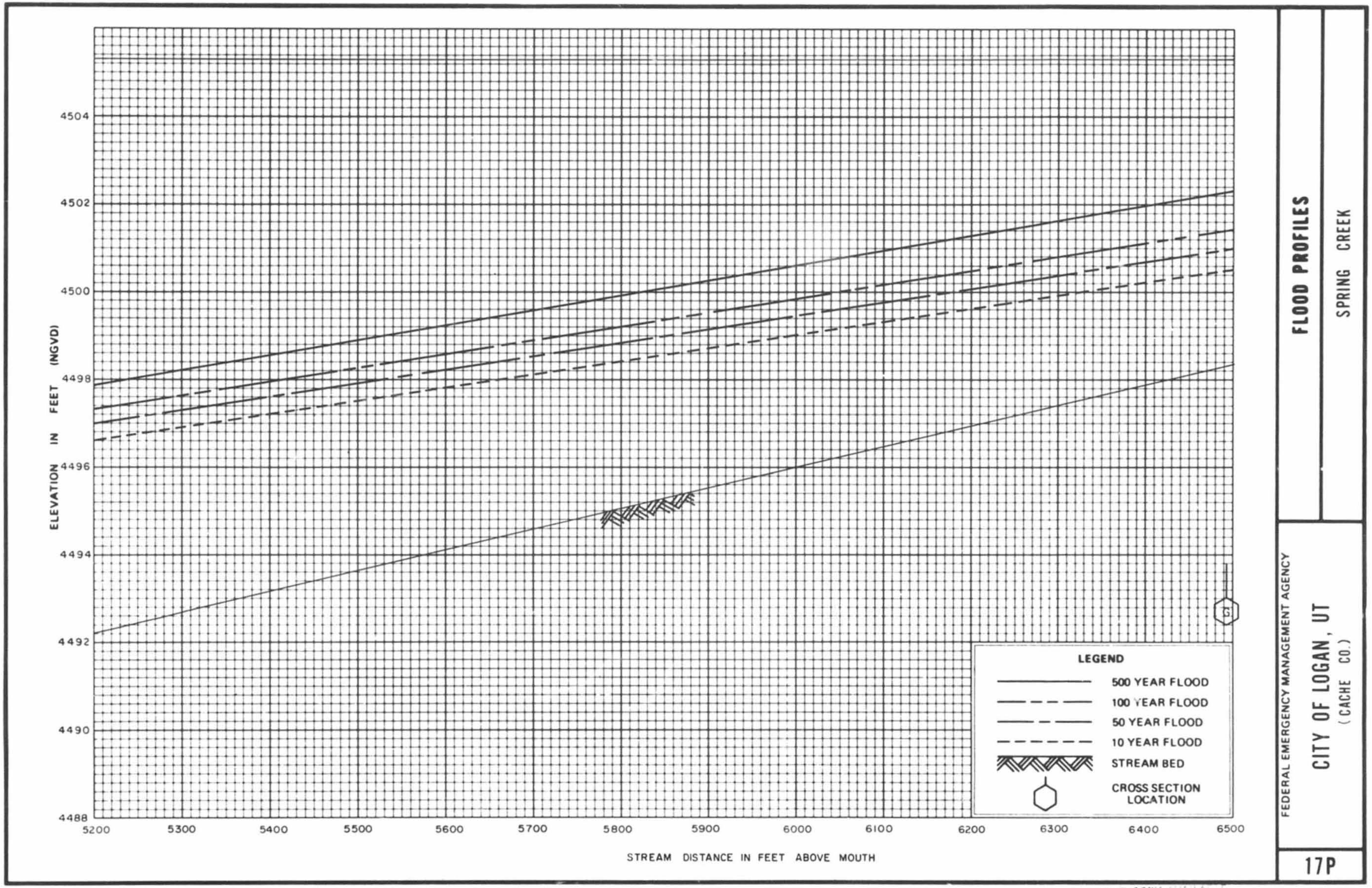
CITY OF LOGAN, UT
(CACHE CO.)

