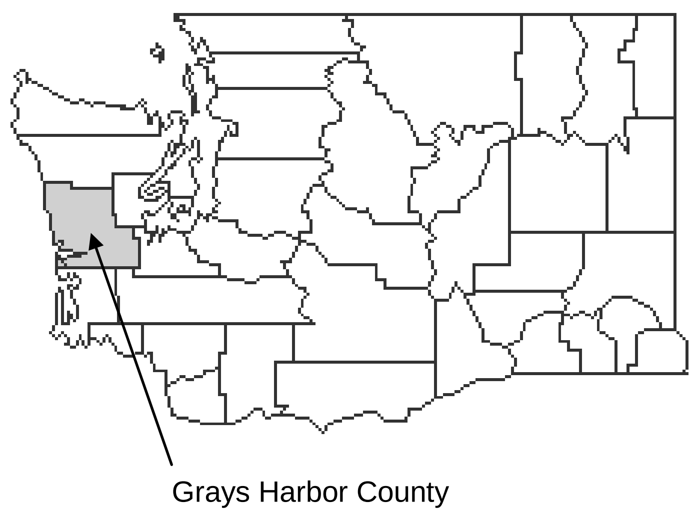
FLOOD INSURANCE STUDY

PRELIMINARY
AUGUST 5, 2011

GRAYS HARBOR COUNTY, WASHINGTON
AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
ABERDEEN, CITY OF	530058
CONFEDERATED TRIBES OF CHEHALIS RESERVATION	530334
COSMOPOLIS, CITY OF	530059
ELMA, CITY OF	530060
GRAYS HARBOR COUNTY UNINCORPORATED AREAS	530057
HOQUIAM, CITY OF	530061
McCLEARY, CITY OF	530062
MONTESANO, CITY OF	530063
OAKVILLE, CITY OF	530064
OCEAN SHORES, CITY OF	530065
WESTPORT, CITY OF	530067



Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
53027CV000A

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) report may not contain all data available within the Community Map Repository. Please contact the Community Map Repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

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

Old Zone(s)	New Zone
Al through A30	AE
B	X
C	X

Initial Countywide FIS Effective Date: To Be Determined

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GRAYS HARBOR COUNTY, WASHINGTON
AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) report investigates the existence and severity of flood hazards in the geographic area of Grays Harbor County, Washington, including the Cities of Aberdeen, Cosmopolis, Elma, Hoquiam, Oakville, Ocean Shores, McCleary, Montesano, Westport; the Confederated Tribes of the Chehalis Reservation; and the Unincorporated Areas of Grays Harbor County (referred to collectively herein as Grays Harbor County).

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

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

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

1.2 Authority and Acknowledgments

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

This FIS was prepared to include all jurisdictions within Grays Harbor County into a countywide format FIS. Information on the authority and acknowledgements for each of the previously printed FISs for communities within Grays Harbor County was compiled, and is shown below.

Aberdeen, City of	This study was started by Tippetts-Abbett-McCarthy-Stratton (TAMS) for the Federal Insurance Administration (FIA) under Contract No. H-4022. Most of the cross section data were collected under this initial contract. The hydrologic and hydraulic analyses for this study were completed by CH2M HILL, Inc., using the TAMS data. The work was performed for FIA under Contract No. H-4810. This work, which was completed in July 1981, covered all significant flooding sources affecting the City of Aberdeen (Reference 1).
Cosmopolis, City of	This study was started by TAMS for FIA under Contract No. H-4022. Most of the cross section data were collected under this initial contract. The hydrologic and hydraulic analyses for this study were completed by CH2M HILL, Inc., using the TAMS data. The work was performed for the FIA under Contract No. H-4810. This work, which was completed in March 1981, covered all significant flooding sources affecting the City of Cosmopolis (Reference 2).
Elma, City of	The hydrologic and hydraulic analyses for this study were performed by CH2M HILL, Inc., as determined for the FIS for Grays Harbor County, Washington (Reference 3).
Grays Harbor County, Unincorporated Areas	This study was initiated by TAMS for FEMA, under Contract No. H-4022. Some of the cross section data were collected under this initial contract. The hydrologic and hydraulic analyses for this study were performed by CH2M HILL, Inc., for FEMA, under Contract Nos. H-48l0 and EMW-C-0950. This study was completed in 1985 (Reference 4).
Hoaquim, City of	The hydrologic and hydraulic analyses for this study were performed by the U.S. Army Corps of Engineers (USACE), Seattle District, for the FIA, under Interagency Agreement No. IAA-H-7-76, Project Order No. 11. This work, which was completed in May 1977, covered all significant flooding sources in the City of Hoquiam (Reference 5).

McCleary, City of	This study was started by TAMS, for FIA under Contract No. H-4022. Most of the cross section data were collected under this initial contract. The hydrologic and hydraulic analyses for this study were completed by CH2M HILL, Inc., using the TAMS data. The work was preformed for FIA under Contract No. H-4810. This work, which was completed in January 1981, covered all significant flooding sources affecting the City of McCleary (Reference 6).
Ocean Shores, City of	The hydrologic and hydraulic analyses for this study were done by CH2M HILL, Inc., for FIA under Contract No. H-3815. This work, which was completed in October 1976, covered all flooding sources in the City of Ocean Shores (Reference 7).
Westport, City of	The hydrologic and hydraulic analyses for this study were performed by TAMS, for FIA under Contract Number H-4022. This work, which was completed in August 1977, covered all significant flooding sources in the City of Westport. A limited planimetric map was developed concurrently with the topographic map by Bush, Roed and Hitchings, Inc., under subcontract to TAMS. A hydrologic and hydraulic restudy was performed by CH2M HILL, Inc., for the FIA under Contract Number H-4810, as amended. This work, which was completed in November 1979, covered tidal flooding sources affecting the City of Westport (Reference 8).

No previous reports were prepared for the Cities of Oakville and Montesano; and the Confederated Tribes of the Chehalis Reservation.

This countywide update was performed by Tetra Tech for the Washington Department of Ecology and the FEMA under Contract No. C0400289. Work on the countywide update was completed in January 2010.

The digital base map information was provided by Grays Harbor County. The coordinate system used for the production of the FIRM is Universal Transverse Mercator, Zone 10, American Datum of 1983, Geodetic Reference System 1980. Differences in the datum and spheroid used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on this FIRM.

1.3 Coordination

An initial Consultation Coordination Officer's (CCO) meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS and to identify streams to be studied by detailed methods. A final CCO meeting is held typically with the same representatives to review the results of the study. The initial and final meeting dates for the previous FIS reports for Grays Harbor County and its communities are listed in Table 1, "Initial and Final CCO Meetings".

Table 1 – Initial and Final CCO Meetings

Community Name	Initial Meeting	Intermediate Meeting	Final Meeting
Aberdeen, City of	April 8, 1976	December 8, 1980	January 27, 1982
Cosmopolis, City of	April 8, 1976	October 22, 1980	October 21, 1981
Elma, City of	*	*	September 20, 1984
Grays Harbor County, Unincorporated Areas	April 8, 1976	July 15, 1982	September 25, 1985
Hoquiam, City of	February 25, 1975	February 23, 1976	July 26, 1977
McCleary, City of	April 8, 1976	September 24, 1980	September 23, 1981
Ocean Shores, City of	July, 21, 1975	*	August 31, 1976
Westport, City of	April 8, 1976	July 7, 1977	September 26, 1977

* Data not available

For this countywide revision, the final CCO meeting was held on ___________, and attended by representatives of ______________. All problems raised at that meeting have been addressed.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Grays Harbor County, Washington, including communities listed in Section 1.1.

Table 2, "Areas Studied by Detailed Methods" lists the streams studied by detailed methods. Limits of Detailed Study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

Table 2 – Areas Studied by Detailed Methods

Stream	Limits of Detailed Study
Alder Creek	From confluence with the Chehalis River to 800 feet upstream of Huntley Street
Bush Creek	From confluence with Cloquallum Creek to Cloquallum-Lost Lake Road
Chehalis River	From (River Mile) RM 1.5 to RM 9.2

Table 2 – Areas Studied by Detailed Methods (Continued)

Stream	Limits of Detailed Study
Cloquallum Creek	From approximately 1.3 miles upstream of U.S. Highway 12 to the confluence with Bush Creek
Dry Bed Creek	From U.S. Highway 12 to 1,000 feet north of Burlington Northern Railroad
East Fork Hoquiam River	From confluence with Hoquiam River to approximately 0.8 miles upstream of confluence with Hoquiam River
East Fork Wildcat Creek	From approximately 370 feet upstream of U.S. Highway 410 to approximately 1,200 feet upstream of McCleary Summit Road
Fry Creek	From confluence with the Chehalis River to 300 feet downstream of Hemlock Street
Grays Harbor	Port of Grays Harbor
Harris Creek	From Garrard Creek Road to 1,000 feet north of Burlington Northern Railroad
Hoquiam River	From confluence with Grays Harbor to approximately 800 feet upstream of the confluence with Little Hoquiam River
Little Hoquiam River	From confluence with Hoquiam River to approximately 1.9 miles upstream of U.S. Route 101
Mill Creek	From approximately 800 feet upstream of Altenau Street to approximately 250 feet upstream of C Street
Newman Creek	From approximately 2,300 feet downstream of O'Neil Road to the confluence of the East and West Branch Newman Creek
Pacific Ocean Coast	From the Grays Harbor – Pacific County border north to the City of Westport city limits
Pacific Ocean Coast	Within the city limits of the City of Westport
Pacific Ocean Coast	Within the city limits of the City of Ocean Shores
Pacific Ocean Coast	From Ocean Shores City limits north to Copalis Rock National Wildlife Refuge
Pacific Ocean Coast	From Copalis Rock National Wildlife Refuge north to Copalis Head
Pacific Ocean Coast	From 0.3 mile south of State Highway 109 bridge over Joe Creek north for 0.6 mile, near Pacific Beach
Pacific Ocean Coast	From Quinault Indian Reservation south for 1.3 miles, near Moclips
Roundtree Creek	From confluence with Harris Creek to 650 feet north of Burlington Northern Railroad
Satsop River	From approximately 4,500 feet downstream of U.S. Highway 12 to approximately 1.8 miles upstream of the confluence of West and East Fork

Table 2 – Areas Studied by Detailed Methods (Continued)

Stream	Limits of Detailed Study
Stewart Creek	From confluence with the Wishkah River to the north side of Valley Street
South Bay	From Hunt Club Road south of Laidlaw Island to the Westport city limits
Tributary to Mill Creek at mile 0.15	Entire reach within the City of Cosmopolis limits
Vance Creek	From U.S. Highway 12 to 0.5 mile north of Burlington Northern Railroad
Wilson Creek	From confluence with the Chehalis River to approximately 200 feet upstream of Henry Street
Wishkah River	From the confluence with Grays Harbor to approximately 3,000 feet upstream of the confluence with Stewart Creek
Wynoochee River	Approximately 300 feet downstream of the confluence of Caldwell Creek to approximately 4,200 feet upstream of the confluence with Wedekind Creek

Tidal flooding from Grays Harbor was also studied by detailed methods. The tidal flooding sources affecting Ocean Shores are the Pacific Ocean and Grays Harbor. The portions of Grays Harbor that affect Ocean Shores are called North Bay and Harbor Entrance in this report. Grand Canal, Duck Lake, and Lake Minard are the three sources of freshwater flooding at Ocean Shores.

Tidal sources of flooding were studied in detail for the City of Westport. Storm influenced tide levels were considered separately on the Pacific Ocean and Grays Harbor sides of the Westport peninsula.

Table 3, "Areas Studied by Approximate Methods" lists the streams studied by approximate methods.

Table 3 – Areas Studied by Approximate Methods

Stream	Limits of Approximate Study
Alder Creek	From 800 feet upstream of Huntley Street to the city limits of the City of Aberdeen
Chehalis River	RM 9.2 to 44.9
Devonshire Slough	From the mouth at the Chehalis River to Huntley Road at the north and 500 feet north of the southern city limits of the City of Aberdeen at the south
Division Street Drainage	From Simpson Avenue through the East Fork to Alden Road and through the West Fork the same northerly distance as the East Fork

Table 3 – Areas Studied by Approximate Methods (Continued)

Stream	Limits of Approximate Study
East Branch Newman Creek	From the fork with West Branch Newman Creek to the east section line of Section 16, T18N, R6W
East Fork Wildcat Creek	Reach within Sections 11 and 14, T18N, RSW, at the City of McCleary, except that portion within the city limits of the City of McCleary
Fry Creek	From 300 feet downstream of Hemlock Street to the city limits of the City of Aberdeen
Middle Branch Newman Creek	From the fork with West Branch Newman Creek to the east-west quarter section line of Section 16, T18N, R6W
Mill Creek	From 250 feet above C Street to the City of Cosmopolis city limits
Newman Creek	To the east section line of Section 16, T18N, R6W
Stewart Creek	From north side of Valley Street to the city limits of the City of Aberdeen
Tributary to Stewart Creek	From confluence with Stewart Creek to the city limits of the City of Aberdeen
West Branch Newman Creek	From the fork with East Branch Newman Creek to the north section line of Section 20, T18N, R6W
Wilson Creek	From 200 feet upstream of Henry Street to 1,200 feet upstream of Henry Street
Wynoochee River	From confluence with Chehalis River to RM 6.0

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and Grays Harbor County.

Table 4, “Letters of Map Change (LOMCs)” presents the incorporated LOMCs into this countywide study:

Table 4 – Letters of Map Change (LOMCs)

LOMC	Case Number	Date Issued	Project Identifier
LOMR*	98-10-179P	September 3, 1998	Chehalis River Levee in the City of Aberdeen
LOMR	99-10-598P	November 2, 1999	Within banks of the Chehalis River, downstream of U.S. Highway 101; reinstate SFHA
LOMR	99-10-006P	January 6, 1999	Detailed analysis of Pacific Ocean shoreline at the Quinalt Resort Complex, encompassing the northern part of Ocean City State Park and the area to the north
LOMR	06-10-B484P	October 26, 2006	Grays Harbor – just west of the intersection of Port Road and West First Street to Approximately 2,000 feet west along the Grays Harbor shoreline

* Letter of Map Revision (LOMR)

2.2 Community Description

Grays Harbor County is located in southwestern Washington. The County is bordered to the west by the Pacific Ocean; to the south by Pacific and Lewis Counties; to the east by Thurston and Mason Counties; and to the north by Jefferson County. The Olympic Mountains rise in the northeast, and the Black Hills are in the southeast. The County seat is the City of Montesano, and its largest city is Aberdeen.

The major population center of the county is located in the Hoquiam-Aberdeen-Cosmopolis area, at the head of Grays Harbor. Remaining population areas are located along the coast or in the Chehalis River valley. The total population of the County in 1980 was 66,314. The population was 67,194 at the 2000 census (Reference 9).

Grays Harbor County has a mid-latitude, west coast, marine-type climate with warm and relatively dry summers; and mild, wet, mostly cloudy winters. The average mean temperature ranges from 68 degrees Fahrenheit (ºF) in August to 47ºF in January. The highest recorded temperature was 105ºF in 1981. The lowest recorded temperature was 6ºF in 1950 (Reference 10). Normal annual precipitation varies from 50 inches in the southeast to over 240 inches in the high peaks of the Olympic Mountains. Most of the precipitation occurs between October and March.

Annual prevailing winds are south westerly with storms coming frequently from the southwest. Winter storms also originate from an east-to-west range. Wind velocities up to 95 miles per hour from the west, on the coast, have been recorded.

Vegetation varies from tidal flat and marshland grasses in the estuaries to forests of western hemlock, Douglas-fir, and western red cedar. The uplands around Aberdeen are covered by mixed deciduous and coniferous forests. Deciduous plants are predominantly found in the lowlands. There are some brackish marsh environments along the shores of the rivers and the harbor.

The economy of the County is based primarily on the forest industry. Other growing industries include fish processing, cranberry processing, and tourism.

Development is restricted by topography, which is quite steep throughout the County. Most of the development has occurred along the coast and in the lower river valleys. The flood plains of the Chehalis and Hoquiam Rivers are heavily developed with little undeveloped land left. Industrial areas are located near the rivers and harbor. Commercial development has mainly occurred along U.S. Highway 101. Land use in most of the remaining flood plain is residential. Here the floodplain is a mixture of residential areas with small scattered commercial establishments and undeveloped areas. The undeveloped areas are predominantly wetlands. The flood plains along the upper Hoquiam, Little Hoquiam and East Fork Hoquiam Rivers contain scattered wood industry plants and pockets of residences. Some developmental pressures are apparent in these areas.

The smaller streams studied: Alder Creek, Division Street Drainage, Stewart Creek, Wilson Creek, an unnamed tributary to Stewart Creek, and Devonshire Slough; have total drainage areas of 620; 250; 1,890; 730; 60; 330; and 375 acres, respectively.

The Chehalis and Wishkah Rivers have total drainage basin areas of 2,114 and 102 square miles, respectively (Reference 11). Both rivers are influenced at their mouths by the tides in Grays Harbor.

Cloquallum, Dry Bed and Vance Creeks flow south into the Chehalis River.

Fry Creek has a drainage area of approximately 1,420 acres, draining the steep, wooded hillsides on the northern boundary of the City of Aberdeen and a portion of the City of Hoquiam. The creek emerges from the hills between Myrtle and Oak Streets in City of Aberdeen and flows due south to Grays Harbor.

Grays Harbor is a large saltwater bay in the southern part of the county. Several major rivers discharge into Grays Harbor, including the Chehalis, Hoquiam, Humptulips, and Wishkah Rivers. The Chehalis River drains a large portion of the County. The Satsop and Wynoochee Rivers are the two major tributaries of the Chehalis River.

The Grays Harbor estuary is approximately 15 miles long and 6 miles wide and provides ocean vessel access to the City of Hoquiam.

The Hoquiam River valley contains little cultivated land, and the upper reaches have little or no flood plain. Tillable land is mostly on the benches and is of marginal quality. The lower reaches of the river are poorly drained and affected by tidal action. Much of the lower river is used for log storage and transport, and other industrial uses.

The Hoquiam River drains an area of 90.2 square miles. The East Fork Hoquiam River and the Little Hoquiam River drain areas of 40.4 and 9.9 square miles, respectively.

Mill Creek leaves the hills south of the City of Cosmopolis, flows through Mill Creek Park, and then continues northwest through the western part of the city. A tributary flowing southeast from Aberdeen joins Mill Creek 0.15 mile above its confluence with the Chehalis River. A small concrete dam has been constructed on the stream in Mill Creek Park. The associated reservoir is for recreational purposes. Property owners have built up to the channel banks along most of the stream.

The Wishkah River discharges into the Chehalis River. The City of Aberdeen is relatively flat and is bounded on both the north and south by steep hills. Several small streams flow out of the nearby hills and discharge into: the Chehalis River, the Wishkah River, or Grays Harbor.

The flood plain areas are largely underlain by alluvial silt and fine sand, locally with organic material. Some areas have been mantled by artificial fill. Close to the fairly abrupt boundary between the flood plain and the adjacent uplands zones of coarse sand and gravel are probably interblended with the finer grained materials (References 4, 12, 13, and 14). Soils in the study area are predominantly in the Melbourne-Wilkeson soil association, which are silty clay loams (Reference 15).

The City of Ocean Shores is located on a low sandy peninsula, and the highest point in the city is about 40 feet above sea level. There is a long lake and canal system running the length of the city. This freshwater lake and canal system is protected from tidal fluctuation by a flap gate which allows the canal system to drain into the harbor at the southwest edge of the city. Vegetation at Ocean Shores consists of beach dune grass and wild strawberry on the west side of the peninsula. Shore pine and blue spruce grow from the center of the peninsula to the east shore.

The City of Westport is located south of Point Chehalis on a sand spit separating South Bay of Grays Harbor from the Pacific Ocean. The Pacific Ocean, the entrance channel of Grays Harbor, and South Bay are natural boundaries on three sides of Westport. Runoff from the main dune ridge westward percolates to the ground-water table in the sand flat. An open storm drainage channel runs from the south boundary of Westport through the older portion of the community discharges through a tide gate in a levee into South Bay.

The Westport sand spit was formed by coastal processes in recent geologic times and is comprised of unconsolidated marine sediments. Well-stabilized inland sand dunes, ranging in elevation from 20 to 60 feet, form the higher ridge in Westport. The older portion of Westport developed east of this ridge. The western slope of the ridge drops abruptly to accreted sand flats which extend to the lower ridge of beachfront dunes. These foredunes are as high as 30 feet, where they have not been disturbed or breached by roots.

Shore pine and spruce trees grow on the main dunes of the peninsula and the eastern slope. Alders, blackberry brambles, and various kinds of brush also grow on the east slope. Scotch broom and a variety of dune grasses grow on the western sand flats and fore dunes, and border the South Bay tide flats.

2.3 Principal Flood Problems

Flooding in Grays Harbor County occurs principally in the winter. High tides and strong winds from winter storms produce storm surges that cause coastal flooding. Heavy rains with some snowmelt produce the highest runoff flows in the winter. The Pacific weather fronts that produce the storm surges also bring heavy rains and high river flows are held back by tides, producing the greatest flooding at river mouths. High river flows may coincide with high tides and aggravate flooding.

The highest river and harbor water stages in the Grays Harbor County result from a combination of high astronomic tides, low barometric pressure, and strong onshore winds. In the past, high tidal stages caused by this combination have resulted in extensive water damage to homes, businesses, and public property.

Flooding could also be caused by high tides overflowing dikes or other barriers. This can be aggravated by wave attack and runup by causing erosion which could contribute to a dike failure.

Flows have been recorded on the Chehalis River at Porter since January 1952. Two floods on record at this station had discharges of 55,660 cubic feet per second (cfs) (January 1972) and 49,600 cfs (January 1971). The USACE estimated these discharges to have a recurrence interval of 75 years and 60 years, respectively (Reference 16).

The USACE completed construction of a dam on the Wynoochee River at RM 51.8 in August 1972. Until January 1982, the highest flow recorded at the gage (located just above Black Creek) was 18,100 cfs in December 1972. Based on the exceedence-frequency curve developed by the USGS for this gaging site, this discharge has a recurrence interval of approximately two years.

A gage on Cloquallum Creek located just downstream of the State Highway 12 bridge was operated continuously from July 1944 to September 1972. Annual peak discharges were recorded for 1973 through 1979. From 1944 to 1979, the highest discharge recorded at this gage was 5,080 cfs, recorded on December 15, 1959. Based on the exceedence-frequency curve developed by the USGS for this site, this discharge has a recurrence interval of approximately 20 years.

A high tide on Grays Harbor occurred on December 17, 1933, and resulted in serious flooding in the Cities of Aberdeen and Hoquiam. Intense rainfall occurred from December 16 through 22, and 90-mile-per-hour winds were recorded on December 17. During the storm, a high tide of 13.4 feet (North American Vertical Datum of 1988 (NAVD88)) was observed at the Port of Grays Harbor staff gage. Flooding resulted from the combination of high tide and high river flows. The December 17, 1933, tide had a recurrence interval of approximately 80 years (Reference 17).

As an indication of frequency of high tide conditions at Hoquiam, the ten highest tides, measured at the Port of Grays Harbor staff gage in the City of Aberdeen, are shown in Table 5, “Highest Tides at Aberdeen”.