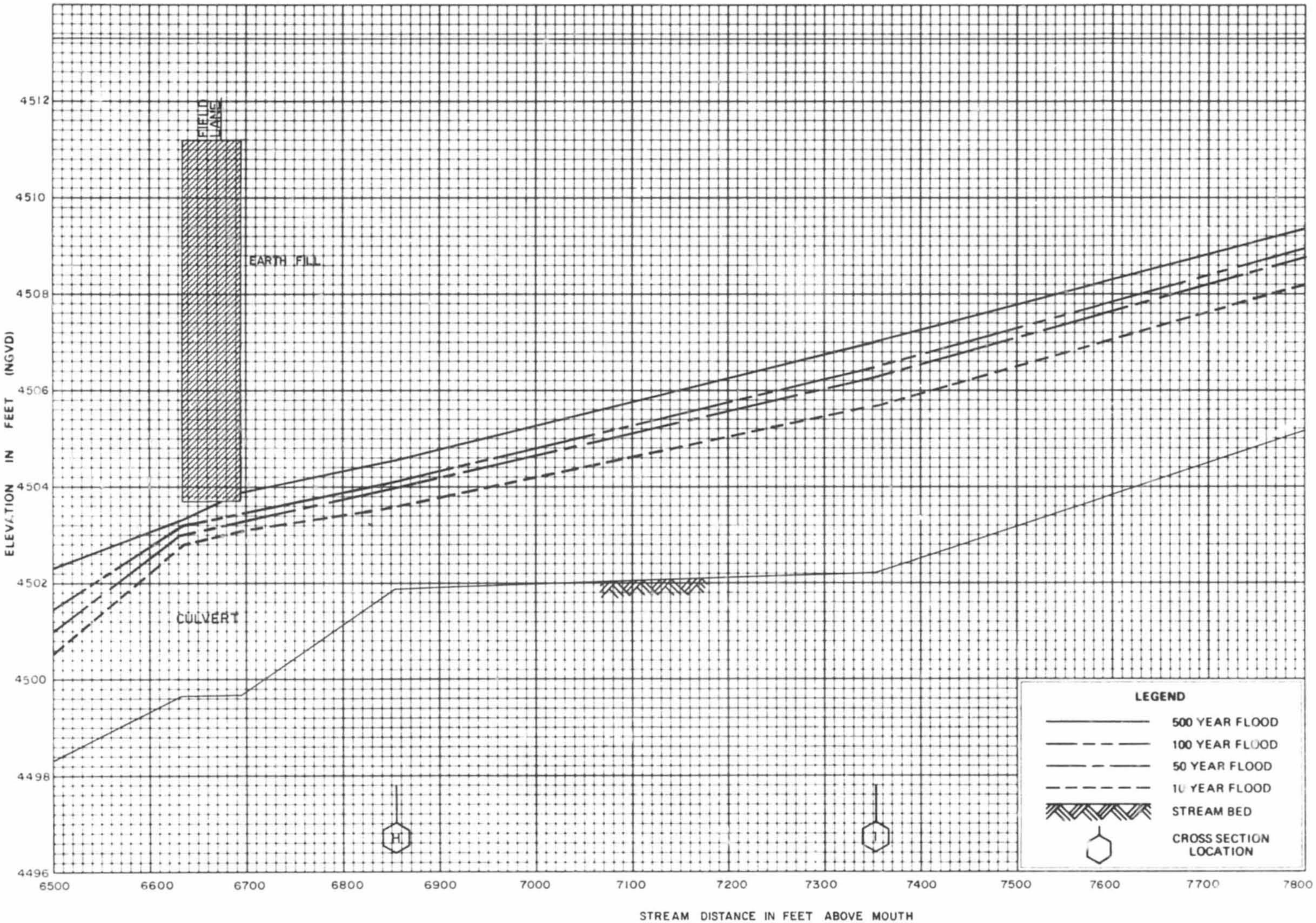
14P



REACH 1
ZONE A1
CORPORATE LIMITS
1200 SO. ST.
OLD STATE HIGHWAY
LIMIT OF FLOODING AFFECTING CITY OF LOGAN
EARTH FILL
ELEVATION IN FEET (NGVD)
4476
4478
4480
4482
4484
4486
4488
4490
4492
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
STREAM DISTANCE IN FEET ABOVE MOUTH
B
C
D
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
15P


ST. RD. 101
EARTH FILL
CULVERT
ELEVATION IN FEET (NGVD)
4482
4484
4486
4488
4490
4492
4494
4496
4498
3900
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100
5200
STREAM DISTANCE IN FEET ABOVE MOUTH
E
F
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
16P