Table 5 – Highest Tides at Aberdeen

Date	Gage Height (Feet[1])	Stage (Feet)
December 17, 1933	15.8	13.4
December 1934	15.5	13.1
December 25, 1923	15.2	12.8
November 1913	15.2	12.8
November 1912	15.0	12.6
December 1920	14.9	12.5
December 22, 1972	14.7[2]	12.4
January 27, 1964	14.7	12.3
December 18, 1960	14.7	12.3
December 13, 1941	14.7	12.3

[1] Port of Grays Harbor staff gage at Pier No.1, unless otherwise noted. In some years, gage reading may not be highest for the year since some high tides were not measured; gage datum (zero) equals 9.4 feet (NAVD88)

[2] USACE staff gage; gage datum (zero) equals 9.3 feet (NAVD88)

Flooding is due primarily to high water in the rivers causing backup into the creeks and inundating adjacent low areas. This can be aggravated during rainstorms by backup of city storm drainage systems as intense local runoff is prevented from entering rivers.

Flooding in Elma occurs principally during the winter months, when heavy rains with some snowmelt produce the highest runoff.

Rapid runoff from the steep hillsides of the Fry Creek watershed often exceeds the channel capacity of Fry Creek, causing flooding. Flood waters emerging from Fry Creek, flow west, along east-west streets, particularly Cherry Street. During the January 15, 1976 flood, the City of Hoquiam constructed a temporary dike along Myrtle Street which prevented Fry Creek waters from entering the city.

The Hoquiam River originates in hills that are less than 1,000 feet in elevation and flows into Grays Harbor. Tidal influence from Grays Harbor extends up the Hoquiam River to beyond the study limits. High Hoquiam River flows may coincide with high tides and aggravate flooding, but high flows in the nearby Chehalis River do not affect the Hoquiam area, since the river influence is submerged by high tides.

The major potential source of flooding within the City of McCleary is East Fork Wildcat Creek. The other potential source of flooding is an unnamed tributary, which meets East Fork Wildcat Creek near the western city limits. This stream had a history of flooding. In 1976, the U.S. Soil Conservation Service (SCS), as part of the Columbia Pacific Resource Conservation and Development project, designed and subsequently constructed flood control measures (Reference 18).

There have been few flooding problems along Mill Creek (in the City of Cosmopolis) due to the culverts for street crossings; as long as those culverts are not blocked by trash.

Some of the property owners in the reaches above those influenced by high water in the Chehalis River, whose homes are located on low ground near the stream, reported annual flooding of their basements. However, flooding along the lower section of Mill Creek is due primarily to high water in the Chehalis River backing up the creek and inundating adjacent low areas.

A gage on the Satsop River at RM 2.3 has been in operation since March 1929. The highest discharge recorded at the gage was 46,600 cfs in January 1935. Based on the exceedence-frequency curve developed by the USGS for this gage site, this discharge has a recurrence interval of approximately 50 years.

The Wilson Creek drainage basin was clear cut in 1974. Additional logging operations have been carried out since then. This has caused an increase in the volume of water in this creek during rainstorms.

Coastal flooding occurs mainly in the winter months, when storms with high winds cause storm surges and high waves. Waves due to seismic disturbances in the Pacific Ocean, called tsunamis, can also cause flooding. The principal areas of flooding occur up the beach access roads, which have been cut through the dune line to the ocean beach and in the extreme southern end of the city, which is at a lower elevation. Most of the developed or developing areas have a lower risk of serious flooding. Local ordinances have prevented development in serious flood hazard areas.

A storm in December 1973 breached the jetty and the bulkhead at the south end and caused some flooding which threatened the sewage treatment plant. High water from this storm traveled up the beach access roads but caused no flooding.

Waves due to seismic disturbances, tsunamis, can develop in the Pacific Ocean. The flooding effects depend upon the direction of approach and local hydrography. The tsunami created by the 1964 Alaskan earthquake was the last one of note. Water ran up the beach access road at Chance a Lamer Boulevard past Ocean Shores Boulevard and left standing water on Ocean Shores Boulevard, which parallels the ocean behind the dune line.

The most serious coastal flooding problems have been experienced at the tip of Point Chehalis. If a severe Pacific Ocean storm coincides with one of the highest predicted tides, coastal flooding can be expected. In December 1967, unofficial measurements along the coast placed the tide levels four feet above the predicted levels when such a combination occurred.

The highest waves occur during winter months, when sea and swell are greater than 8 feet (deep-water significant wave height) 50 to 75 percent of the time. Throughout the year, wave heights greater than eight feet occur about 35 percent of the time and greater than 20 feet about 10 percent of the time.

On March 9, 1977, waves reported to be 25 feet high destroyed protective works scattering rocks and logs over a three-block area at the north end of the City of Westport (References 19, 20, and 21). Wave wash beyond the sea-wall was over one foot deep in nearby buildings and streets. Onshore winds were over 40 miles per hour from the west. Waves also ran up the ocean beach access roads. Since that area was still undeveloped, no damage resulted.

Local strong easterly winds generate waves in Grays Harbor on top of high tides which can cause flooding beyond Montesano Street at Veteran Avenue in the southeast portion of the City of Westport. Wind generated waves up to six feet high are not unusual in Grays Harbor (Reference 22). South of the airport, a natural ridge and levee protect a portion of Westport from wind-generated waves.

The accreted flats on the ocean side of Westport, although not extensively developed, are subject to erosion and potential flooding from Pacific Ocean storms. In moderate storms, the storm surge and accompanying waves typically subside before the beach has been significantly eroded. In severe storms, or after a series of moderate storms, the backshore may be completely eroded, after which the waves will begin to erode the coastal dunes or land behind the beach. The extent of storm erosion depends on wave conditions, storm surge, the stage of the tide, and storm duration. Potential flood damage to property behind the beach depends on all these factors and on the volume of sand stored in the beach dune system when a storm occurs.

2.4 Flood Protection Measures

Levees provide the County with some degree of protection against flooding. However, it has been ascertained that some of these levees may not protect the community from rare events such as the 1-percent-annual-chance flood. The criteria used to evaluate protection against the 1-percent-annual-chance flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 1-pecent-annual-chance flood are not considered in the hydraulic analysis of the 1-percent-annual-chance floodplain.

Levees are located along the Chehalis River between the Cities of Montesano and Satsop. There are also levees along both sides of the Copalis River in the vicinity of the Town of Copalis. These levees do not provide protection against the 1-percent-annual-chance flood.

The City of Aberdeen has a system of dikes along both banks of the Chehalis River and Grays Harbor. These dikes do not provide protection from the 1-percent-annual-chance flood since the elevation at the top of most of the dikes is below the 1-percent-annual-chance tidal elevation. Aberdeen adopted Flood Prevention Ordinance No. 5578, dated May 6, 1981. This ordinance requires a minimum floor elevation of 13.5 (NAVD88) feet for new residential and commercial construction. The referenced dike (levee) above was modified in 1997 to provide additional protection and this area was re-mapped in accordance with LOMR 98-10-179P. However, the USACE levees are pending levee certification.

A dike was built in 1978 to protect the area in northwestern portion of the City of Cosmopolis that is bounded on the south by Mill Creek, on the northeast by the Burlington Northern Railroad, on the north by the city corporate limits, and on the west by the tributary to Mill Creek. This dike is insufficient to protect the area from floods with recurrence intervals of 20 years or greater. The city has a resolution which requires that lowest floor elevations be 2 feet above the 1-percent-annual-chance flood elevation established by the USACE for the Chehalis River.

The referenced dike (levee) above was modified in 1997 to provide additional protection and this area was re-mapped in accordance with LOMR 98-10-179P. However, the USACE levees are pending levee certification.

Most of the City of Hoquiam is surrounded by levees. Portions of the levee system were constructed by the USACE in 1936, along with a system of interior drains, as an Emergency Relief Administration project. In 1973 a portion of damaged levee, protecting east Hoquiam, was repaired by the USACE as an emergency project. However, based on a limited evaluation of the levee system in 1976 and 1977 by the USACE, it was determined that the levees probably would be unable to withstand a 1-percent-annual-chance flood.

In 1978 the SCS constructed a flood protection measure for the unnamed tributary to East Fork Wildcat Creek in the City of McCleary. The project was designed to provide in-stream capacity for the 1-percent-annual-chance flood event (Reference 23). The project increased the conveyance capacity of the stream channel and provided stream bank protection. The open channel sections were rebuilt with more capacity and with riprap to protect the bottom and sides. A parallel pipe was added to supplement the 1,700-foot-long pipeline that is located along Maple Street. Inlet and outlet structures were built for both pipelines. The project protects the area adjacent to the tributary between First Street and East Fork Wildcat Creek.

The City of McCleary adopted a resolution (Reference 24) requiring the Grays Harbor County Building Inspector to review new construction and substantial improvements to ascertain whether they are designed consistent with the need to minimize flood hazards.

Wynoochee Dam, completed in August 1972, has resulted in reduced flooding downstream.

The City of Ocean Shores enacted ordinances for controlling development in flood-prone areas defined by the FIA preliminary flood study. Development in wetland areas is controlled by State Law.

A jetty was built by the USACE on the south end of Point Brown and protects the southern part of the city. The jetty was damaged in the December 1973 storm and was rebuilt in 1975. A breakwater protects a small-boat basin at the southwest end of Ocean Shores. Many residents have rip-rapped the banks at the shoreline to prevent erosion to their land on the east side of the peninsula.

In the City of Westport local ordinances have prevented development in most serious coastal flood hazard areas. Marine and protective structures are concentrated at Point Chehalis at the entrance to Grays Harbor. They consist of a jetty, revetment, groins, boat basin, and breakwaters.

The first USACE project at Point Chehalis was a jetty authorized in 1895 to create a self-maintaining channel through the harbor bar sufficient for ocean-going vessels. The jetty was constructed of rock in 1902, and extended westerly from the west side of the point 13,734 feet.

The USACE reconstructed various portions of the jetty and the revetments over the years. Portions of the Point Chehalis revetment have been rebuilt several times since 1960.

Repairs were needed after a storm on March 8, 1977, and were accomplished with the planned rehabilitation of the Point Chehalis revetment. In preceding years, after winter storms displaced armor rock several hundred feet, a design memorandum (Reference 25) recommended placing heavier, larger, armor rock on an existing 500 foot section.

3.0 ENGINEERING METHODS

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

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for the flooding source studied by detail methods affecting the communities within Grays Harbor County. Information on the methods used to determine the peak discharge-frequency relationships for each flooding source studied by detailed methods is shown below.

Pre-countywide Analysis

The hydrologic analyses for Grays Harbor County are divided into two categories: riverine, and tidal/ coastal.

Riverine Analysis

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Alder Creek, the Division Street Drainage and branches, Fry Creek, Stewart Creek and tributary, Mill Creek, and Wilson Creek are ungaged streams. The 10-, 2-, 1-, and 0.2-percent chance floods on it were determined by the application of the method described in the SCS publication *Urban Hydrology for Small Watersheds* (Reference 26). This method includes the effects of soils, ground slope, drainage basin size and shape, and land use in the determination of runoff flows.

Bush Creek, Dry Bed, Harris Creek, Newman Creek, Roundtree Creek, and Vance Creeks are ungaged streams. The 10-, 2-, 1-, and 0.2-percent chance flood flows for each of these streams were determined by the application of the methodology described in a USGS publication entitled *Magnitude and Frequency of Floods in Washington* (Reference 27).

Discharges for the 4-, 2-, 1-, and 0.5-percent-annual-chance (25-, 50-, 100-, and 200-year recurrence interval) floods on the Chehalis River were obtained from a 1975 report on the Chehalis River that was prepared by the USACE (Reference 28).

Discharges for the 10-, 2-, 1-, and 0.2-percent chance floods on the East Fork Hoquiam, Hoquiam, Little Hoquiam Rivers were obtained from a Flood Plain Information Report completed in 1971 (Reference 29). Since stream gage records were not available for these streams, the discharges were derived from gage records of four other streams in the region. The flows were estimated by a statistical analysis of stage-discharge records, following the standard log-Pearson Type III method as outlined in Bulletin 17 of the Water Resources Council (Reference 30). Preliminary hydraulic analyses with these flows indicated that riverine flooding was not significant compared with tidal flooding; therefore, a new detailed hydrologic study of the Hoquiam River system was not completed.

Discharges for the 4-, 2-, 1-, and 0.5-percent-annual-chance floods on the Wishkah River were obtained from a 1971 analysis of the water-surface profiles of the Wishkah River that was carried out by the USACE (Reference 31).

The Cloquallum Creek exceedence-frequency relationships were obtained from the USGS analysis of 35 years of data collected for the gage near the U.S. Highway 12 bridge.

The Satsop River exceedence-frequency relationships were obtained from the USGS analysis of 50 years of data collected for the gage located at RM 2.3.

The Wynoochee River exceedence-frequency relationships were obtained from the USGS analysis of 24 years of data collected for the gage located just above Black Creek. The USGS analysis included the effects of the Wynoochee Dam.

Peak discharge-drainage area relationships for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods for each stream studied by detailed methods are presented in Table 6, "Summary of Discharges".

Table 6 – Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (CFS) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
ALDER CREEK					
Confluence with Grays Harbor	1.11	175	*	241	277
800 feet above Huntley Road	0.58	*	*	120	*
BUSH CREEK					
Confluence with Cloquallum Creek	4.20	388	550	624	795
CHEHALIS RIVER					
Confluence with Grays Harbor	2,114	55,000	70,500	77,000	102,000
CLOQUALLUM CREEK					
Confluence with Chehalis River	66.40	4,680	5,920	6,420	7,540
Above U.S. Highway 12	64.90	4,590	5,800	6,290	7,390
Above Wildcat Creek	39.60	3,020	3,790	4,110	4,830
DEVONSHIRE SLOUGH					
At mouth	0.73	86	*	113	147
DIVISION STREET DRAINAGE					
Confluence with Grays Harbor	0.36	*	*	110	*
DRY BED CREEK					
Above U.S. Highway 12	0.70	74	103	116	145
EAST BRANCH DIVISION STREET DRAINAGE					
Confluence with West Branch Division Street Drainage	0.17	*	*	46	*

* Discharge-frequency relationship not determined

Table 6 – Summary of Discharges (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (CFS) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
EAST FORK SATSOP RIVER					
Confluence with West Fork Satsop River	199	25,500	33,500	36,900	44,000
EAST FORK WILDCAT CREEK					
SW boundary of City of McCleary	6.60	426	602	682	880
Confluence with unnamed tributary	5.10	343	484	548	700
FRY CREEK					
Confluence with Grays Harbor	2.22	260	460	540	810
300 feet downstream of Hemlock Street	1.66	*	*	360	*
HARRIS CREEK					
Above Garrard Creek Road	3.70	200	278	314	345
Confluence with Roundtree Creek	1.30	83	114	129	164
MILL CREEK					
Confluence with Chehalis River	2.85	417	*	575	603
Above Altenau Street	2.00	144	281	331	530
NEWMAN CREEK					
Confluence with Vance Creek	13.5	890	1,270	1,450	1,880
Above Montesano-Elma Road	8.90	630	890	1,010	1,310
ROUNDTREE CREEK					
Confluence with Harris Creek	1.40	86	119	134	170
SATSOP RIVER					
River Mile 2.3 Gage	299	36,200	47,500	52,300	62,500

* Discharge-frequency relationship not determined

Table 6 – Summary of Discharges (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (CFS) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
SHANNON SLOUGH					
At mouth	0.22	30	*	39	51
STEWART CREEK					
Confluence with Wishkah River	2.95	250	460	560	870
Downstream of Valley Street	2.35	*	*	430	*
TRIBUTARY TO STEWART CREEK					
Confluence with Stewart Creek	0.52	55	105	130	210
VANCE CREEK					
Above U.S. Highway 12	4.50	350	500	565	725
WEST BRANCH DIVISION STREET DRAINAGE					
Confluence with East Branch Division St Drainage	0.14	*	*	39	*
WILSON CREEK					
Confluence with Chehalis River	1.14	166	263	301	403
WISHKAH RIVER					
Confluence with Chehalis River	102	12,000	16,500	18,600	23,300
WYNOOCHEE RIVER					
Above Black Creek	155	18,000	20,500	23,000	28,500
Above Wedekind Creek	141	16,600	18,900	21,200	26,300

* Discharge-frequency relationship not determined

Tidal/Coastal Analysis

Flood damage from storms in coastal areas is the result of the combination of high stillwater levels and wave action. Stillwater is composed of astronomical tide, caused by gravitational effects of the sun and moon; storm surge, the rise in water level due to wind stress and low atmospheric pressure; and wave setup, an increase in water level due to shoreward mass transport of water. Tide gages measure stillwater levels. The runup of breaking waves can cause flooding and structural damage at elevations above the stillwater level of the flood.

The Grays Harbor tidal frequency analysis (Reference 30) was used in this study. That analysis was based on a record of the 15 highest tides observed at the Port of Grays Harbor staff gage during the period of 1912 to 1964.

Stillwater levels for the Pacific Ocean coast were based on the levels determined for the Pacific Ocean coast in the FIS for the City of Ocean Shores (Reference 32).

Stillwater levels for South Bay were based on the levels determined for South Bay in the FIS for the City of Westport (Reference 8).

Estimated wave runup elevations for the selected recurrence intervals were determined by adding the stillwater levels to computed wave runup for wave and breaker heights associated with the same storm frequency.

The USACE Waterways Experiment Station, Vicksburg, Mississippi, completed a study of flood levels on the west coast due to tsunamis (waves of seismic origin). The results of the study showed that tsunami-caused flooding at the 1-percent-annual-chance level is lower than that caused by winter storms (Reference 33).

For Ocean Shores, the 3-hour average astronomical tide height-frequency distribution was computed utilizing hourly predicted tides calculated using the tide tables in the National Ocean Survey (Reference 34).

Surface weather maps at 3-hour intervals for 1942-1975 were used to compile statistics on significant storm surge-producing events on the southwest Washington coast. Daily surface weather maps were used to extend these statistics back to 1901. These data were separated into three wind direction classes so that appropriate wave statistics could be combined with storm surge statistics generated with the storm surge model. A description of the storm surge model is given in Section 3.2 Hydraulic Analyses.

Wave statistics for wind-generated waves were computed using the 5MB procedure (Reference 35). The frequency distributions of winds for the three direction classes were computed using pressure gradients taken from the weather maps of significant storm events, and the geostrophic wind equation was corrected to compute surface winds.

For the same direction class, wind waves of a certain probability were assumed to take place with a storm surge of the same probability since the same meteorological conditions produce both.

Waves produced by Pacific Ocean and Gulf of Alaska storms traveling to the Washington coast have the same probability of occurrence as the wind-generated waves (Reference

36). However, they are less likely to occur during high storm surges than are the wind-generated waves.

A combined probabilistic analysis was made for storm surge, wave runup, and astronomical tide for each direction class on the ocean coast. The water level predicted for a combined recurrence interval was used for drawing the flood boundaries shown on the FIRM.

On the east shoreline bordering North Bay, tide gage correction factors were used to adjust the combined astronomical tide and storm surge for the open coast. Local wind setup and wind waves in the bay were determined from the winds associated with the storm surges. Strong east winds will also produce significant wave action on this shoreline. The probability of local wind setup and waves from this direction was combined with the probability of an astronomical tide.

Data from the preceding two analyses were combined to obtain flood levels and their associated recurrence intervals for tidal flooding areas.

The hydrologic analysis of the internal canals and lakes in the City of Ocean Shores was performed by considering the tidal elevation associated with the 10-percent-annual-chance and 1-percent-annual-chance storms and the freshwater runoff expected at the time of these high tides. The 10- and 1-percent-annual-chance tidal levels at the outlet tide gate were taken from the results of the tidal flooding analysis.

The combination of the 1-percent-annual-chance tide with the 10-percent-annual-chance freshwater flow was used to represent the 1-percent chance flooding condition (Reference 37). A 10-percent-annual-chance tide in conjunction with a 20-percent-annual-chance runoff was selected as representative of the 10-percent-annual-chance flooding event. Only the 10- and 1-percent-annual-chance flooding conditions were considered for the analysis of the internal flooding problems at the City of Ocean Shores.

The 20-percent-annual-chance and 10-percent-annual-chance freshwater flows were developed by the Columbia Pacific Resource Conservation and Development office of SCS in Raymond, Washington. These flows were developed using the SCS TR20 computer model as no stream flow data were available for the internal lakes and canals in the City of Ocean Shores.

The 10- and 1-percent-annual-chance tidal levels at the outlet tide gate were taken from results of the tidal flooding analysis. Table 7, "Hydrologic Flooding Parameters", summarizes the hydrologic parameters used for the internal flooding analysis of the City of Ocean Shores.

Table 7 – Hydrologic Flooding Parameters

	10%-ANNUAL-CHANCE	**1%-ANNUAL-CHANCE**
Tidal Elevation (feet above NAVD88)	11.1	13.9
Freshwater Flow (cubic feet per second)	185	350

For the City of Westport, coastal flood levels due to storm surge, astronomical tides, and wave setup were estimated by developing the stillwater level-frequency curve. The stillwater curve is based on continuous tide gage records for the period from August 8, 1968, through December 2, 1976 (Reference 38).

The more frequent lower flood levels of the curve were defined by a statistical analysis of an annual peak series from the recorded data. Less frequent higher flood levels of the curve were defined to correlate with the tidal stage-frequency for Ocean Shores (Reference 39). The Aberdeen tidal stage-frequency curve (Reference 28) was also correlated with the curve for Westport. Relative tidal correction factors published annually by the National Oceanic and Atmospheric Administration (Reference 40) were used to adjust stillwater levels for comparison and for the open coast relative to the Point Chehalis tide gage.

The computed wave runup water surface stillwater elevation-frequency relationships for Grays Harbor, North Bay, and Pacific Ocean were obtained from these analyses are listed in Table 8, “Summary of Wave Runup Elevations”.

Table 8 – Summary of Wave Runup Elevations

	WAVE RUNUP ELEVATION (feet NAVD88)			
FLOODING SOURCE AND LOCATION	**10%-ANNUAL-CHANCE**	**2%-ANNUAL-CHANCE**	**1%-ANNUAL-CHANCE**	**0.2%-ANNUAL-CHANCE**
GRAYS HARBOR ENTRANCE				
Reach 1 (Ocean Shores Side)	13.2	15.2	16.0	17.9
Reach 2 (Westport Side- Point Chehalis)	18.4	21.2	22.9	25.4
NORTH BAY				
Reach 1 (Ocean Shores)	12.7	14.3	15.1	16.7
Stillwater	11.4	13.1	13.9	15.8
PACIFIC OCEAN				
At Moclips	18.4	23.0	25.4	29.3
South of Moclips	19.1	24.5	27.9	31.9
At Pacific Beach	19.3	24.8	28.3	32.4
At Joe Creek	17.7	21.6	23.0	27.0
0.8 Mile South of Boone Creek	20.8	28.1	33.8	38.2
1.0 Mile South of Boone Creek	19.2	24.7	28.2	32.2
North of Copalis Rock National Wildlife Refuge	18.0	22.1	23.9	27.6

Table 8 – Summary of Wave Runup Elevations (Continued)

FLOODING SOURCE AND LOCATION	WAVE RUNUP ELEVATION (feet NAVD88) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
PACIFIC OCEAN (Continued)				
From Copalis Rock National Wildlife Refuge to City of Ocean Shores except at Sea View Estates and Quinalt Casino and Resort	18.2	22.5	24.5	28.3
City of Ocean Shores Reach 1 (To Taurus Boulevard)	18.0	22.2	24.1	27.9
City of Ocean Shores Reach 2 (South of Taurus Boulevard)	17.4	21.6	23.4	27.2
City of Westport Reach 1	18.4	21.7	23.5	27.5
At Westport	18.6	23.3	25.8	29.7
South of Westport	19.3	24.9	28.5	32.6
North of Grayland	19.6	25.6	29.6	33.7
At Grayland	19.0	24.2	27.4	31.3
Stillwater	11.0	12.6	13.2	15.1

The computed wave runup water surface stillwater elevation-frequency relationships for Grays Harbor, Pacific Ocean, and South Bay were obtained from these analyses are listed in Table 9, "Summary of Wave Setup Elevations".

Table 9 – Summary of Wave Setup Elevations

FLOODING SOURCE AND LOCATION	WAVE SETUP ELEVATION (feet NAVD88) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
GRAYS HARBOR				
Port of Grays Harbor	12.3	13.2	13.5	14.0
PACIFIC OCEAN				
From Moclips to Grayland	11.1	12.7	13.3	15.2
Shallow flooding Behind Point Chehalis Revetment	*	*	4.5 – 5.5	*
South Bay Westport Shoreline and Westhaven Cove	12.2	13.4	13.9	16.1

* Data Not Available

3.2 Hydraulic Analyses

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

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5-foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the FIRM (Exhibit 2). Unless specified otherwise, the hydraulic analyses for these studies were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For those study reaches subject to tidal inundation, the flood profiles were extended downstream to the limit of the coastal velocity zone or to where the mean high tide exceeded normal depth from a riverine only flood, whichever occurred farthest upstream.

All elevations shown on the Flood Profiles and FIRM (Exhibits 1 and 2) are referenced to the NAVD88.

<u>Pre-countywide Analysis</u>

The sections of Alder Creek, Fry Creek, Stewart Creek and tributary to Mill Creek that were to be studied by detailed methods are within the 1-percent-annual-chance floodplains of the Chehalis and/or the Wishkah Rivers. The 1-percent-annual-chance flows in the detailed study reaches of these small streams will not cause flooding greater than that due to the 1-percent chance flood of the Chehalis or Wishkah Rivers. Therefore, no further hydraulic analyses were conducted for those sections of the streams.

For Bush Creek, Cloquallum Creek, East Fork Wildcat Creek, Harris Creek, Mill Creek, Newman Creek, Roundtree Creek, Satsop River, Wilson Creek and Wynoochee River, the water-surface elevations of floods were computed through use of the USACE Hydrologic Engineering Centers-2 (HEC-2) step-backwater computer program (Reference 41).

Dry Bed and Vance Creeks flow through a relatively flat floodplain. The 1-percent-annual-chance flooding from these creeks is on the average less than 1 foot deep; therefore the HEC-2 backwater analysis is not appropriate. Depths were determined by normal-depth analysis.

The hydraulic analysis of the Chehalis River is based on the USACE report, *Suggested Hydraulic Floodway Chehalis River, Aberdeen to Satsop and Vicinity, Grays Harbor County, Washington* (Reference 42). That report indicates that the tidal influence of

Grays Harbor extends up the Chehalis River to Satsop. Because the Chehalis River is controlled by backwater from Grays Harbor, a flood profile for the Chehalis River is not shown in this study. The study determined only the 1-percent chance flood elevations. The 2- and 0.2-percent chance flood elevations for the Chehalis River were not determined. The 10-percent-annual-chance flood elevation for the Chehalis River was assumed to be the higher of the river bank elevation or the 10-percent-annual-chance tidal elevation.

The reach of the Satsop River from its mouth to the USGS gaging station (RM 2.3) was calibrated by matching the elevations at the gaging station predicted by the HEC-2 computer analysis with the elevations for those discharges from the USGS stage-discharge curve for the gage.

The hydraulic analysis of the Wishkah River is based on *Wishkah River, Washington, Water-Surface Profiles* (Reference 31). In that study, the USACE determined the 4-, 2-, and 1-percent-annual-chance water-surface profiles for the first 4.16 miles of the Wishkah River. Further analysis of the Wishkah River was conducted because the USACE study did not include the determination of a floodway. The data that the USACE used were converted to the format required by the HEC-2 step-backwater computer program (Reference 41). The roughness coefficients were varied until the HEC-2 results for the 1-percent chance flood matched the results from the USACE study when the same starting water-surface elevation was specified. This calibrated model was then used for the hydraulic analysis of the Wishkah River.

Starting water-surface elevations for Cloquallum Creek, East Fork Wildcat Creek, Harris Creek, Newman Creek, Roundtree Creek and the Satsop River were determined by the slope-area method.

The elevation of the 10-percent-annual-chance tide was used for the starting water-surface elevation for the Copalis River for the 1-percent-annual-chance riverine flood. The results of this analysis indicated that the 1-percent-annual-chance stillwater elevation for the Pacific Ocean is higher than the 1-percent-annual-chance water-surface elevation anywhere on the Copalis River. Therefore, for the section of the Copalis River that was studied in detail, base flood elevations were determined from the stillwater tidal elevations for the Pacific Ocean in this area.

Starting water surface elevations for Mill Creek, Wilson Creek, and Wishkah River were assumed to be the 10-percent-annual-chance tidal elevation.

Starting water-surface elevations for the Wynoochee River were specified from the stage-discharge relationships derived by the USGS at the gaging station on this river.

A study of coincident streamflow in the Naselle River (at Naselle) was conducted to determine whether there is a correlation between storm tides and storm runoff. The Naselle River was selected because of its long record length and because the drainage area size is similar to that of the Hoquiam River. The resulting plot showed that most storm-augmented tides occurred during times of nearly base flow and flood flows generally occur without abnormally high tides. It was found through analysis that tides at the 10-, 2-, 1-, and 0.2-percent chance frequency levels coincident with the mean annual peak river flow would produce the highest stages for the respective events.

Cross sections for the backwater analyses of Bush Creek, East Fork Wildcat Creek, Harris Creek, Mill Creek, Newman Creek, Roundtree Creek, Satsop River, Wilson Creek, and Wynoochee River were surveyed by TAMS (References 43, 44, 45, and 46) under the original study contract and were visually checked by CH2M HILL. Additional cross sections for these streams were surveyed by CH2M HILL, to better approximate the shape of the flood channels. CH2M HILL also surveyed cross sections for Copalis River, Cloquallum Creek, East Fork Newman Creek, and Wildcat Creek.

Cross-section data for East Fork Hoquiam River, Hoquiam River and Littler Hoquiam River were obtained from aerial photographs, from various site plans, and by field measurement; the below-water sections were obtained by field measurement. All bridges and culverts were surveyed to obtain elevation data and structural geometry. Water-surface profiles were developed using a USACE, Seattle District step-backwater computer program (Reference 47).

Channel and overbank roughness factors used in the hydraulic computations were estimated by engineering judgment and based on field observation at each cross-section and adjusted with known high-water marks and stream gage rating curves where possible. Table 10, "Manning's "n" Values", shows the channel and overbank "n" values for the streams studied by detailed methods.

Table 10 – Manning's "n" Values

Stream	Channel "n"	Overbank "n"
Bush Creek	0.030 – 0.060	0.050 – 0.120
Chehalis River	0.030 – 0.060	0.050 – 0.120
Cloquallum Creek	0.030 – 0.060	0.050 – 0.120
East Fork Hoquiam River	0.035 – 0.045	0.070 – 0.110
East Fork Satsop River	0.030 – 0.060	0.050 – 0.120
East Fork Wildcat Creek	0.090	0.100
Harris Creek	0.030 – 0.060	0.050 – 0.120
Hoquiam River	0.035 – 0.045	0.070 – 0.110
Little Hoquiam River	0.035 – 0.045	0.070 – 0.110
Mill Creek	0.035 – 0.045	0.050 – 0.080
Newman Creek	0.030 – 0.060	0.050 – 0.120
Roundtree Creek	0.030 – 0.060	0.050 – 0.120
Satsop River (above the USGS gaging stations)	0.150	0.180 – 0.300
Satsop River (from mouth to USGS gaging stations)	0.035	0.070
Wishkah River	0.030 – 0.096	0.020 – 0.168
Wilson Creek	0.030 – 0.050	0.030 – 0.080
Wynochee River	0.030 – 0.060	0.050 – 0.120

The Manning's channel "n" values are higher than normal, since the area defined as channel in the East Fork Wildcat Creek application of HEC-2 contained a significant overbank area that is densely vegetated with bushes and small trees.

The HEC-2 model for the Satsop River above the USGS gaging stations was calibrated by adjusting the Manning's "n" values so that the elevations of observed high-water marks were reproduced to a reasonable degree by the computer model. This process resulted in unusually high "n" values.

Manning's "n" values for the Wishkah River were varied until the results of the HEC-2 runs for the 1-percent-annual-chance flood with the same starting water surface elevation as that used by the USACE matched the results of the USACE study (Reference 31) on which the analysis of the Wishkah River was based. This yielded the "calibrated" model for the river.

The approximate flooding for the Chehalis River was taken from data for a USACE, Seattle District, report entitled *Chehalis River Basin, Washington, Chehalis River -Satsop to Porter, Water-Surface Profiles* (Reference 48).

Certain areas of the 1-percent-annual-chance flooding along Grays Harbor were delineated using approximate methods. These areas are where floodwaters collect in low-lying areas due to wave action.

The extent of flooding along the upper portion of the Little Hoquiam River was delineated by extrapolating 1-percent-annual-chance flood elevations from detailed analyses downstream (Reference 49).

3.3 Wave Height Analysis

Since extreme tides would most likely be associated with a severe winter storm, the probability of the extreme tides and heavy wind wave action occurring simultaneously is likely. Under these circumstances, the possibility of wave damage should be considered when determining the flood potential.

Figure 1 is a profile for a hypothetical transects showing the effects of energy dissipation on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations and being increased by open, unobstructed wind fetches. Actual wave conditions may not necessarily include all of the situations shown in Figure 1, "Transect Schematic".

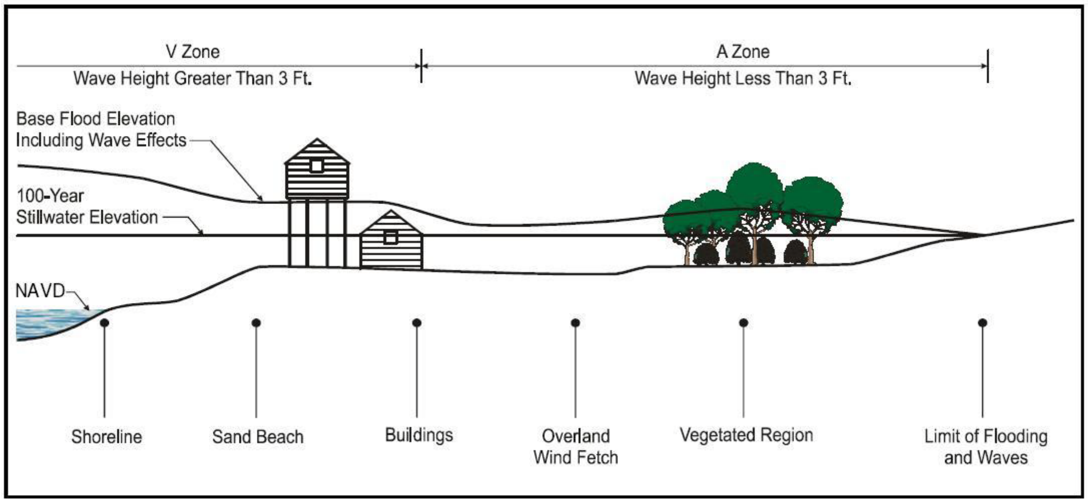


Figure 1 – Transect Schematic

The determinations of wave runup for the stretches of the Pacific Ocean coast studied in detail were based on determinations for similar beaches for the Ocean Shores FIS (Reference 32) and for the Pacific County FIS (Reference 50).

Tides in Grays Harbor are of the mixed type typical of the Pacific Northwest; two unequal high and low tides occur each day. Tidal fluctuations and extreme high tides as used in the tidal frequency curve, not including local wave effects, are the combined result of astronomical (predicted) tides and meteorologic effects (storm surge). At Hoquiam, the average daily tidal range is 13.6 feet and the maximum astronomical tide is 11.8 feet (NAVD88). The height and duration of storm surge is associated with the intensity of the storm. At Hoquiam, it is estimated that as much as 2.5 feet may be added to the astronomical tide by storm surge, not including local wave effects. Storm surge effects are included in the tidal frequency analysis discussed in Section 3.1.

Wave heights for the City of Hoquiam area were determined from an analysis of wind speed, direction, duration, fetch length, and water depth. Wind data were obtained from a USACE wind recorder at Westport, Washington, for the period of August 4, 1971 through November 15, 1973, and wind duration curves for various directions were developed. These winds were considered representative of those in the major wave-generating regions of Grays Harbor. Effective fetches to the south, southwest, and west vary from 1.2 to 5.9 miles. A large portion of these fetches is shallow tidelands necessitating corrections for bottom friction effects. After refraction effects were considered, wave heights were found to be about 2.5 to 4.5 feet for most of the shoreline bordering Grays Harbor and less than 1.5 feet for the lower reaches of the Hoquiam River. These wave heights reflect the maximum event occurring during the wind record period and are considered a reasonable estimate of waves that would occur during a 1-percent-annual-chance frequency tide.

Wave runup is a function of wave height, wave period, and beach character. For the steep banks and revetments typical of the Hoquiam shoreline, the increase in elevation due to runup would be approximately 0.7 to 0.8 times the incident wave height. Along the shoreline fronting the Anderson-Middleton Lumber Company and Bowerman Field

Road, the wave runup height would be approximately 3 feet, decreasing to less than 1.5 feet on the lower reaches of the Hoquiam River. East of the Hoquiam River, runup heights would be about 2.5 feet near the river mouth and 2 feet to the east of the Grays Harbor Paper Company.

Included in these values is the increase in the water-surface elevation due to wave setup. Wave setup is a result of wave action creating an onshore mass transport of water and is a function of wave height, wave period, and beach character. Coastal areas with elevations near the height of the estimated maximum tide may experience varying degrees of levee overtopping and erosion, and failure of under-designed shore protection structures is a possibility. The 14.0 feet (NAVD88) feet base flood elevation as shown on the maps does not reflect any increases from wave action because of the variability of the factors involved and intermittent nature of the effect.

For the ocean coastline of the City of Ocean Shores, the stillwater level was calculated by combining the astronomical tide height and storm surge height. The storm surge height was computed using a computer program called COAST. This program was constructed by rewriting the National Weather Service program, SPLASH Part 2 (Reference 51) to accommodate Pacific Northwest coast storm types. Input for this program is the offshore water depths at each point in a two-dimensional grid. One side of the grid coincides with the coast. Atmospheric pressure and pressure gradient fields also must be specified in the grid area. Other parameter values for the program were obtained in Reference 37 and through trial and error calibration to match high water marks from past storms.

Pressure fields from representative surge producing storms of the last 32 years were input to the computer model, COAST, for calculation of storm surge water levels on the southwest Washington coast. Height-frequency relationships for three storm wind-direction classes were calculated.

Combinations of wave heights, periods, and directions for the various recurrence intervals were used to synthesize waves which were tracked from the deepwater locations to shore using a wave refraction and shoaling program, called WAVES 2. This program was a modified version of a program called WAVES (Reference 52). The required data for this program was ocean bottom topography, wave height, period, direction, and starting location.

Once the wave is at the shoreline, calculations specified in the USACE, Shore Protection Manual (Reference 34) were used to compute wave runup. An effective beach slope of 20:1 was used in the calculations. This value was found by hind-casting waves from the December 1973 storm to match open coast high water marks which were 19.4 feet (NAVD88). The runup was added to the stillwater level to produce the water levels for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods.

The VE-Zones for the City of Ocean Shores were determined by estimating the height to which logs would be carried by the wave runup. Waves with the power to carry logs would be the main source of velocity damage at Ocean Shores. The VE-Zone was estimated to be seaward from a line about 2 feet vertically below the high water line on the ocean shoreline of Ocean Shores.

Hydraulic analysis of flooding from the internal lakes and canals in Ocean Shores was accomplished by obtaining the geometry of the outlet works and tide gate at the southeastern end of the city near the boat harbor. With a 10-percent-annual-chance discharge from freshwater of 350 cfs and a 1-percent-annual-chance tidal level of 13.9 feet (NAVD88), the capacity of the tide gate is exceeded and flow over the road will occur. The flow over the road will be at an elevation of 14.9 feet (NAVD88). The elevation of the 10-percent-annual-chance flood was established at 12.4 feet (NAVD88) by similar hydraulic calculations.

For Westport, wave runup data established for the open coast at the City of Ocean Shores were analyzed to develop associated deepwater, wave-frequency relationships. Published accounts of storms and waves substantiated the analysis (References 19, 36, 37, and 53). Wave heights and resultant runup were determined using analytical methods presented in the Shore Protection Manual (Reference 36). Maximum wave runup for the open coast and for Point Chehalis was then calculated.

Areas seaward from the Point Chehalis revetment and the dunes along the Grays Harbor entrance are subject to the same stillwater storm surge levels as the open coast. However, waves will be reduced due to diffraction and refraction as they enter Grays Harbor.

Breaking waves at the face of the Point Chehalis revetment have sufficient energy to overtop the revetment. Methods outlined in the Shore Protection Manual (Reference 53) were used to calculate the volume of water overtopping and flooding behind the revetment. If a portion of the revetment failed, the volume of water breaching the lowered section would increase substantially, but for this study it is assumed that the revetment will not fail.

Shallow flooding is expected to be less than two feet deep behind the northwestern portion of the revetment, decreasing to less than one foot deep in the area southeast of Coast Street and east of the intersection of Westhaven Drive and Revetment Drive.

An estimation of local wind-generated wave heights and frequencies of South Bay were based on a computation of the effective fetch for irregular shorelines. Northeast to east winds have the most effect on South Bay shores at Westport. Wind velocity-duration data recorded at Westport from August 1971, to November 1973, by the USACE show that strong gale-force winds lasting over two hours can be expected as annual maximums from the northeast to southeast quadrant. Although high winds can occur from the northeast and east, their occurrence is independent of the astronomical tide height; and, therefore, the 1-percent-annual-chance wind is as likely to blow during a low tide as a high tide. These strong winds are not expected during the high stillwater caused by winter storms which originate over the Pacific Ocean. The waves expected from northeast and east winds will be three to five feet high; but because of the breakwater at Westhaven Cove and the shallow, grass-covered flats along most of the east shore of Westport, these waves are considered to be a flood threat.

Beach runup parameters were obtained from the surveyed beach transects. The angle of the seaward beach slopes and the heights of seawalls or berms were measured from plotted survey data.

Runup procedures specified (Reference 47) were used to estimate wave runup. These procedures are based on empirical studies and include the effects of wave setup. Flood elevations for the maximum stillwater flood event were obtained by adding the recurrence interval runup estimate to the same predicted recurrence interval stillwater elevation. Statistical combinations of recurrence interval maximum-sustained wind setup and wave runup with recurrence interval astronomical tide heights were done to determine flood elevations for the maximum wind event. The event producing the higher flood elevation was used to establish the base flood elevation (1-percent-annual-chance) (BFE). Estimation of runup heights was verified based on knowledge of the transects from site visits, on understanding the strengths and limitations of the runup procedures, and on engineering judgment.

Countywide Analyses

The following riverine flooding sources with detailed study were redelineated: Chehalis River (from approximately 1.50 miles upstream of the confluence with Grays Harbor to approximately 9.1 miles upstream); Cloquallum Creek (from approximately 4,700 feet upstream of the confluence with Chehalis River to cross-section F); East Fork Hoquiam River (from confluence with Hoquiam River to approximately 0.80 miles upstream); Harris River (from approximately 7,100 feet upstream of the confluence with Chehalis River to 12,740 feet upstream); Hoquiam River (from confluence with Gray Harbor to approximately 3.04 miles upstream); Little Hoquiam River (from confluence with Hoquiam River to approximately 1.98 miles upstream); Mill Creek (from approximately 2,600 feet upstream of the confluence with Grays Harbor to approximately 5,760 feet upstream); Newman Creek (from approximately 14,350 feet upstream of the confluence with Wenzel Slough to cross-section M); Roundtree Creek (from the confluence with Harris Creek to approximately 2,950 feet upstream); Satsop River (from approximately 6,650 feet upstream of the confluence with Chehalis River to cross-section E); and Wilson Creek (from the confluence with Chehalis River to approximately 2,160 feet upstream).

All qualifying benchmarks within a given jurisdiction that are catalogued 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.

Benchmarks 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 (e.g. mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation (e.g. concrete bridge abutment)
- 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)

In addition to NSRS benchmarks, the FIRM may also show vertical control monuments established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for benchmarks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov.

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

3.4 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the NAVD88, many FIS reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. Some of the data used in this revision were taken from the prior effective FIS reports and FIRMs and adjusted to NAVD88.

As noted above, the elevations shown in the FIS report and on the FIRM for Grays Harbor County 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 factor from NGVD29 to NAVD88 for Grays Harbor County is **+3.46 feet**. The locations used to establish the conversion factor were USGS 7.5-minute topographic quadrangle corners that fell within the County, as well as those that were within 2.5 miles outside the County. These quadrangle corners were then evaluated using the USACE's CORPSCON datum conversion software, Version 6.0 (Reference 54). The benchmarks are referenced to NAVD88.

Conversion locations and values for Grays Harbor County are shown below in Table 11, "Vertical Datum Conversion Values."