ELEVATION IN FEET (NGVD)
4504
4502
4500
4498
4496
4494
4492
4490
4488
5200
5300
5400
5500
5600
5700
5800
5900
6000
6100
6200
6300
6400
6500
STREAM DISTANCE IN FEET ABOVE MOUTH
G
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
17P



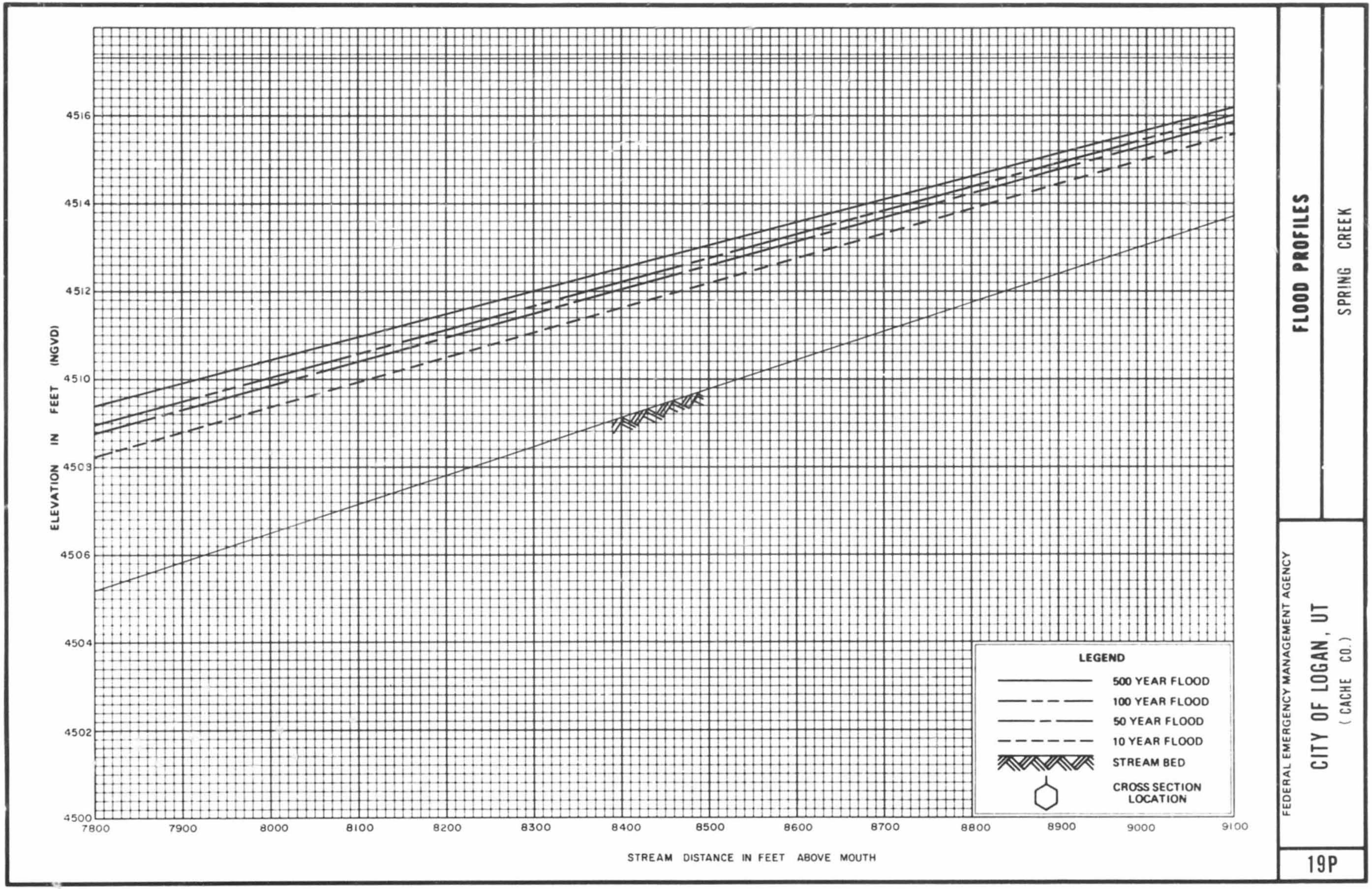
FLOOD PROFILES

SPRING CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

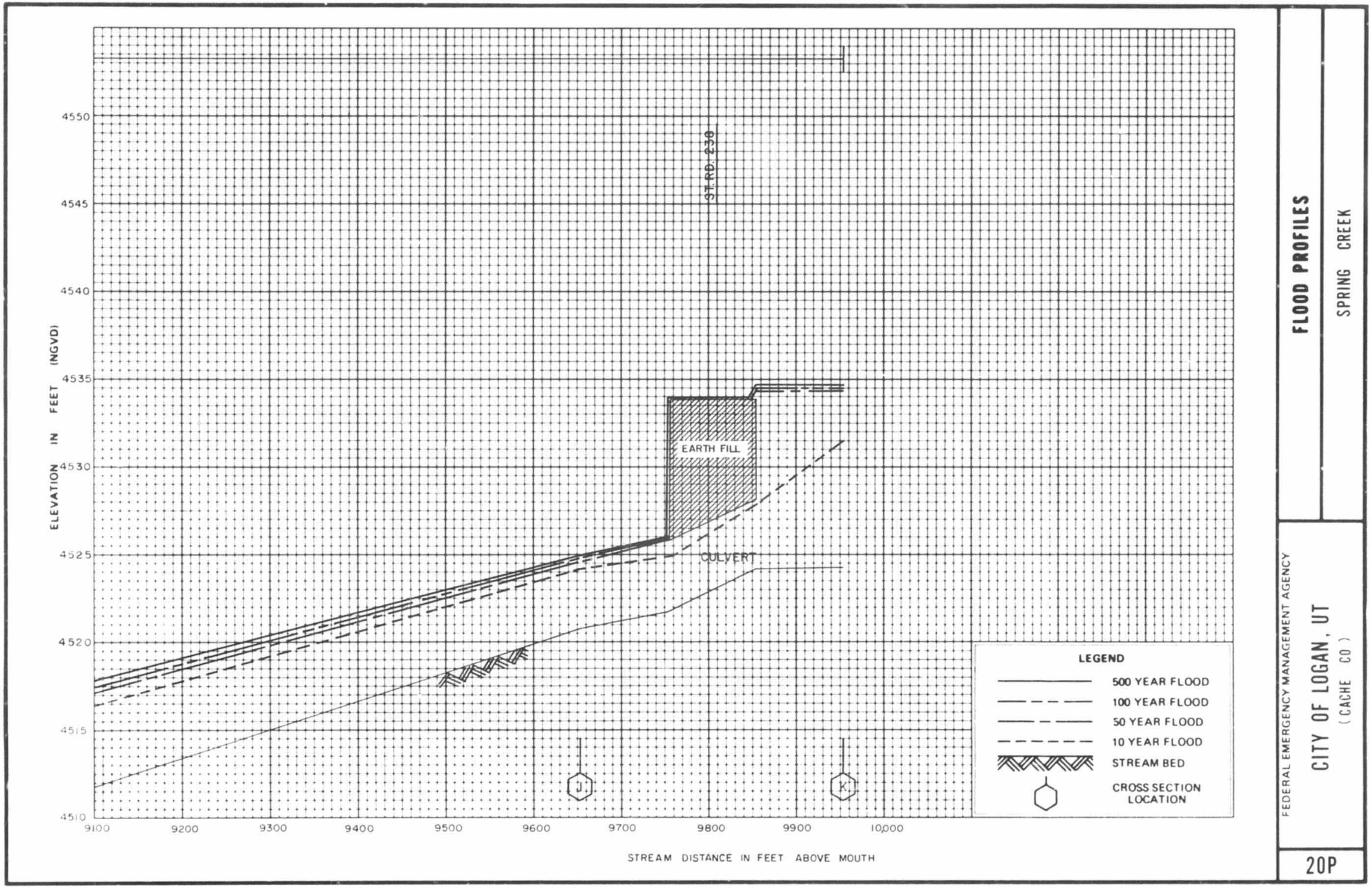
CITY OF LOGAN, UT
(CACHE CO.)