Table 11 – Vertical Datum Conversion Values

USGS 7.5-Minute Quadrangle Name	Corner	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Conversion from NGVD29 to NAVD88 (foot)
ABERDEEN	NE	-123.750	47.000	3.47
ABERDEEN GARDENS	NE	-123.750	47.125	3.36
ABERDEEN SE	NE	-123.750	46.875	3.54
(ALL WATER)	NE	-124.375	47.500	3.45

Table 11 – Vertical Datum Conversion Values (Continued)

USGS 7.5-Minute Quadrangle Name	Corner	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Conversion from NGVD29 to NAVD88 (foot)
(ALL WATER)	NE	-124.375	47.375	3.45
(ALL WATER)	NE	-124.250	47.250	3.35
(ALL WATER)	NE	-124.250	47.125	3.48
BLUE MOUNTAIN	NE	-123.375	46.875	3.52
BROOKLYN	NE	-123.500	46.875	3.48
BURNT HILL	NE	-123.750	47.375	3.48
CAPITOL PEAK	NE	-123.125	47.000	3.47
CARLISLE	NE	-124.000	47.250	3.37
CEDARVILLE	NE	-123.250	46.875	3.49
CENTRAL PARK	NE	-123.625	47.000	3.43
COLONEL BOB	NE	-123.625	47.500	3.72
COPALIS BEACH	NE	-124.125	47.125	3.39
COPALIS CROSSING	NE	-124.000	47.125	3.36
ELKHORN CREEK	NE	-123.625	46.875	3.47
GRAYLAND	NE	-124.000	46.875	3.66
GRAYLAND	NE	-124.125	46.875	3.62
GRISDALE	NE	-123.500	47.375	3.54
HOQUIAM	NE	-123.875	47.000	3.47
HUMPTULIPS	NE	-123.875	47.250	3.37
LAKE QUINAULT EAST	NE	-123.750	47.500	3.66
LAKE QUINAULT WEST	NE	-123.875	47.500	3.46
LARSEN CREEK	NE	-123.625	47.375	3.46
MACAFEE HILL	NE	-124.000	47.375	3.35
MALONE	NE	-123.250	47.000	3.42
MOCLIPS	NE	-124.125	47.250	3.36
MONTESANO	NE	-123.500	47.000	3.38
NEW LONDON	NE	-123.875	47.125	3.34
OAKVILLE	NE	-123.125	46.875	3.45
O'TOOK PRAIRIE	NE	-124.125	47.500	3.45
POINT BROWN	NE	-124.125	47.000	3.47
PRICES PEAK	NE	-123.500	47.125	3.37
RAILROAD CAMP	NE	-123.750	47.250	3.41
SHALE SLOUGH	NE	-124.125	47.375	3.38

Table 11 – Vertical Datum Conversion Values (Continued)

USGS 7.5-Minute Quadrangle Name	Corner	Longitude (Decimal Degrees)	Latitude (Decimal Degrees)	Conversion from NGVD29 to NAVD88 (foot)
SOUTH ELMA	NE	-123.375	47.000	3.37
STEVENS CREEK	NE	-123.875	47.375	3.43
TAHOLAH	NE	-124.250	47.375	3.42
THIMBLE MTN	NE	-124.000	47.500	3.45
TUNNEL ISLAND	NE	-124.250	47.500	3.45
WESTERN	NE	-123.875	46.875	3.64
WESTPORT	NE	-124.000	47.000	3.50
WYNOOCHEE LAKE	NE	-123.500	47.500	3.79
WYNOOCHEE VALLEY NE	NE	-123.500	47.250	3.41
WYNOOCHEE VALLEY NW	NE	-123.625	47.250	3.40
WYNOOCHEE VALLEY SW	NE	-123.625	47.125	3.39
			AVERAGE	**+3.46 foot**

NAVD88 = NGVD29 + 3.46 feet

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD29 should apply the conversion factor to elevations shown on the Flood Profiles and supporting data tables in this FIS report, which are shown at a minimum to the nearest 0.1 foot.

Flood elevations for the City of Ocean Shores were based on Ruskin Fisher and Associates Datum (RFAD) and were converted to NAVD88 elevations by adding 5.48 feet.

For additional information regarding conversion between the NGVD29 and NAVD88, visit the National Geodetic Survey website at http://www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

Vertical Network Branch, N/CG13
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191

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

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at http://www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (500-year) floodplain boundaries and 1-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles and Floodway Data Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps of varying scales based on the availability of data.

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

Pre-Countywide Analysis

For each stream studied by detailed methods, the original 1- and 0.2-percent-annual-chance floodplain boundaries were delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps of varying scales based on the availability of data.

For Alder Creek, Chehalis River (within the City of Aberdeen), East Fork Hoquiam River, Hoquiam River, Little Hoquiam River (lower portion), Fry Creek, Stewart Creek, Wilson Creek, and Wishkah River the boundaries of the 1- and 0.2-percent-annual-chance floods were delineated using topographic maps at a scale of 1:4,800, with a contour interval of 10 feet (Reference 55 and 56).

Field work performed by the Engineering Department of the City of Aberdeen and information obtained from PGH and other private organizations were also used to delineate the 1-percent-annual-chance flood for detail-studied streams in the City of Aberdeen.

For Bush Creek, Cloquallum Creek, East Fork Wildcat Creek, Harris Creek, Newman Creek, Roundtree Creek, Satsop River, and Wynoochee River the boundaries were of the 1- and 0.2-percent chance floods were delineated using USGS topographic maps at a scale of 1:62,500, with contour intervals of 40 and 80 feet (Reference 57 and 58). For Cloquallam Creek, in the City of Elma, the topographic maps were subsequently enlarged to a scale of 1:6,000 with a contour interval of 40 feet (Reference 59).

The topographic maps used for Chehalis River (above Porter), Harris Creek, and Roundtree Creek had a scale of 1:2,400, and a contour interval of 5 feet (Reference 59).

For the Chehalis River (within the City of Cosmopolis), Mill Creek, and Tributary to Mill Creek the boundaries of the 1- and 0.2-percent chance floods were delineated using topographic maps at a scale of 1:1,200, with a contour interval of 2 feet (Reference 60).

The topographic maps used for the analyses of Copalis River, South Bay, and the stretches of the Pacific Ocean coast along Copalis Beach, south of Copalis Head, near Pacific Beach, near Moclips, and between Grayland and Westport had a scale of 1:4,800, with a contour interval of 2 feet (Reference 61).

Flood plain boundaries for Dry Bed and Vance Creeks were determined by combining engineering judgment with discussions with the residents of the affected areas about past floods.

Flood boundaries along the upper portion of the Little Hoquiam River were delineated by extrapolation of the 1-percent chance flood boundaries determined by detailed analysis downstream through the use of the above referenced topographic maps.

The topographic maps used for the analysis of the Pacific Ocean coast near Grayland had a scale of 1:3,600, with a contour interval of 2 feet (Reference 62).

For the City of Westport the boundaries of the 1- and 0.2-percent-annual-chance floods were delineated using ground contours at intervals of 5 feet mapped from aerial imagery (Reference 63).

For the streams studied by approximate methods only the 1-percent-annual-chance floodplain boundary is shown on the FIRM. The original boundary of the 1-percent chance flood was developed from normal-depth calculations and the topographic maps referenced.

The approximate flood plain boundaries for the Chehalis River (below Porter) were taken from the 1976 USACE report (Reference 48). Approximate 1-percent chance flood plain boundaries in some portions of the study area were taken directly from the Flood Hazard Boundary Map (Reference 64).

Certain areas of 1-percent-annual-chance flooding along Grays Harbor were delineated using approximate methods, such as where floodwaters to collect in low-lying areas due to wave action.

The flood boundaries shown for Cities of Ocean Shores and Westport are based on conditions existing at the time of the original FIS report. Due to beach erosion and accretion, the flood boundaries may change over time. The flood boundaries account for the protection from wave action afforded by the primary dune line. During a severe storm, waves will spillover the primary dune line after breaking. The water running down the back side of the dune line will not have the energy to cause velocity damage and will not have sufficient volume to flood the area behind the dunes to the same level as in front of the dunes. Therefore, the VE Zone ends at the primary dune line and the flood level behind the dune is less than that in front of the dune.

Countywide Analyses

Floodplain boundaries were remapped as part of the countywide update to reflect more recent or more detailed topographic and base map data for the county. Floodplain boundaries for detailed study streams were redelineated in areas where updated contour data was available. The topographic data used for the redelineation (mapping with a vertical contour interval of two feet) was obtained from the Puget Sound 'Light Distance And Ranging' (LiDAR) Consortium (Reference 65).

All riverine flooding sources with detailed study were redelineated except: Bush Creek, Cloquallum Creek (upstream of cross-section F), East Fork Wildcat Creek, Newman Creek (upstream of cross-section M), Satsop River (upstream of cross-section E), Wishkah River, and Wynoochee Creek. These reaches did not have new topographic data available so they were converted/fitted based on the effective FIRMs, new basemap data, and orthophotos.

The coastal detailed study areas were not covered by new topographic data so they were fitted based on the effective FIRMs, new basemap data, and orthophotos. Gutters were digitized and kept at the same locations.

Approximate riverine and coastal study areas were converted and fitted based on the effective FIRMs, new basemap data (Reference 66), and orthophotos (Reference 63, 65, and 66) so that they overlay the water course they represent and fit the available aerial photography, base map data, and limited older topography (References 48, 57, and 64).

In accordance with FEMA Procedure Memorandum 36 (Reference 67), profile baselines have been included in all areas of detailed study. Profile baselines are shown in the location of the original stream centerline or original profile baseline without regard to the adjusted floodplain position on the new base map. This was done to maintain the relationship of distances between cross sections along the profile baseline between hydraulic models, flood profiles, and floodway data tables.

The profile baselines depicted on the FIRM represent the hydraulic modeling baselines that match the flood profiles on this FIS report. As a result of improved topographic data, the profile baseline, in some cases, may deviate significantly from the channel centerline or appear outside the Special Flood Hazard Area.

Rectification of approximate flood hazard areas was based on limited older contour data with the orthophotos and road data as additional references.

4.2 Floodways

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

The floodways presented in this FIS report and on the FIRM were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations have been tabulated for selected cross sections Table 12, “Floodway Data”. The computed floodways are shown on the FIRM. In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation (WSEL) of the base flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2, “Floodway Schematic”.

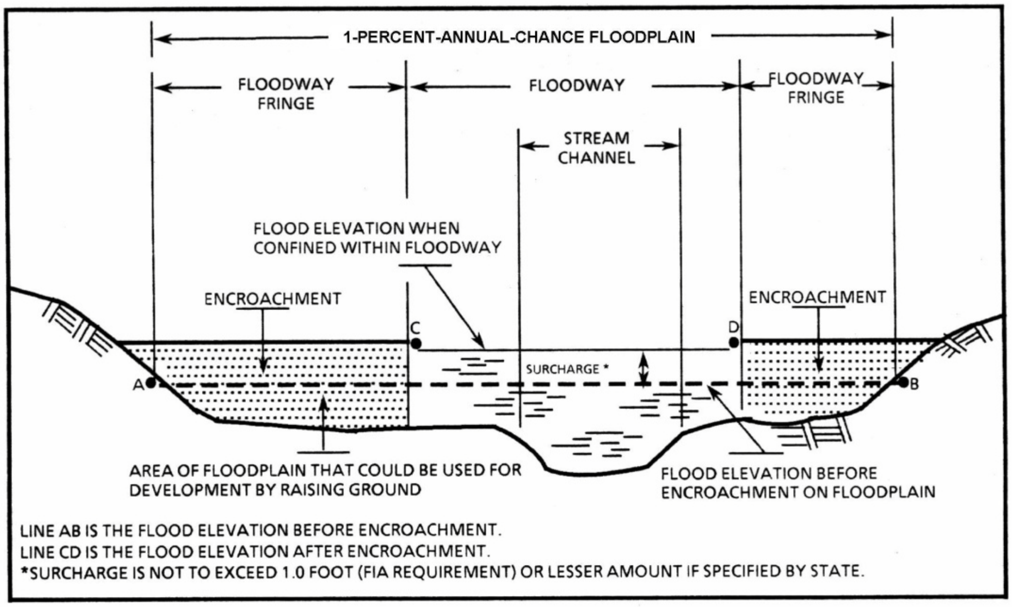


Figure 2 – Floodway Schematic

Floodways were computed on the basis of equal conveyance reduction from each side of the floodplain.

With the approval of the FEMA Consultation Coordination Officer, no floodway was determined for the areas that are subject to tidal flooding.

The hydraulic analysis of the Chehalis River indicates that the tidal influence of Grays Harbor extends up the Chehalis River to Satsop River. Since the Chehalis River is controlled by backwater from Grays Harbor, a flood profile for the Chehalis River is not shown in this study.

No floodways were determined for Alder Creek, Chehalis River, Copalis River, Dry Bed Creek, East Fork Hoquiam River, Fry Creek, Grays Harbor, Hoquiam River, Little Hoquiam River, Pacific Ocean Coast, Stewart Creek, South Bay, Tributary to Mill Creek, and Vance Creek.

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
BUSH CREEK								
A	70[1]	28	134	4.7	92.6	92.6	92.8	0.2
B	2,070[1]	18	59	10.5	105.0	105.0	105.0	0.0
CLOQUALLUM CREEK								
A	6,900[2]	150	1,274	5.0	45.5	45.5	46.3	0.8
B	7,122[2]	126	1,111	5.8	45.8	45.8	46.7	0.9
C	9,522[2]	176	1,153	5.6	50.1	50.1	50.7	0.6
D	11,522[2]	125	939	6.8	54.0	54.0	55.0	1.0
E	11,761[2]	100	847	7.4	55.0	55.0	56.0	1.0
F	14,561[2]	380	1,844	3.4	61.0	61.0	61.9	0.9
G	18,361[2]	160	1,032	6.1	67.6	67.6	68.4	0.8
H	18,531[2]	220	1,937	3.2	69.9	69.9	70.2	0.3
I	19,131[2]	509	3,115	2.0	70.1	70.1	70.8	0.7
J	19,495[2]	595	4,646	1.4	72.5	72.5	72.8	0.3
K	22,695[2]	149	573	11.0	76.6	76.6	77.1	0.5
L	23,455[2]	866	2,404	1.7	80.2	80.2	81.2	1.0
M	23,700[2]	106	796	5.2	84.1	84.1	84.1	0.0
N	24,000[2]	163	1,152	3.6	84.1	84.1	84.6	0.5
O	24,186[2]	145	1,310	3.1	87.5	87.5	87.5	0.0
P	26,186[2]	149	425	9.7	90.0	90.0	90.0	0.0

[1] Feet above confluence with Cloquallum Creek

[2] Feet above confluence with Chehalis River

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

BUSH CREEK – CLOQUALLUM CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
EAST FORK WILDCAT CREEK								
A	1.23[1]	42	191	3.6	232.8	232.8	233.8	1.0
B	1.32[1]	26	138	5.0	236.6	236.6	237.3	0.7
C	1.38[1]	35	198	3.5	239.1	239.1	240.1	1.0
D	1.43[1]	37	199	2.8	240.7	240.7	241.5	0.8
E	1.51[1]	35	194	2.8	243.7	243.7	244.6	0.9
F	1.79[1]	31	89	6.1	258.0	258.0	258.0	0.0
G	2.16[1]	72	112	4.9	277.5	277.5	277.9	0.4
H	2.17[1]	93	239	2.3	278.8	278.8	278.8	0.0
I	2.19[1]	49	162	3.4	279.7	279.7	280.3	0.6
J	2.23[1]	55	219	2.5	280.8	280.8	281.8	1.0
K	2.28[1]	59	362	1.5	284.1	284.1	284.8	0.7
L	2.33[1]	20	112	4.9	284.3	284.3	285.3	1.0
M	2.45[1]	69	249	2.2	288.6	288.6	289.6	1.0
HARRIS CREEK								
A	7,133[2]	46	90	3.5	77.5	77.5	78.5	1.0
B	7,160[2]	280	1,833	0.2	77.8	77.8	78.7	0.9
C	8,110[2]	208	768	0.4	77.9	77.9	78.8	0.9
D	9,060[2]	41	82	3.8	78.0	78.0	78.8	0.8

[1] Miles above confluence with Wildcat Creek

[2] Feet above confluence with Chehalis River

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

EAST FORK WILDCAT CREEK – HARRIS CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
HARRIS CREEK (Continued)								
E	10,030[1]	63	184	1.7	81.6	81.6	82.6	1.0
F	10,152[1]	22	71	4.4	82.0	82.0	82.0	0.0
G	10,200[1]	38	110	2.8	82.4	82.4	82.4	0.0
H	10,720[1]	18	75	4.2	83.1	83.1	84.1	1.0
I	11,660[1]	223	411	0.8	84.7	84.7	85.7	1.0
J	11,790[1]	10	51	2.5	85.3	85.3	86.2	0.9
K	11,860[1]	11	30	4.4	85.6	85.6	85.6	0.0
L	12,060[1]	165	205	0.6	86.0	86.0	86.3	0.3
M	12,740[1]	13	19	6.9	94.6	94.6	94.6	0.0
MILL CREEK								
A	3,850[2]	13	59	5.7	14.2	14.2	14.3	0.1
B	4,090[2]	14	83	4.0	16.3	16.3	16.7	0.4
C	4,200[2]	14	87	3.8	16.5	16.5	17.0	0.5
D	4,440[2]	21	95	3.5	17.2	17.2	17.9	0.7
E	4,660[2]	18	96	3.5	17.8	17.8	18.4	0.6
F	4,910[2]	16	87	3.8	19.5	19.5	20.0	0.5
G	4,970[2]	16	82	4.1	19.6	19.6	20.1	0.5

[1] Feet above confluence with Chehalis River

[2] Feet above confluence with Grays Harbor

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

HARRIS CREEK – MILL CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
MILL CREEK (Continued)								
H	5,270[1]	24	106	3.1	20.1	20.1	20.7	0.6
I	5,370[1]	49	144	2.3	20.3	20.3	20.9	0.6
J	5,550[1]	20	165	2.0	25.0	25.0	25.4	0.4
K	5,760[1]	23	164	2.0	25.1	25.1	25.6	0.5
NEWMAN CREEK								
A	15,320[2]	25	181	5.6	47.5	47.5	47.9	0.4
B	15,488[2]	38	266	3.8	48.1	48.1	48.6	0.5
C	15,578[2]	29	244	4.1	48.3	48.3	48.8	0.5
D	17,360[2]	27	177	5.7	51.9	51.9	52.6	0.7
E	17,555[2]	50	274	3.7	52.4	52.4	53.4	1.0
F	17,830[2]	53	299	3.4	53.1	53.1	53.8	0.7
G	18,080[2]	44	147	6.9	54.9	54.9	55.2	0.3
H	18,280[2]	306	367	2.8	56.5	56.5	56.7	0.2
I	19,570[2]	75	234	4.3	59.6	59.6	60.6	1.0
J	20,700[2]	974	1,004	1.0	61.7	61.7	62.7	1.0
K	20,794[2]	738	308	3.3	61.7	61.7	62.7	1.0
L	20,894[2]	72	113	9.0	63.1	63.1	63.3	0.2
M	22,800[2]	102	375	2.7	70.1	70.1	71.1	1.0

[1] Feet above confluence with Grays Harbor

[2] Feet above confluence with Wenzel Slough

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

MILL CREEK – NEWMAN CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
NEWMAN CREEK (Continued)								
N	24,300[1]	176	194	5.2	73.9	73.9	74.2	0.3
O	24,424[1]	30	146	6.9	74.3	74.3	75.1	0.8
P	24,544[1]	61	193	5.2	75.9	75.9	76.0	0.1
Q	25,930[1]	199	497	2.0	78.4	78.4	79.4	1.0
R	26,147[1]	100	155	6.5	79.4	79.4	80.1	0.7
S	26,500[1]	97	413	2.4	80.7	80.7	81.7	1.0
ROUNDTREE CREEK								
A	620[2]	18	59	2.3	84.8	84.8	85.8	1.0
B	1,150[2]	26	82	1.6	85.8	85.8	86.6	0.8
C	1,610[2]	26	45	3.0	87.1	87.1	87.3	0.2
D	1,689[2]	5	14	9.8	88.0	88.0	88.0	0.0
E	1,740[2]	29	98	1.4	90.0	90.0	90.1	0.1
F	1,860[2]	54	137	1.0	90.0	90.0	90.2	0.2
G	2,140[2]	13	28	4.8	90.3	90.3	90.6	0.3
H	2,216[2]	6	21	6.5	92.3	92.3	92.3	0.0
I	2,327[2]	7	46	2.9	94.5	94.5	94.5	0.0
J	2,950[2]	13	19	6.9	109.4	109.4	109.4	0.0

[1] Feet above confluence with Wenzel Slough

[2] Feet above confluence with Harris Creek

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

NEWMAN CREEK – ROUNDTREE CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
SATSOP RIVER								
A	9,180	–[2]	–[2]	–[2]	35.7	35.7	–[2]	–[2]
B	10,450	–[2]	–[2]	–[2]	40.0	40.0	–[2]	–[2]
C	11,100	–[2]	–[2]	–[2]	40.6	40.6	–[2]	–[2]
D	12,100	3,362	22,103	2.4	43.1	43.1	44.1	1.0
E	13,600	3,336	32,497	1.6	47.4	47.4	48.4	1.0
F	17,480	3,294	37,090	1.4	51.8	51.8	52.8	1.0
G	19,720	2,774	27,021	1.9	55.0	55.0	56.0	1.0
H	23,360	4,274	44,029	1.2	58.5	58.5	59.5	1.0
I	27,240	3,738	40,998	1.3	60.9	60.9	61.9	1.0
J	31,400	1,478	18,887	2.8	68.4	68.4	69.4	1.0
EAST FORK SATSOP RIVER								
K	34,640	1,953	24,951	1.5	73.3	73.3	74.3	1.0
L	37,640	2,284	24,868	1.5	76.3	76.3	77.3	1.0
M	41,340	2,085	19,410	1.9	81.9	81.9	82.9	1.0

[1] Feet above confluence with Chehalis River

[2] Floodway not computed for this cross-section

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

SATSOP RIVER – EAST FORK SATSOP RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
WILSON CREEK								
A	895[1]	25	103	2.9	13.5[4]	13.5	13.5	0.0
B	1,275[1]	28	103	2.9	15.0	15.0	15.4	0.4
C	1,445[1]	37	113	2.7	15.4	15.4	15.8	0.4
D	1,610[1]	31	101	3.0	16.2	16.2	16.8	0.6
E	1,750[1]	17	62	4.8	16.2	16.2	16.9	0.7
F	1,880[1]	20	95	3.2	17.4	17.4	17.7	0.3
G	2,160[1]	85	352	0.9	19.9	19.9	20.7	0.8
WISHKAH RIVER								
A	1,800[2]	–[3]	–[3]	–[3]	13.7	–[3]	–[3]	–[3]
B	3,900[2]	–[3]	–[3]	–[3]	13.7	–[3]	–[3]	–[3]
C	5,700[2]	–[3]	–[3]	–[3]	13.7	–[3]	–[3]	–[3]
D	7,730[2]	248	4,789	3.9	13.7	13.7	13.8	0.1
E	9,430[2]	275	5,599	3.3	14.1	14.1	14.4	0.3
F	11,030[2]	253	5,202	3.6	14.3	14.3	14.7	0.4

[1] Feet above confluence with Chehalis River

[2] Feet above confluence with Grays Harbor

[3] Floodway not computed for this cross-section

[4] Backwater effects from Grays Harbor

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

WILSON CREEK – WISHKAH RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
WYNOOCHEE RIVER								
A	31,500	1,925	9,824	2.3	44.4	44.4	45.4	1.0
B	34,580	1,144	5,517	4.2	46.9	46.9	47.9	1.0
C	37,180	1,196	9,206	2.5	49.4	49.4	50.4	1.0
D	40,580	1,481	9,830	2.3	51.7	51.7	52.7	1.0
E	41,940	594	4,505	5.1	53.9	53.9	54.9	1.0
F	43,420	908	7,180	3.2	56.8	56.8	57.8	1.0
G	45,820	1,959	9,642	2.2	58.8	58.8	59.8	1.0
H	48,220	850	5,537	3.8	60.3	60.3	61.3	1.0

[1] Feet above confluence with Chehalis River

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

WYNOOCHEE RIVER

4.3 Base Flood Elevations

Areas within the community have BFEs established in AE and VE Zones. These are the elevations of the 1-percent-annual-chance (base flood) relative to NAVD88. In coastal areas affected by wave action, BFEs are generally at their maximum at the open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in BFEs have been shown in 1-foot increments on the FIRM. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. BFEs shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is elevated to or above the BFE in AE and VE Zones.

4.4 Velocity Zones

The USACE has established the 3-foot wave height as the criterion for identifying coastal high hazard zones (Reference 68). This was based on a study of wave action effects on structures. This criterion has been adopted by FEMA for the determination of VE zones. Because of the additional hazards associated with high-energy waves, the NFIP regulations require much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in VE zones are higher than those in AE zones.

The location of the VE zone is determined by the 3-foot wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the VE zone to be established. The VE zone generally extends inland to the point where the 1-percent-annual-chance stillwater flood depth is insufficient to support a 3-foot wave.

5.0 INSURANCE APPLICATIONS

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

Zone AE

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

Zone AH

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

Zone AO

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

Zone AR

Zone AR is the flood insurance risk zone that corresponds to an area of special flood hazard formerly protected from the 1-percent-annual-chance flood event by a flood-control system that was subsequently decertified. Zone AR indicates that the former flood-control system is being restored to provide protection from the 1-percent-annual-chance or greater flood event.

Zone A99

Zone A99 is the flood insurance risk zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No BFEs or depths are shown within this zone.

Zone V

Zone V is the flood insurance risk zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no BFEs are shown within this zone.

Zone VE

Zone VE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1-foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or base flood depths are shown within this zone.

Zone X (Future Base Flood)

Zone X (Future Base Flood) is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined based on future-conditions hydrology. No BFEs or base flood depths are shown within this zone.

Zone D

Zone D is the flood insurance risk zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

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

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

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

The countywide FIRM presents flooding information for the geographic area of Grays Harbor County. Previously, FIRMs were prepared for each incorporated community of the County identified as flood-prone. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community are presented in Table 13, “Community Map History”.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Aberdeen, City of	June 21, 1974	April 2, 1976	July 16, 1984	
Cosmopolis, City of	May 24, 1974	November 5, 1976	November 3, 1982	
Elma, City of	August 19, 1985	N/A	August 19, 1985	
Grays Harbor County, Unincorporated Areas	June 28, 1974	February 21, 1978	September 29, 1986	February 16, 1990
Hoquiam, City of	June 14, 1974	March 19, 1976	June 15, 1979	
McCleary, City of	May 31, 1974	January 9, 1976	August 16, 1982	
Montesano, City of	May 17, 1974	February 27, 1976	May 10, 1977	October 13, 1981
Oakville, City of	December 13, 1974	December 19, 1975	June 19, 1985	
Ocean Shores, City of	June 21, 1974	N/A	March 1, 1978	
Westport, City of	May 5, 1981	N/A	May 5, 1981	

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

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

Countywide FIS report for the adjacent Washington Counties of Jefferson, Mason, Pacific, and Thurston are currently underway.

Countywide FIS report for the adjacent Washington County of Lewis (2006) has already gone effective (Reference 69).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, Federal Regional Center, 130 228th Street, SW, Bothell, Washington 98021-9796.

9.0 BIBLIOGRAPHY AND REFERENCES

1. Federal Emergency Management Agency, Flood Insurance Study, City of Aberdeen, Grays Harbor County, Washington, Washington, D.C., July 16, 1984.

2. Federal Emergency Management Agency, Flood Insurance Study, City of Cosmopolis, Grays Harbor County, Washington, Washington, D.C., May 3, 1982.

3. Federal Emergency Management Agency, Flood Insurance Study, City of Elma, Grays Harbor County, Washington, Washington, D.C., August 19, 1985.

4. Federal Emergency Management Agency, Flood Insurance Study, Grays Harbor County and Unincorporated Areas, Grays Harbor County, Washington, Washington, D.C., February 16, 1990.

5. Federal Emergency Management Agency, Flood Insurance Study, City of Hoaquim, Grays Harbor County, Washington, Washington, D.C., June 15, 1979.

6. Federal Emergency Management Agency, Flood Insurance Study, City of McCleary, Grays Harbor County, Washington, Washington, D.C., February 16, 1982.

7. Federal Emergency Management Agency, Flood Insurance Study, City of Ocean Shores, Grays Harbor County, Washington, Washington, D.C., September 1, 1977.

8. Federal Emergency Management Agency, Flood Insurance Study, City of Westport, Grays Harbor County, Washington, Washington, D.C., November 5, 1980.

9. U.S. Census Bureau, 2000 Census: Grays Harbor County, Washington. Retrieved January 6, 2011 from http://www.factfinder.census.gov.

10. The Weather Channel, Monthly Averages for Grays Harbor County, Washington. Retrieved January 6, 2011 from http://www.weather.com.

11. Grays Harbor Regional Planning Commission, *Water Quality Management Plan,* March 1974.

12. U.S. Department of Agriculture, Soil Conservation Service, *Southwestern Washington River Basins Type IV Survey,* 1974.

13. Pacific Northwest River Basins Commission, Hydrology and Hydraulics Committee, *River Mile Index, Coastal Tributaries, Pacific-Coast Basin, Washington,* July 1969.

14. U.S. Department of the Army, Corps of Engineers, Seattle District, *Feasibility Report on Flood Control, Chehalis River at South Aberdeen and Aberdeen, Washington,* April 1975.

15. Pacific Northwest River Basins Commission, *Columbia-North Pacific Region Comprehensive Framework Study of Water and Related Lands,* Appendix IV, Volume 2, June 1970.

16. Grays Harbor Regional Planning Commission, *An Interim Floodplain Management Plan for Lower Chehalis Basin, Grays Harbor County,* August 1973.

17. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Hoquiam, Grays Harbor County, Washington, December 1978.

18. Columbia Pacific Resource Conservation and Development Project, *McCleary Flood Prevention Measure,* U.S. Department of Agriculture, Soil Conservation Service, Spokane, Washington, April 1976.

19. Seattle Post-Intelligencer, "Huge Waves Flood Resort," Seattle, Washington, March 9, 1977.

20. Seattle Post-Intelligencer, "Storm Soaks It to Us," Seattle, Washington, March 9, 1977.

21. The Seattle Times, "Corps Starts Repairs on Damaged Seawall," Seattle, Washington, March 11, 1977.

22. University of Washington, *Grays Harbor, Washington, A Literature Survey*, Department of Oceanography, Seattle, Washington, August 1955.

23. U. S. Department of Agriculture, Soil Conservation Service, letter regarding McCleary Flood Prevention Measure, October 30, 1980.

24. City of McCleary, Resolution No. 158, March 1975.

25. U.S. Army Corps of Engineers, *Rehabilitation of the Point Chehalis Groin and Revetment System, Grays Harbor and Chehalis River, Washington,* Seattle District Office: 1977.

26. U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, *Urban Hydrology for Small Watersheds*, Technical Release No. 55, January 1975.

27. U.S. Department of the Interior, Geological Survey, Open-File Report 74-336, *Magnitude and Frequency of Floods in Washington,* J.E. Cummans, M.R. Collings, and E.G. Nassar, Tacoma, Washington, 1975.

28. U.S. Army Corps of Engineers, *Chehalis River at South Aberdeen and Cosmopolis, Washington*. Seattle District Office: Feasibility Report on Flood Control, April 1975.

29. U. S. Army Corps of Engineers, *Flood Plain Information, Chehalis, Wishkah, and Hoquiam Rivers, Aberdeen, Hoquiam, and Cosmopolis,* Washington, Seattle, June 1971.

30. Water Resources Council, "A Uniform Technique for Determining Flood Flow Frequency," Bulletin 15, December 1967.

31. U.S. Department of the Army, Corps of Engineers, Seattle District, *Wishkah River, Washington, Water Surface Profiles*, Drawing E-S-4-4, Seattle, Washington, 1971.

32. U.S. Department of Housing and Urban Development, Federal Insurance Administration, *Flood Insurance Study, City of Ocean Shores, Grays Harbor County, Washington*, 1978.

33. U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, *Type 16 Flood Insurance Study: Tsunami Predictions for the West Coast of the Continental United States*, James R. Houston and Andrew W. Garcia, Vicksburg, Mississippi, December 1978.

34. National Ocean Survey. *Tide Tables, High and Low Water Predictions, West Coast North and South America Including the Hawaiian Islands.* Rockville, Maryland: Department of Commerce/National Oceanic and Atmospheric Administration, 1955-1975.

35. U. S. Army, Coastal Engineering Research Center. *Shore Protection Manual (Vol. I, II, III).* Washington, D. C.: U. S. Government Printing Office. 1973.

36. National Marine Consultants, Inc. *Wave Statistics for Three Deep Water Stations Along the Oregon-Washington Coast.* Prepared for U.S. Army Corps of Engineers, Seattle, Washington, and Portland, Oregon, Districts. Santa Barbara, California, May 1961.

37. National Marine Consultants, Inc., *Elk Creek at Cannon Beach Clatsop County, Oregon Draft Detailed Project Report.* Portland District Office, Portland, Oregon, November 6, 1974.

38. U.S. Army Corps of Engineers, Tide Gage Strip Charts, Westport, Washington, Seattle District Office: Station Records for 1968-1976.

39. CH2M Hill, Inc., *Flood Insurance Study, Town of Ocean Shores, Grays Harbor County, Washington.* U.S. Department of Housing and Urban Development, August, 1976.

40. National Ocean Survey, *Tide Tables, High and Low Water Predictions, West Coast of North and South America Including the Hawaiian Islands.* U.S. Department of

Commerce, National Oceanic and Atmospheric Administration, Rockville, Maryland, 1968-1977.

41. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, *HEC-2 Water-Surface Profiles, Users Manual*, Davis, California, 1973.

42. U.S. Department of the Army, Corps of Engineers, Seattle District, Special Study, *Suggested Hydraulic Floodway Chehalis River, Aberdeen to Satsop and Vicinity, Grays Harbor County, Washington*, February 1978.

43. Tippetts-Abbett-McCarthy-Stratton, *Cross Sections for Mill Creek*, 1977.

44. Tippetts-Abbett-McCarthy-Stratton, *Cross Sections for East Fork Wildcat Creek*, 1977.

45. Tippetts-Abbett-McCarthy-Stratton, *Cross Sections for Alder Creek, Fry Creek, Stewart Creek, and Wilson Creek*, 1977.

46. Tippetts-Abbett-McCarthy-Stratton, *Cross Sections for Satsop River, Wynoochee River, Harris Creek, and Roundtree Creek*, 1977.

47. U.S. Army Corps of Engineers, Seattle District, *Backwater Curve, Method II, with Floodway Analysis Computer Program*, Seattle, Washington, May 1974.

48. U.S. Department of the Army, Corps of Engineers, Seattle District, *Chehalis River Basin, Washington, Chehalis River - Satsop to Porter, Water-Surface Profiles*, April 1976.

49. State of Washington, Department of Highways, Topographic Maps of Grays Harbor County, Scale 1:4,800, Contour Interval 10 feet, 1968.

50. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, Pacific County, Washington, Unincorporated Areas, Revised September 27, 1985.

51. Chester P. Jelesnianski, et al, *SPLASH Programs' User's Guide*. National Weather Service, COM-75-10181, Springfield, Virginia: U.S. Department of Commerce/National Technical Information Service, November, 1974.

52. R.S. Dobson, *Some Applications of a Digital Computer to Hydraulic Engineering Problems*, Technical Report No. 80. Stanford, California: Department of Civil Engineering, Stanford University, June 1967.

53. Bascom, W., *Waves and Beaches*, Doubleday and Company, Inc., Garden City, New York, 1964.

54. U.S. Army Corps of Engineers, *CORPSCON*, Version 6.0, conversion software http://www.agc.army.mil/corpscon/index.html

55. Washington State Highway Commission, Department of Highways, *Grays Harbor County SR 12, Grays Harbor Vicinity to Montesano, Topographic Map*, Contour Interval 10 feet, scale 1:4,800, flown November 13, 1969.

56. State of Washington, Department of Highways, Topographic Maps of Grays Harbor County, Scale 1:4,800, Contour Interval 10 feet, 1968.

57. U.S. Department of the Interior, Geological Survey, *15-Minute Scale Topographic Maps*, Scale 1:62,500, Contour Intervals 40 and 80 feet: Elma, Washington, (1953); Montesano, Washington, (1955); Malone, Washington, (1953); Wynoochee Valley, Washington, (1955).

58. U.S. Department of the Interior, Geological Survey, *15-Minute Series Topographic Maps*, Scale 1:62,500, Contour Interval 40 feet: Malone, Washington (1953); Shelton, Washington (1953); Elma, Washington (1953).

59. CH2M HILL, Inc., *Topographic Map for Grayland, Washington*, Scale 1:3,600, Contour Interval 2 feet, flown January 1981.

60. U.S. Department of the Army, Corps of Engineers, Seattle District, *Topographic Maps of Mill Creek, Washington,* Scale 1:1,200, Contour Interval 2 feet, flown February 11, 1969.

61. CH2M HILL, Inc., *Topographic Maps*, Scale 1:4,800, Contour Interval 2 feet: Moclips, Washington (1982): Pacific Beach, Washington (1982) Copalis Head, Washington (1982): Copalis Beach, Washington (1982): Westport, Washington (1982).

62. CH2M HILL, Inc., *Topographic Map for Grayland, Washington*, Scale 1:3,600, Contour Interval 2 feet, flown January 1981.

63. Bush, Roed & Hitchings, Inc., *Aerial Topographic Survey and Map*, Scale 1:4,800, Base Map, Westport, Washington, 1977.

64. U.S. Department of Housing and Urban Development, Federal Insurance Administration, *Flood Hazard Boundary Map, Grays Harbor County, Washington (Unincorporated Areas)*, Scale 1:24,000, February 21, 1978.

65. Puget Sound LIDAR Consortium, Topographic Data-2 feet contour interval, Public Domain High Resolution Topography for Western Washington. http://pugetsoundlidar.ess.washington.edu/

66. Grays Harbor County, Washington, GIS Department; Washington Department of Natural Resources and National Geodetic Survey; Base map files in digital format compiled in various map scales during time period 2004-2008. Coordinate system is Universal Transverse Mercator, North American Datum of 1983, Geodetic Reference System 1980.

67. Federal Emergency Management Agency *Procedure Memorandum No. 36* - Profile Baselines on Digital Flood Insurance Rate Maps (DFIRMs) with Orthophoto Bases.

68. U.S. Army Corps of Engineers, Hydraulic Laboratory, Waterways Experiment Station, Technical Report H-75-17, Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound, A. W. Garcia and J. R. Houston, Vicksburg, Mississippi, November 1975.

69. Federal Emergency Management Agency, Flood Insurance Study, Lewis County and Incorporated Areas, Lewis County, Washington, Washington, D.C., July 17, 2006.

Burlington Northern Company, Railroad Plan and Profile Master Drawing, From East End of Aberdeen to Grays Harbor City.

City of Aberdeen, Engineer's Office, West End Hydraulic Study, Design and Layout, Storm Drain System for Rice to Myrtle Street Area of West End Aberdeen, February 1962.

City of Hoquiam, Engineering Department, Dike and Flood Control System Map, Scale 1:3,600, 1974, with revisions February 24, 1975 and August 28, 1975.

City of Hoquiam, Engineering Department, Dike System, West bank Hoquiam River, Ekland Avenue to Emerson Avenue, Drawing No. 75-118-D, Scale 1:600, November 25, 1975.

U.S. Army Corps of Engineers, Guidelines for Identifying Coastal High Hazard Zones, Galveston District, Galveston, Texas, June 1975.

10.0 REVISIONS DESCRIPTION

This section has been added to provide information regarding significant revisions made since the original FIS and FIRM were printed. Future revisions may be made that do not result in the republishing of the FIS report. All users are advised to contact the Community Map Repository at the address below to obtain the most up-to-date flood hazard data.

Grays Harbor County Department of Central Services, GIS Program
310 West Spruce Street, Suite 100
Montesano, WA 98563

February 16, 1990 Revision

This study was revised on February 16, 1990 to incorporate the effects of revised wave run-up and wave height analyses for a reach of the Pacific Ocean, north of the mouth of Connor Creek, in the area of Copalis Beach. The revised analyses were based on improved topographic information for the referenced reach, which was prepared by the developers of Sea View Estates, and submitted by the Planning Director of Grays Harbor County. The result of the new analyses was a modification of the floodplain boundary delineations and zone designations along the referenced reach as shown on FIRM panels 53027C0856 and 0858. The revised delineations decreased the Zone VE (EL 24.5 NAVD88) to Zone VE (EL 19 NAVD88) and Zone VE (EL 22 NAVD88), changed the zone designation in the area of Sea View Estates from Zone VE (EL 24.5 NAVD88) to Zone AO (Depth 2), and from Zone B to Zone AO (Depth 2).

Countywide Update

This countywide update was performed by Tetra Tech for the Washington Department of Ecology and FEMA under Contract No. C0400289.

This update combined the FIRMs for Grays Harbor County and incorporated communities into the countywide format. Under the countywide format FIRM panels have been produced using a single layout format for the entire area within the county instead of separate layout formats for each community; Cities of Aberdeen, Cosmopolis, Elma, Hoquiam, Ocean Shores, Oakville, Montesano, Westport; the City of McCleary; and the Unincorporated Areas of Grays Harbor County. The single-layout format facilitates the matching of adjacent panels and depicts the flood-hazard area within the entire panel border, even in areas beyond a community's corporate boundary line. In addition, under the countywide format this single FIS report provides all associated information and data for the entire county area.

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

Floodplain boundaries were remapped as part of the countywide update to reflect more recent or more detailed topographic and base map data for the county. Floodplain boundaries for detailed study streams were redelineated in areas where updated contour data was available. The topographic data used for the redelineation (mapping with a vertical contour interval of two feet) was obtained from the Puget Sound LiDAR Consortium (Reference 65).

The effective flood water-surface elevations were converted from NGVD29 to NAVD88 and used with new topography to redelineate the floodplains. The datum conversion factor for Grays Harbor County was calculated to be +3.46 feet.

The following riverine flooding sources with detailed study were redelineated: Chehalis River (from approximately 1.50 miles upstream of the confluence with Grays Harbor to approximately 9.1 miles upstream); Cloquallum Creek (from approximately 4,700 feet upstream of the confluence with Chehalis River to cross-section F); Harris River (from approximately 7,100 feet upstream of the confluence with Chehalis River to 12,740 feet upstream); Hoquiam River (from confluence with Gray Harbor to approximately 3.04 miles upstream); East Fork Hoquiam River (from confluence with Hoquiam River to approximately 0.80 miles upstream); Little Hoquiam River (from confluence with Hoquiam River to approximately 1.98 miles upstream); Mill Creek (from approximately 2,600 feet upstream of the confluence with Grays Harbor to approximately 5,760 feet upstream); Newman Creek (from approximately 14,350 feet upstream of the confluence with Wenzel Slough to cross-section M); Roundtree Creek (from the confluence with Harris Creek to approximately 2,950 feet upstream); Satsop River (from approximately 6,650 feet upstream of the confluence with Chehalis River to cross-section E); and Wilson Creek (from the confluence with Chehalis River to approximately 2,160 feet upstream).

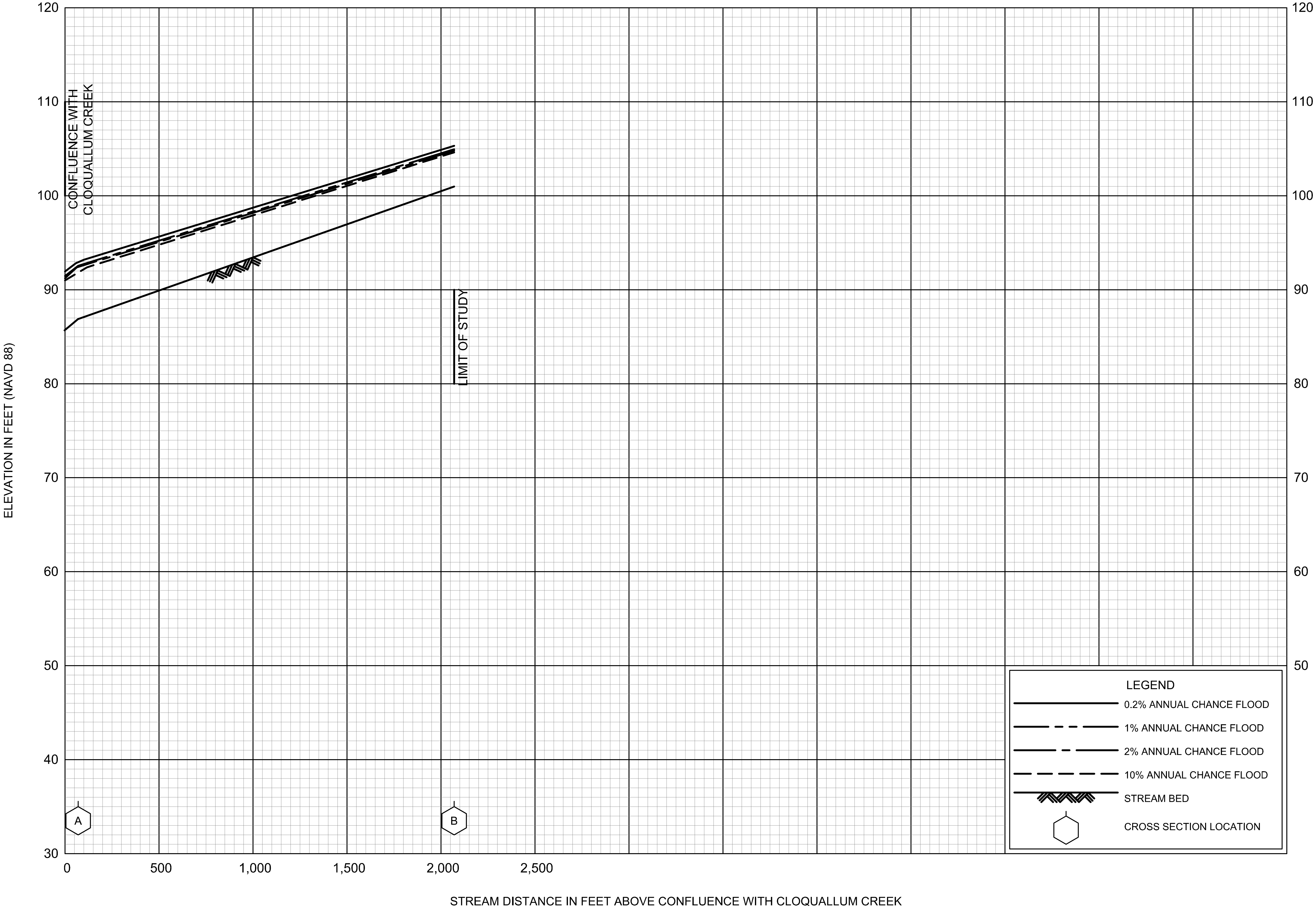
The following detailed flooding sources were not redelineated: Bush Creek, Cloquallum Creek (upstream of cross-section F), East Fork Wildcat Creek, Newman Creek (upstream of cross-section M), Satsop River (upstream of cross-section E), Wishkah River, and

Wynoochee Creek. These reaches did not have new topographic data available so they were converted/fitted based on the effective FIRMs, new basemap data, and orthophotos.

The coastal detailed study areas were not covered by new topographic data so they were fitted based on the effective FIRMs, new basemap data, and orthophotos. Gutters were digitized and kept at the same locations.

Approximate riverine and coastal study areas were converted and fitted based on the effective FIRMs, new basemap data (Reference 66), and orthophotos (Reference 65) so that they overlay the water course they represent and fit the available aerial photography, base map data, and limited older topography.