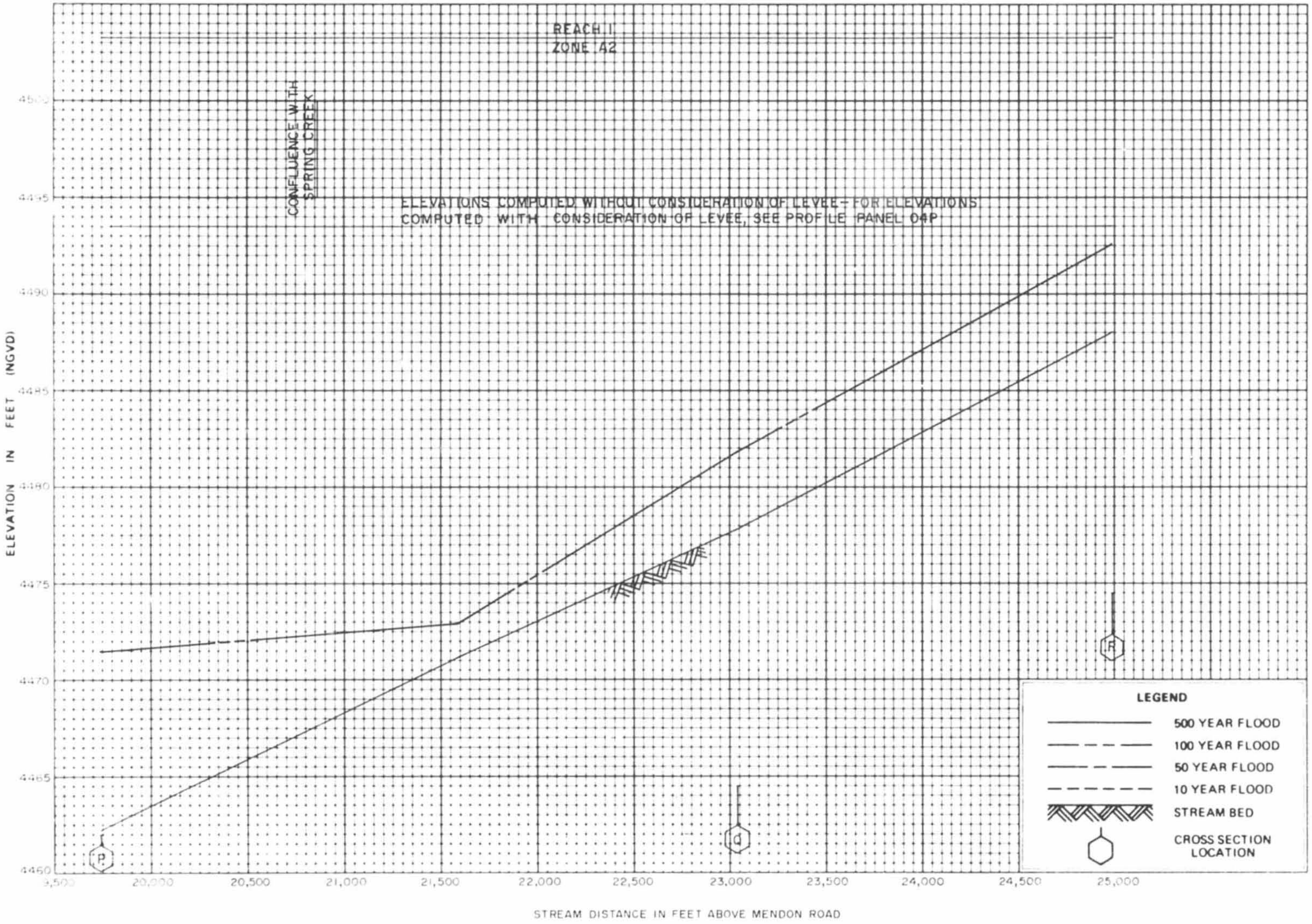
18P



FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO.)
19P
ELEVATION IN FEET (NGVD)
4516
4514
4512
4510
4508
4506
4504
4502
4500
7800
7900
8000
8100
8200
8300
8400
8500
8600
8700
8800
8900
9000
9100
STREAM DISTANCE IN FEET ABOVE MOUTH
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION

40


FLOOD PROFILES
SPRING CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF LOGAN, UT
(CACHE CO)
20P
ELEVATION IN FEET (NGVD)
4550
4545
4540
4535
4530
4525
4520
4515
4510
9100
9200
9300
9400
9500
9600
9700
9800
9900
10,000
STREAM DISTANCE IN FEET ABOVE MOUTH
ST. RD. 230
EARTH FILL
CULVERT
J
K
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION



FLOOD PROFILES

LOGAN RIVER — WITHOUT CONSIDERATION OF LEVEE

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LOGAN, UT
(CACHE CO.)

21P