In accordance with FEMA Procedure Memorandum 36 (Reference 67), profile baselines have been included in all areas of detailed study. Profile baselines are shown in the location of the original stream centerline or original profile baseline without regard to the adjusted floodplain position on the new base map. This was done to maintain the relationship of distances between cross sections along the profile baseline between hydraulic models, flood profiles, and floodway data tables.



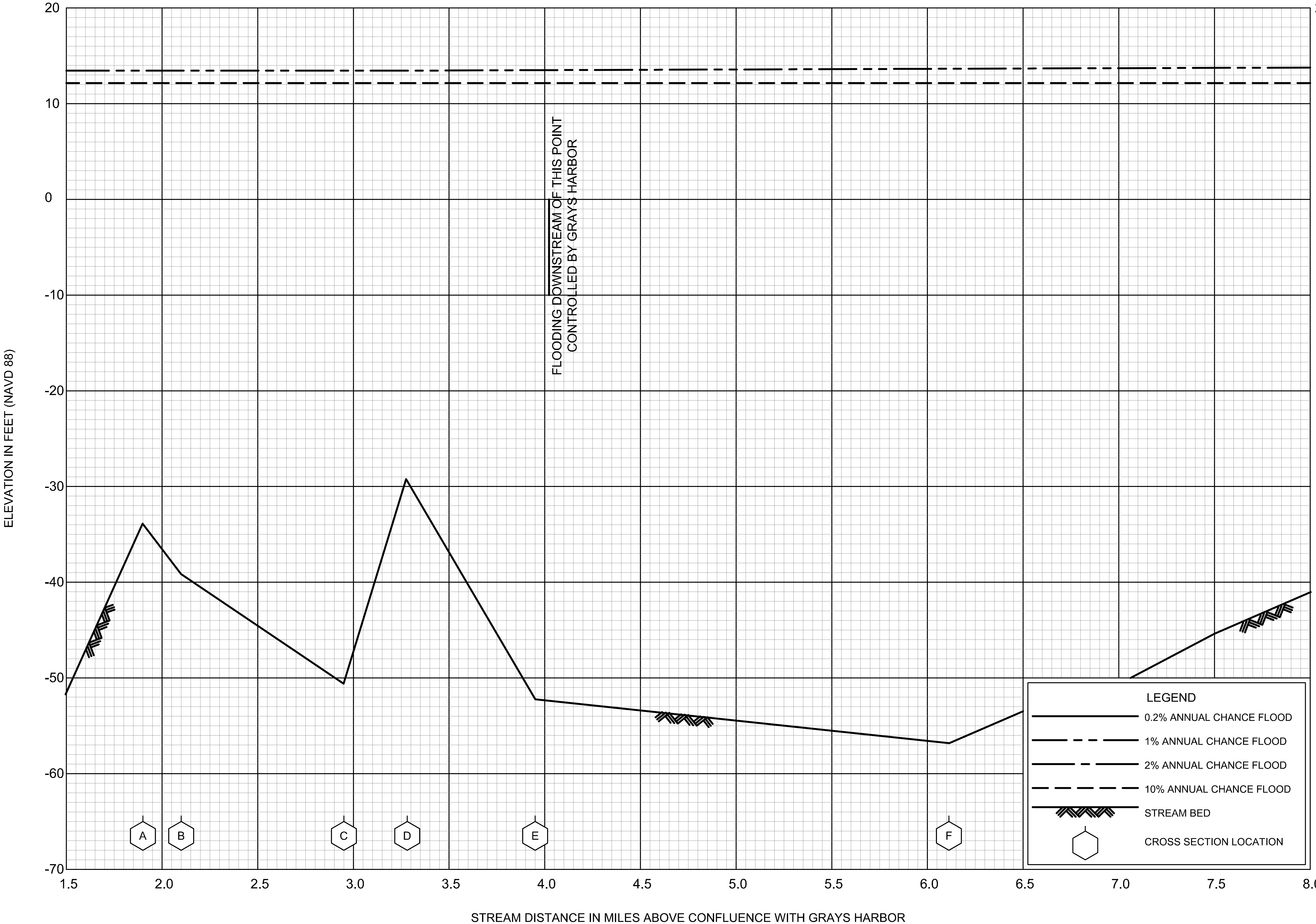
FLOOD PROFILES

BUSH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



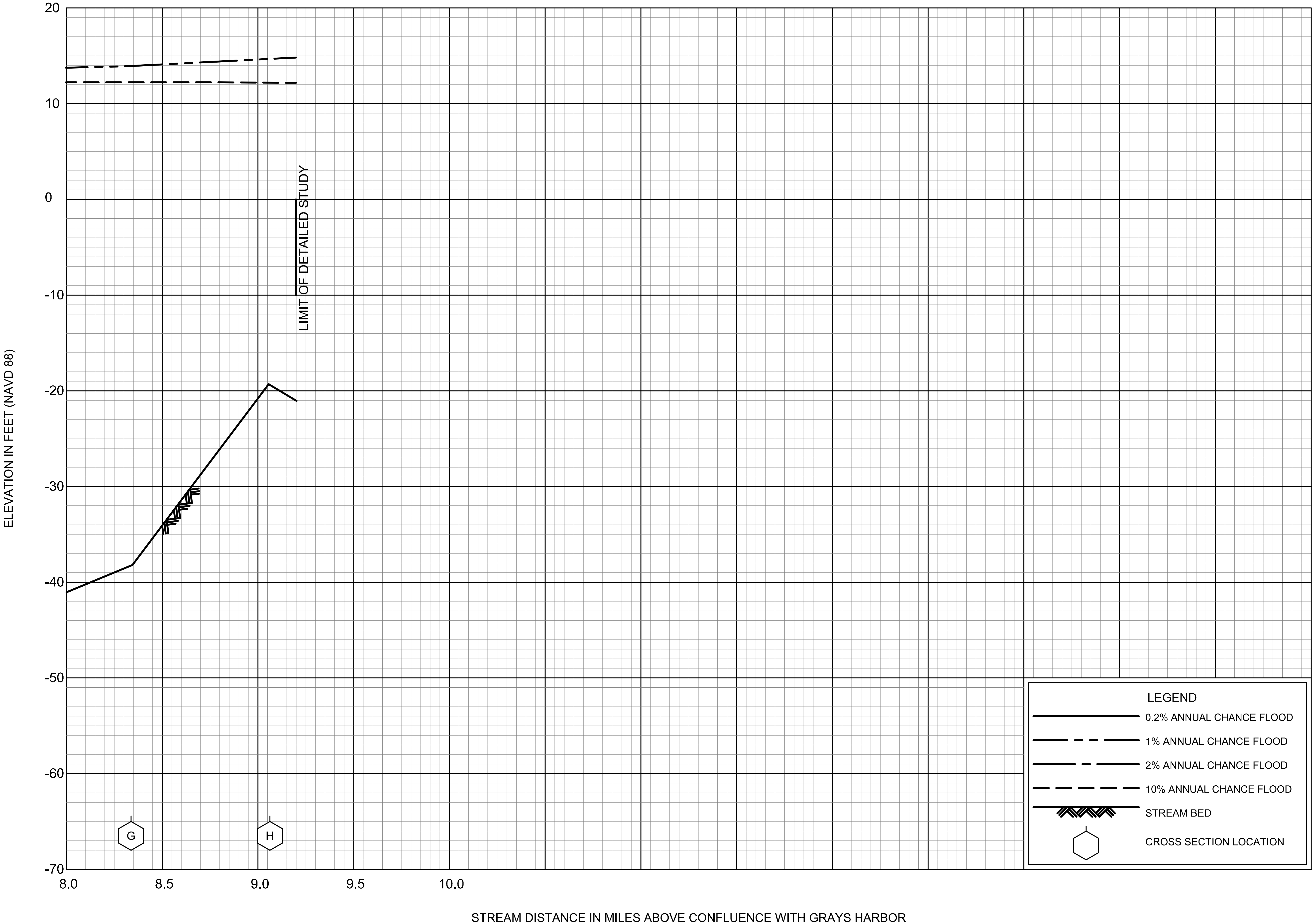
FLOOD PROFILES

CHEHALIS RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA
AND INCORPORATED AREAS

02P

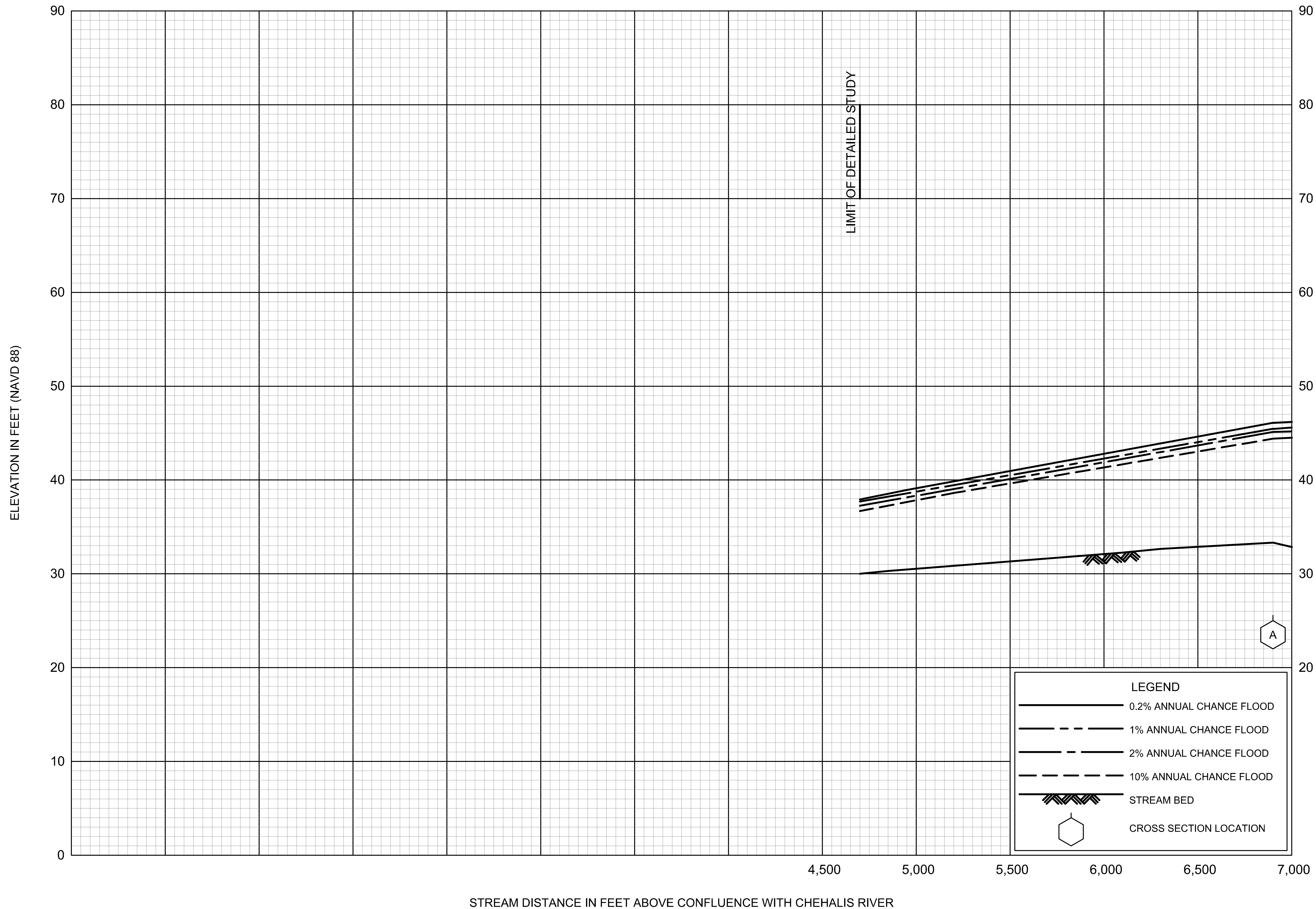


FLOOD PROFILES

CHEHALIS RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA
AND INCORPORATED AREAS



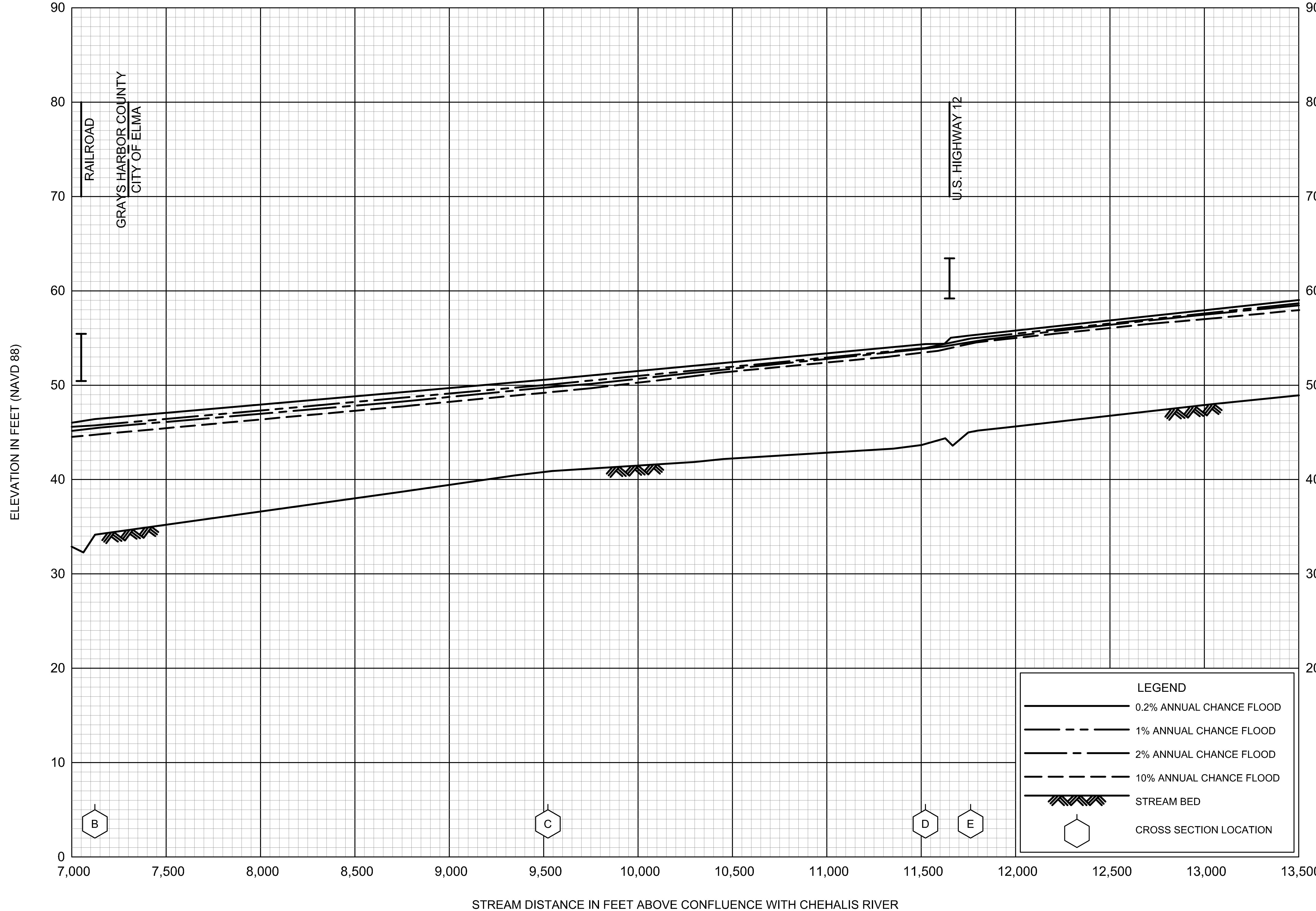
FLOOD PROFILES

CLOQUALLUM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



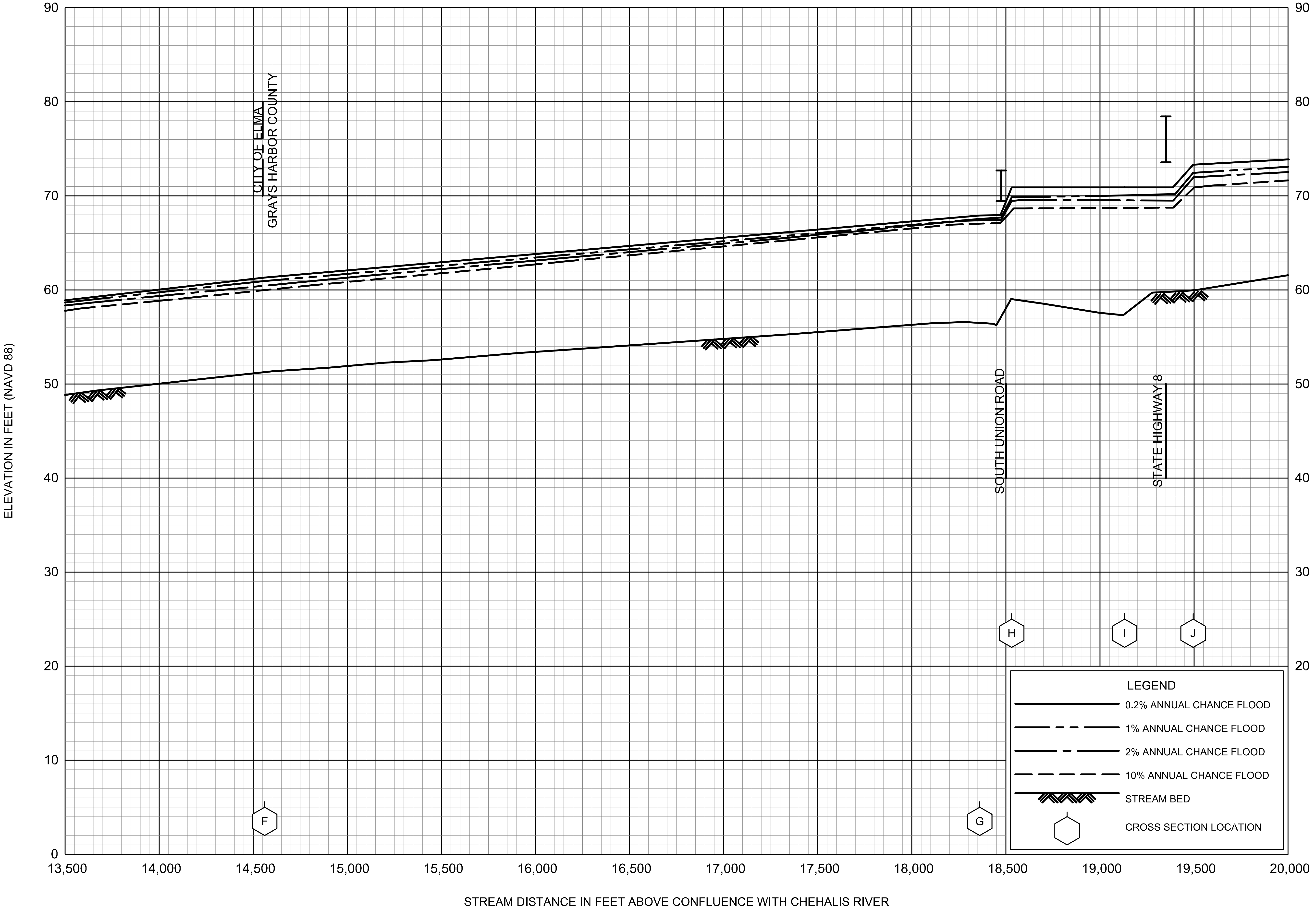
FLOOD PROFILES

CLOQUALLUM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



FLOOD PROFILES

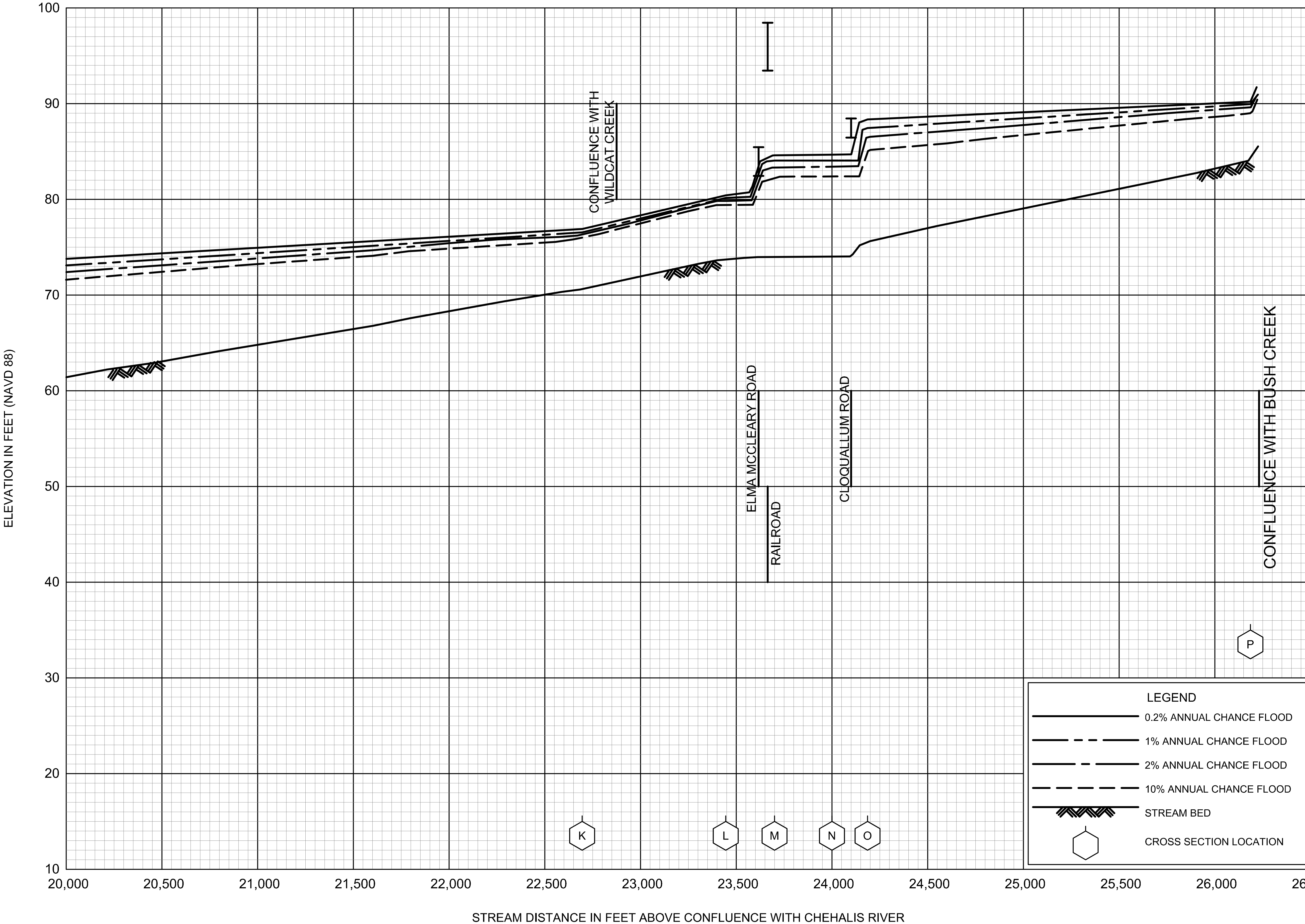
CLOQUALLUM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

06P



FLOOD PROFILES

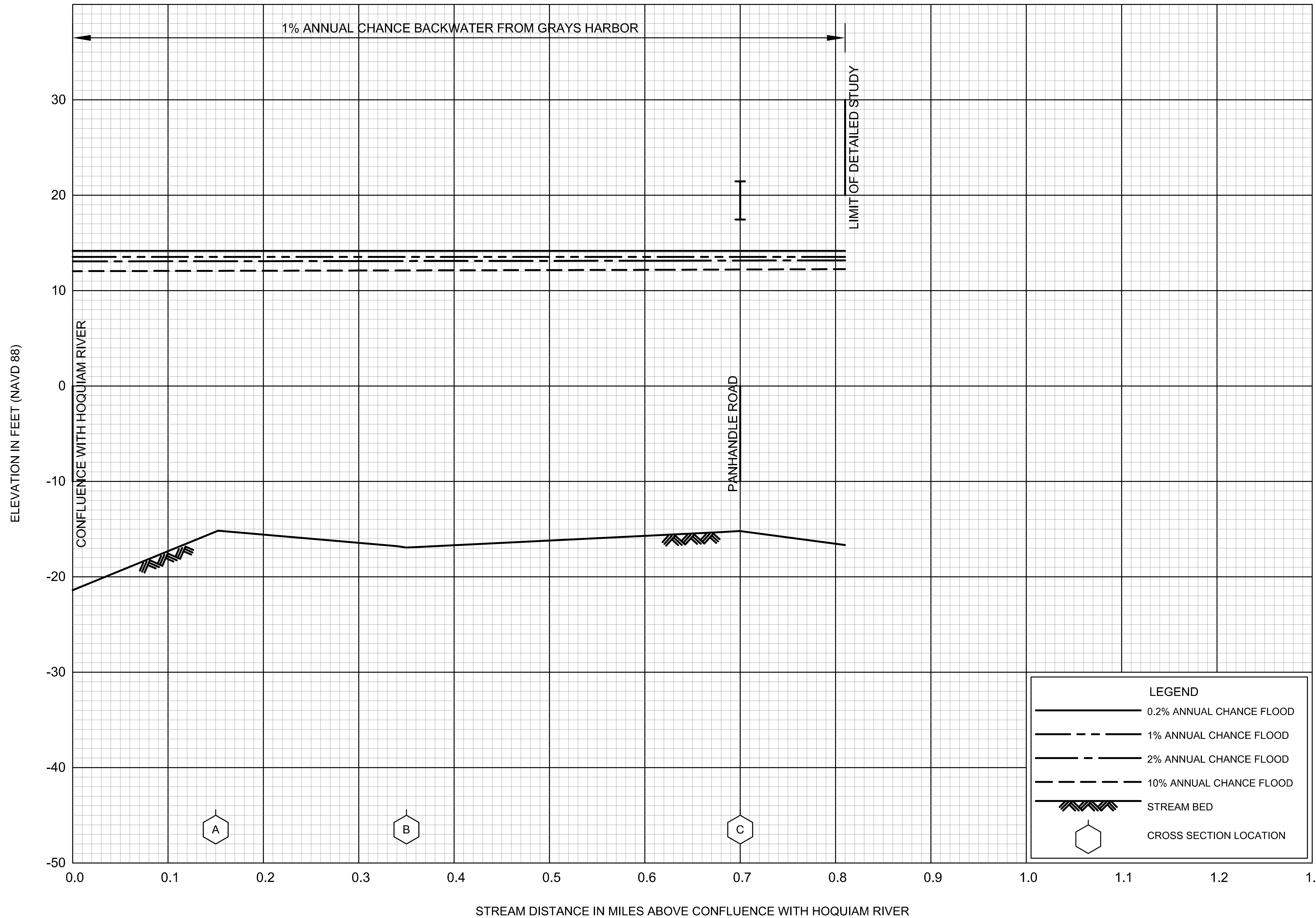
CLOQUALLUM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

07P



FLOOD PROFILES

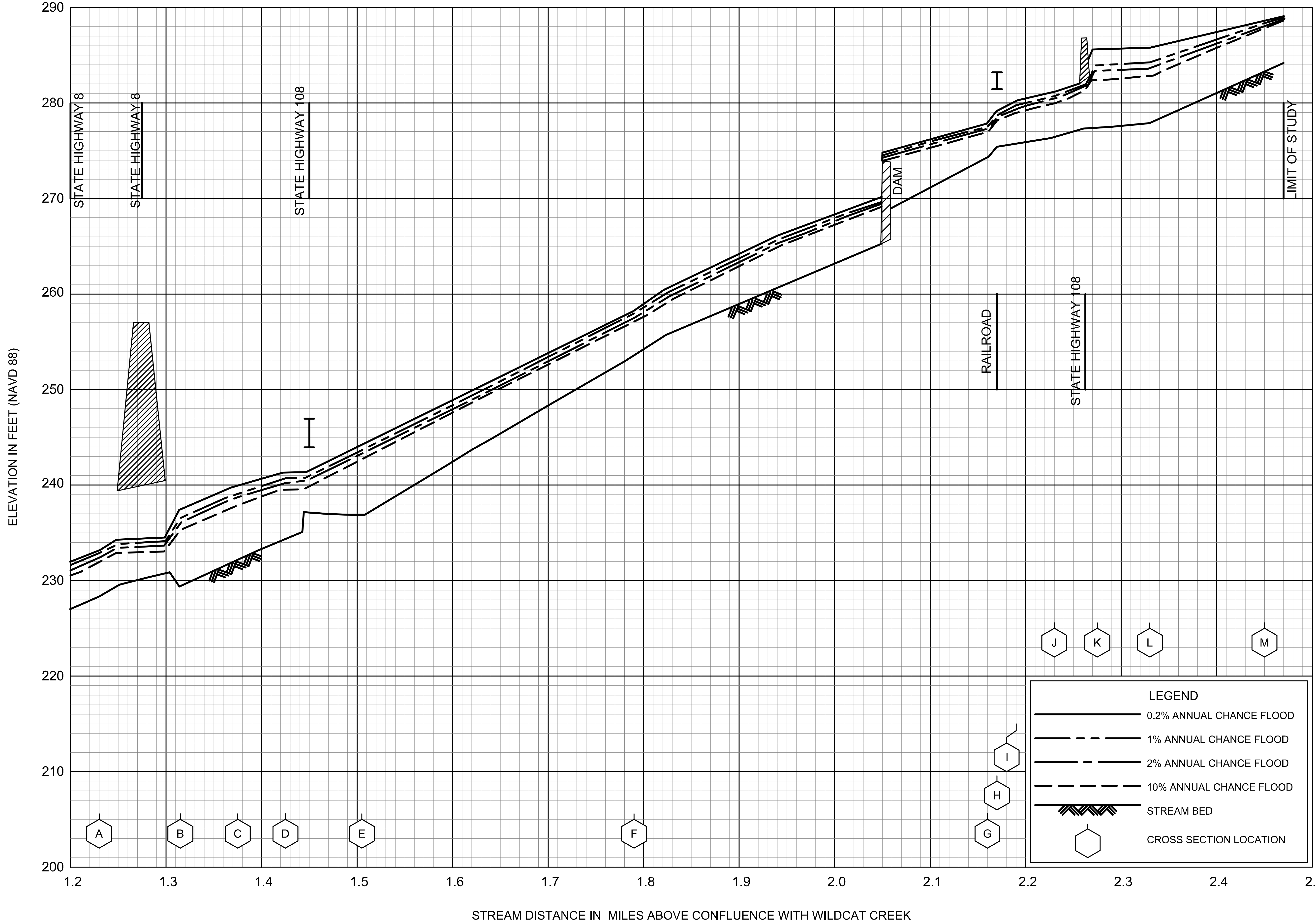
EAST FORK HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

08P



FLOOD PROFILES

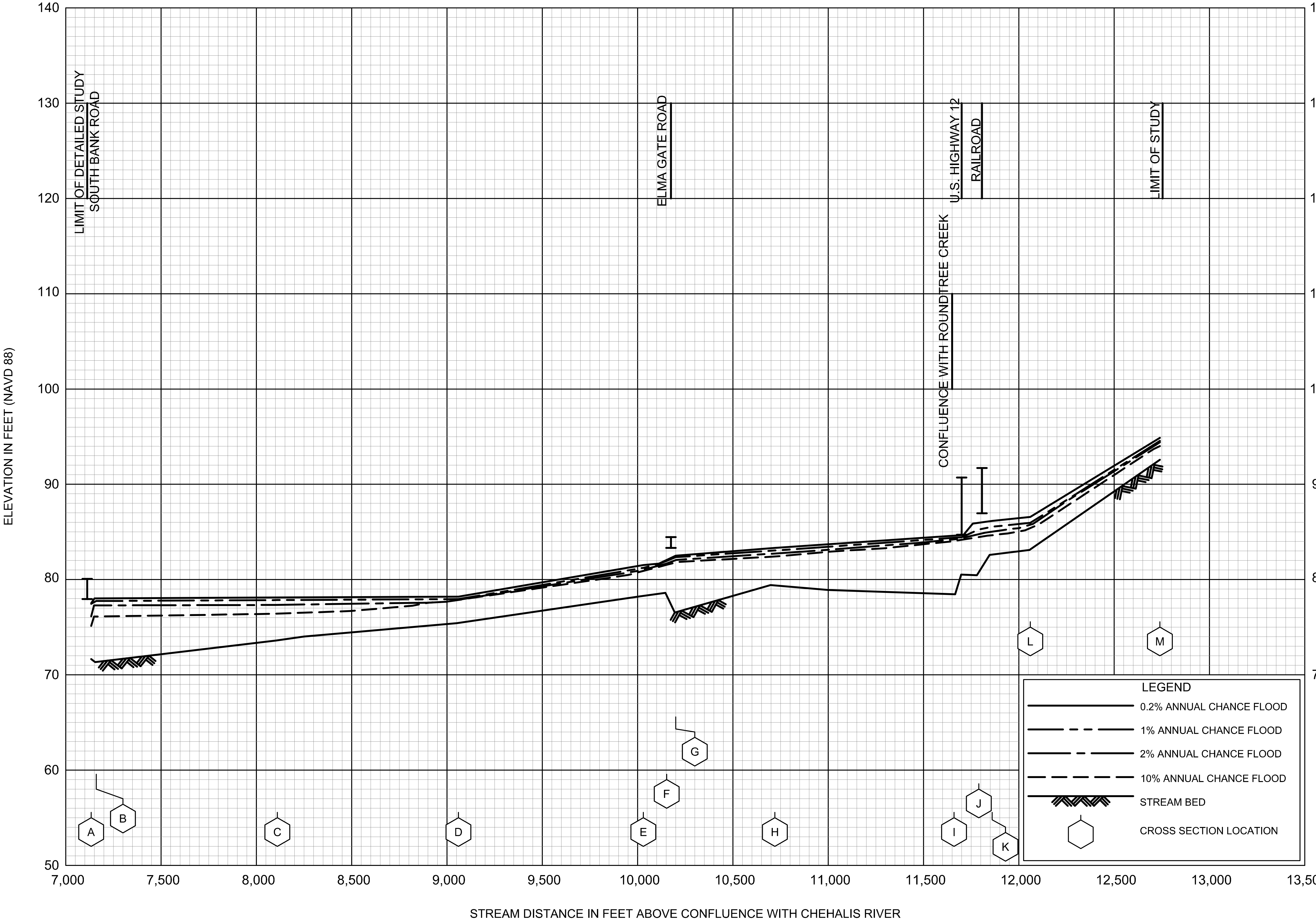
EAST FORK WILDCAT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

09P



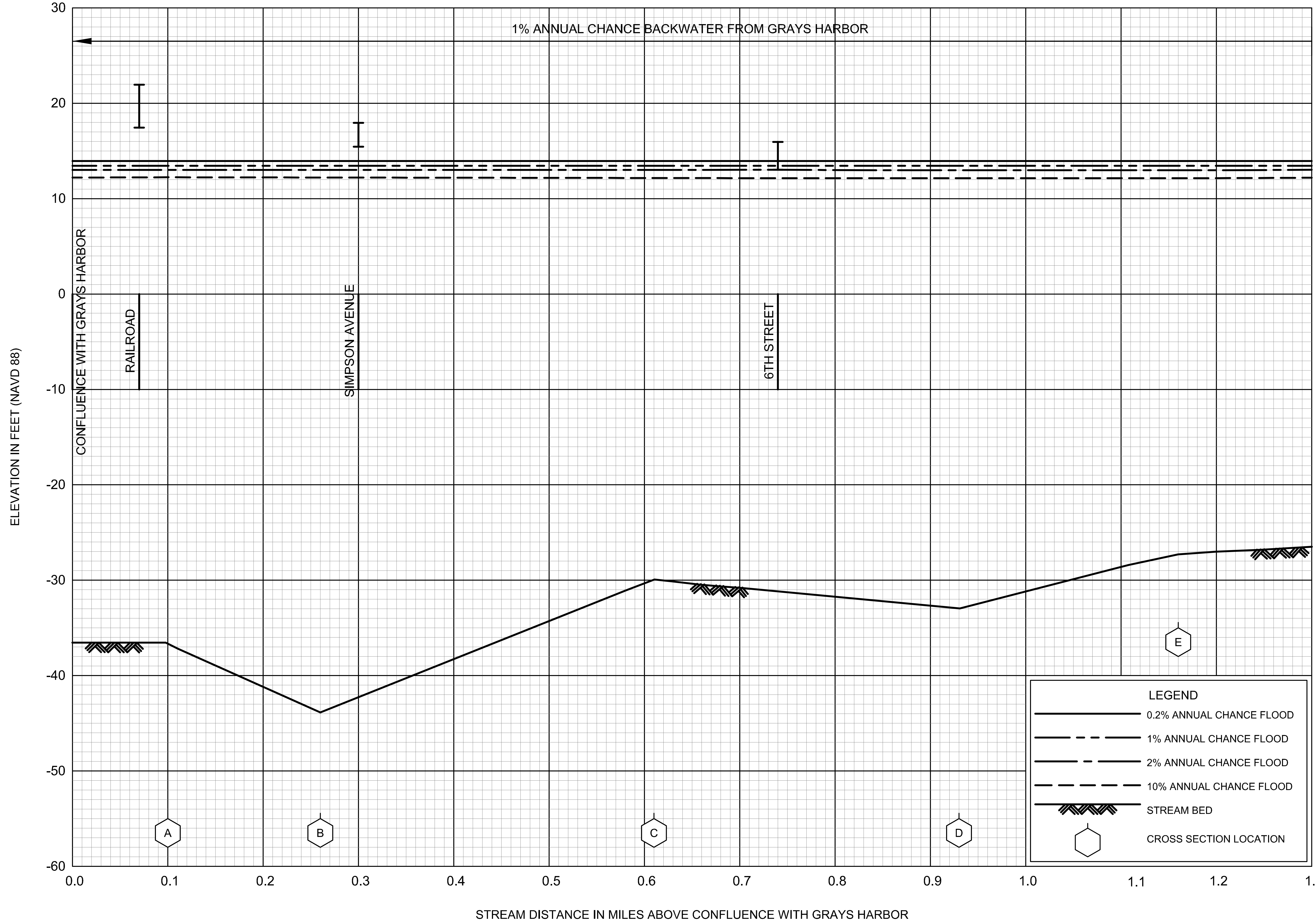
FLOOD PROFILES

HARRIS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



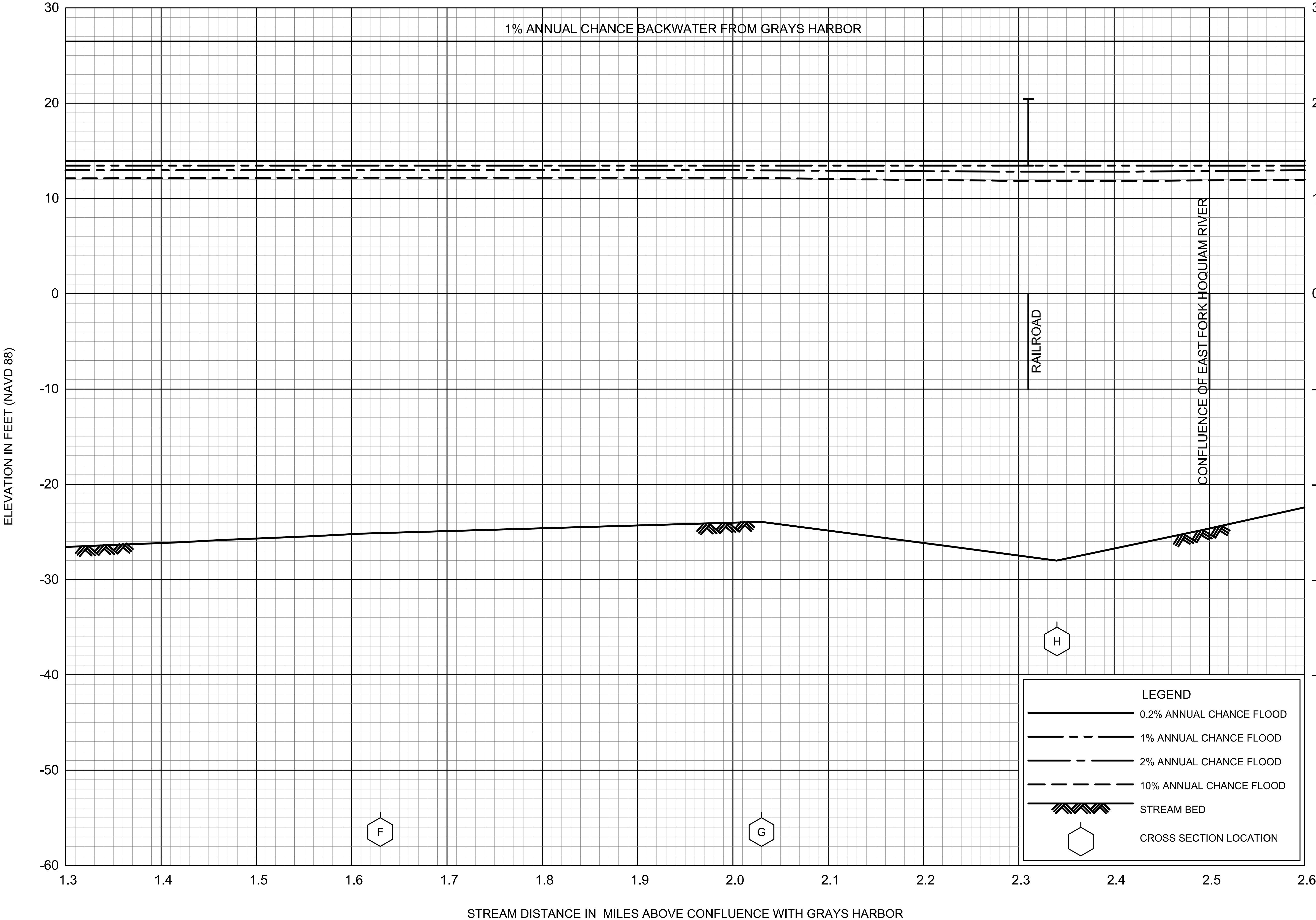
FLOOD PROFILES

HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



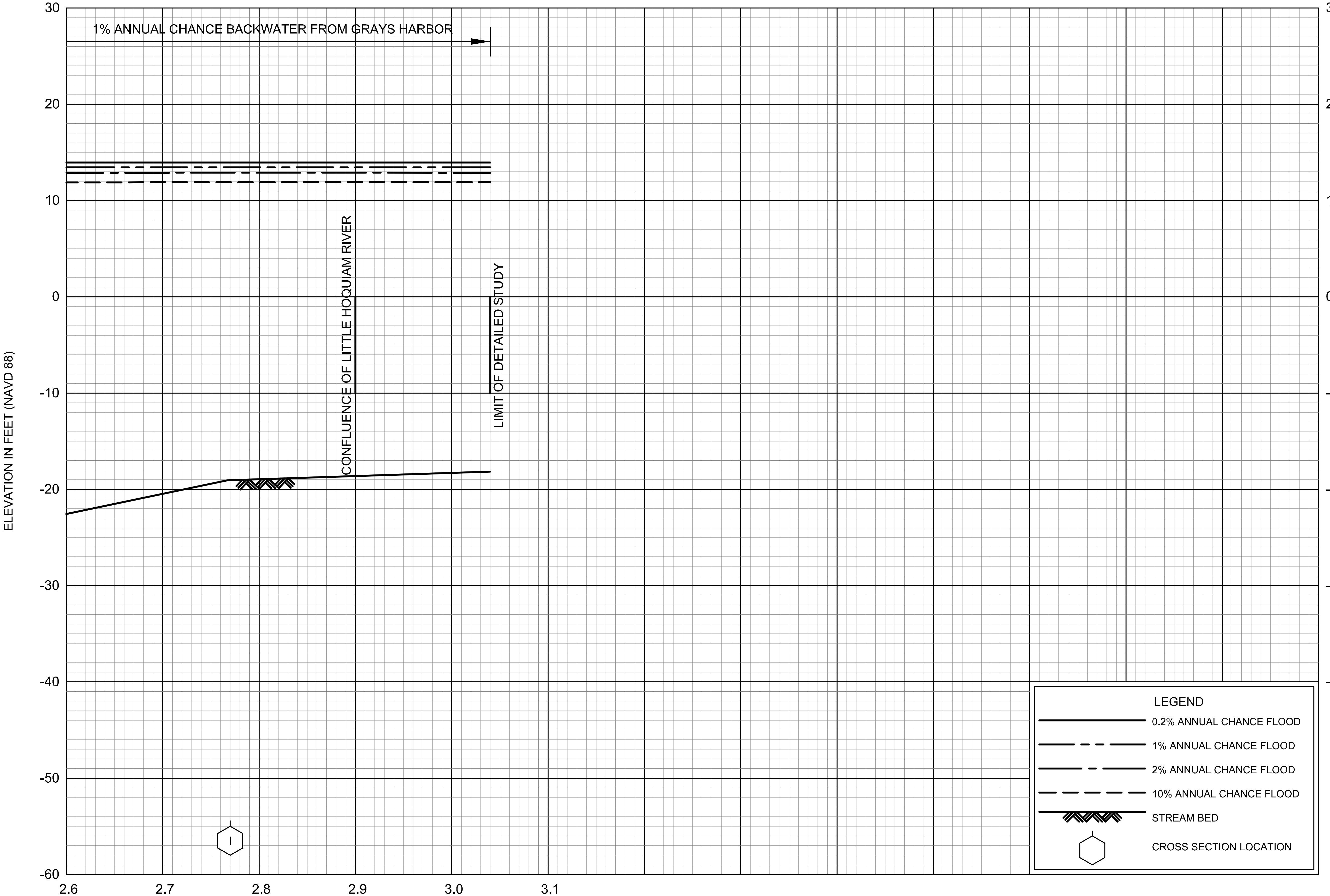
FLOOD PROFILES

HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



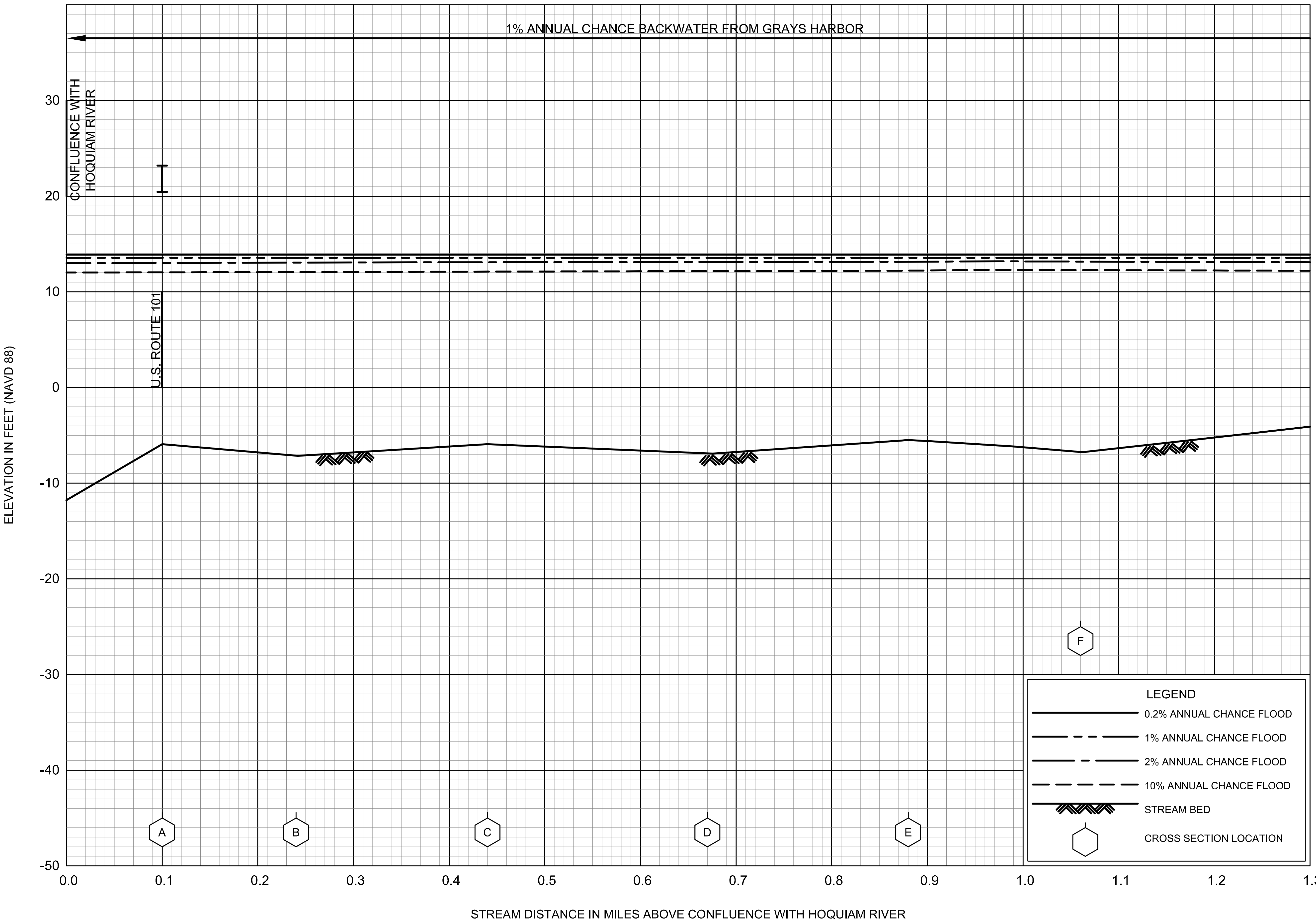
FLOOD PROFILES

HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



FLOOD PROFILES

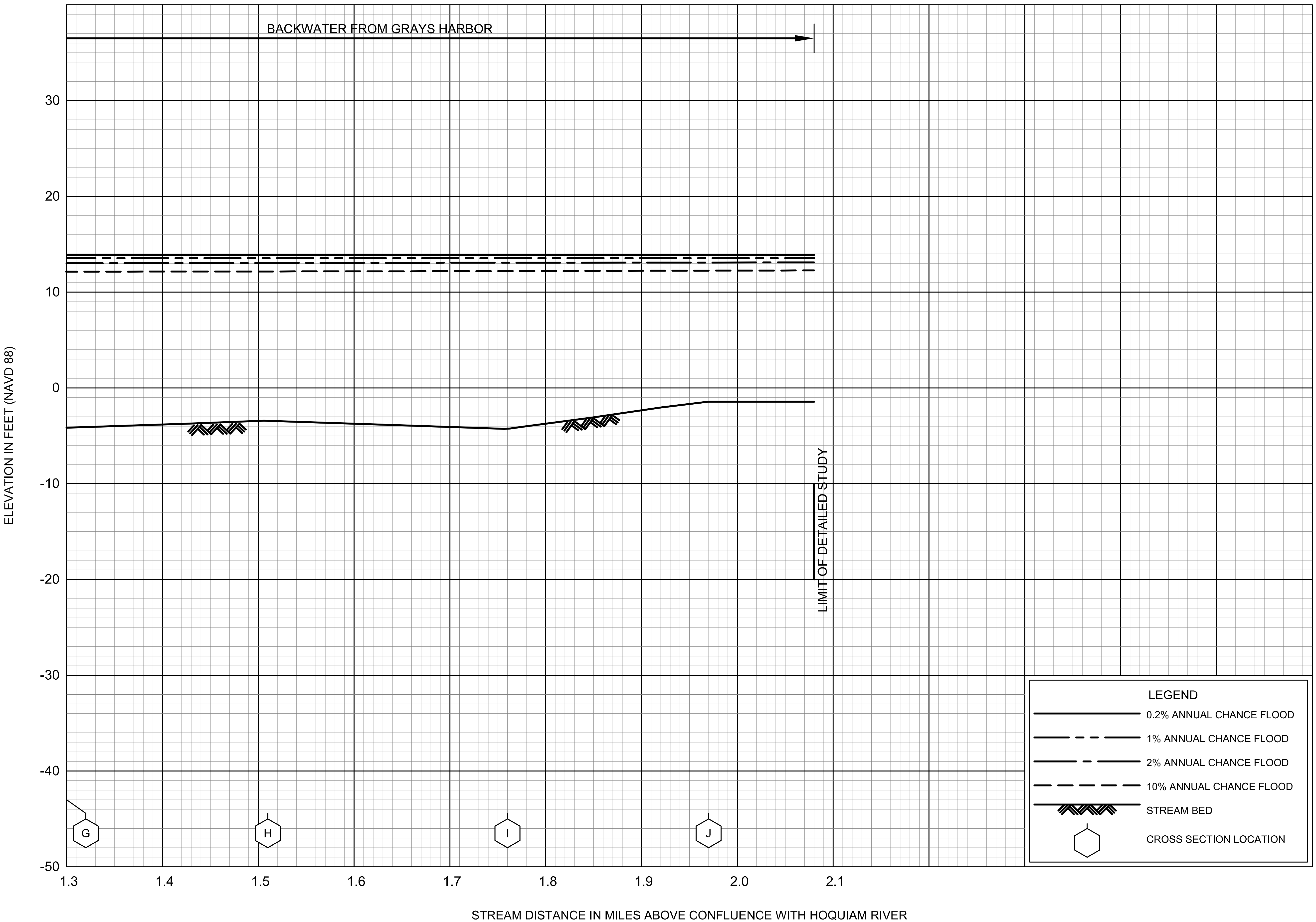
LITTLE HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS

14P



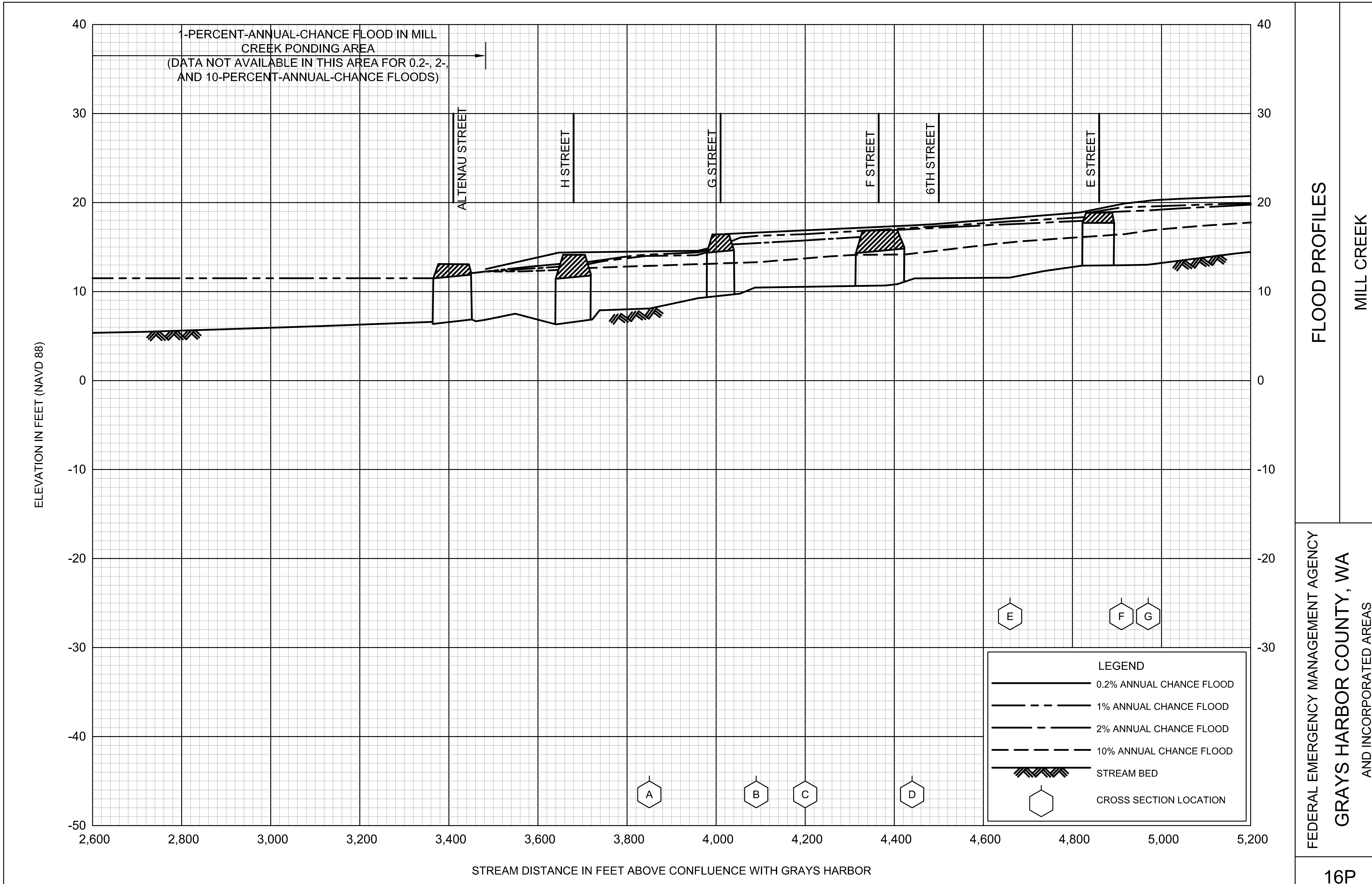
FLOOD PROFILES

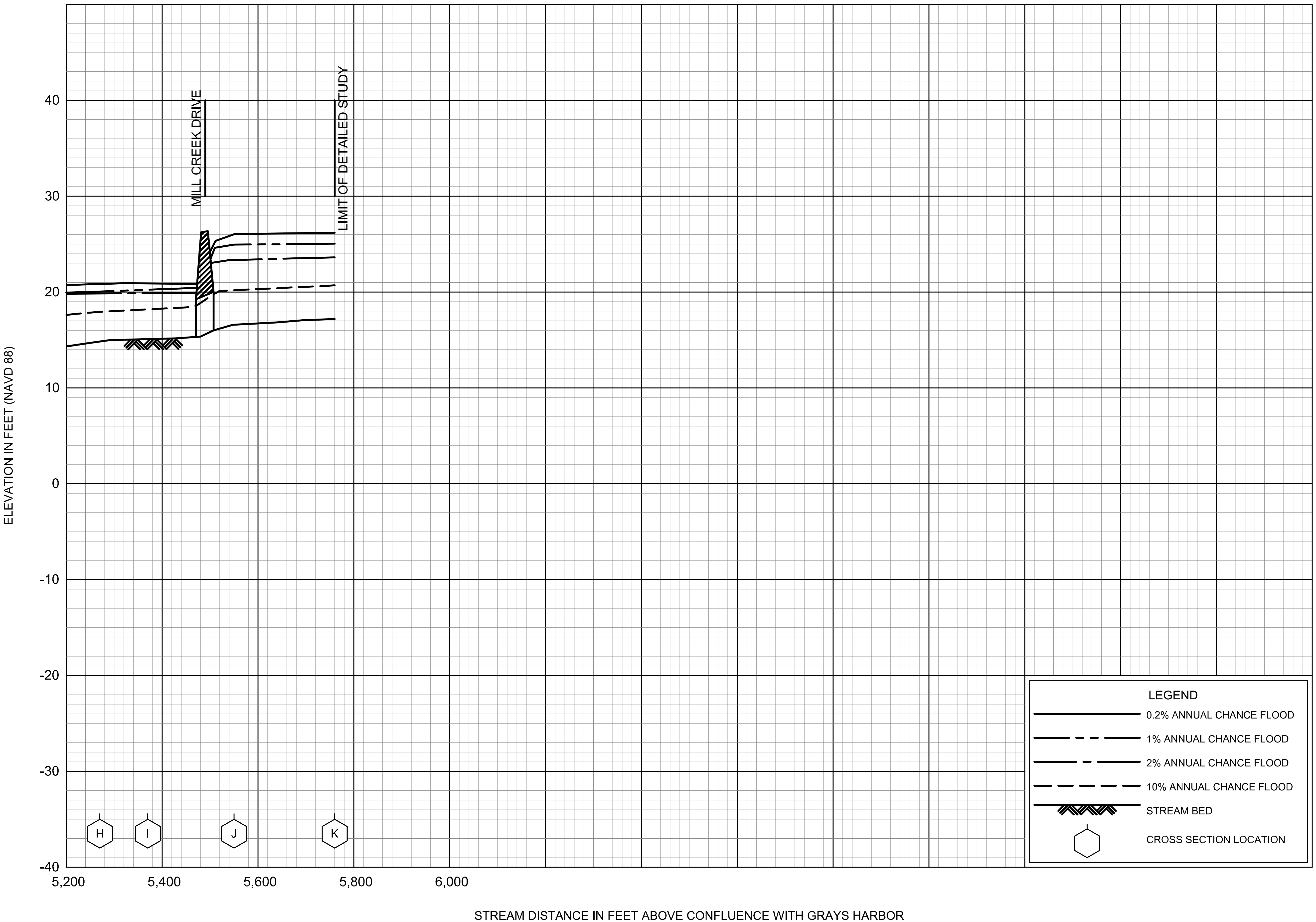
LITTLE HOQUIAM RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS


1-PERCENT-ANNUAL-CHANCE FLOOD IN MILL CREEK PONDING AREA
(DATA NOT AVAILABLE IN THIS AREA FOR 0.2-, 2-, AND 10-PERCENT-ANNUAL-CHANCE FLOODS)
ALTENAU STREET
H STREET
G STREET
F STREET
6TH STREET
E STREET
ELEVATION IN FEET (NAVD 88)
40
30
20
10
0
-10
-20
-30
-40
-50
2,600
2,800
3,000
3,200
3,400
3,600
3,800
4,000
4,200
4,400
4,600
4,800
5,000
5,200
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH GRAYS HARBOR
A
B
C
D
E
F
G
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
MILL CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
GRAYS HARBOR COUNTY, WA
AND INCORPORATED AREAS
16P



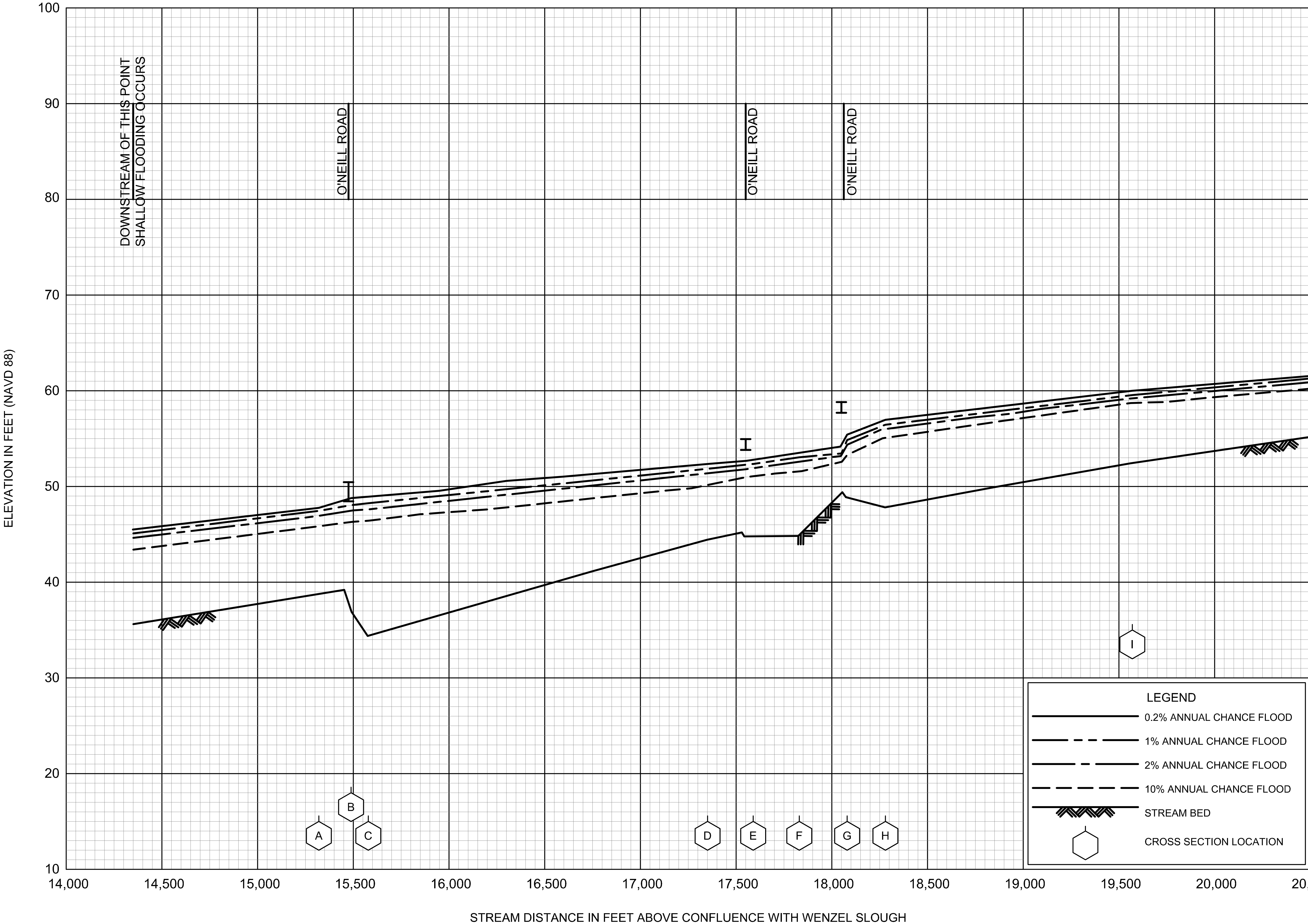
FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



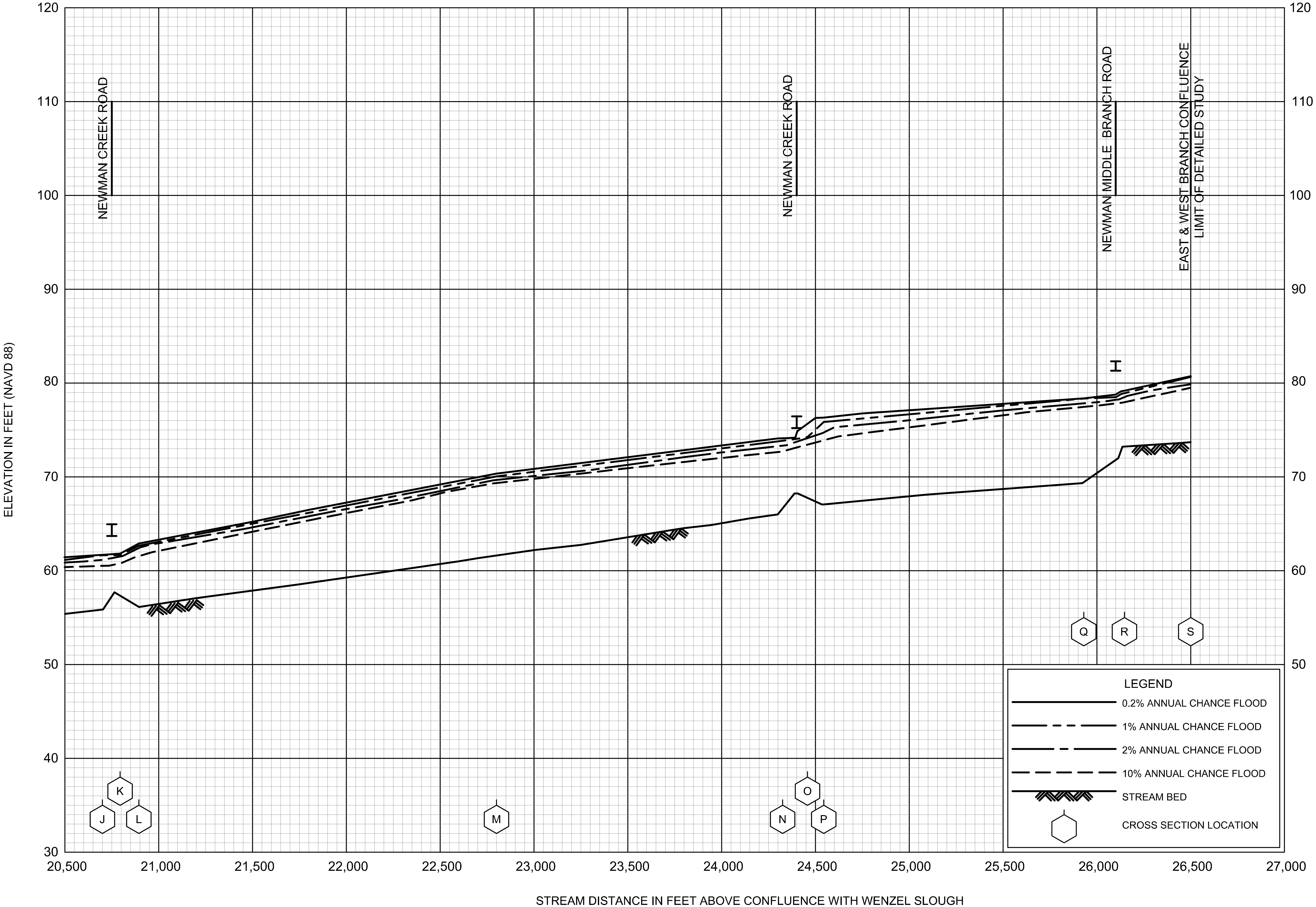
FLOOD PROFILES

NEWMAN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



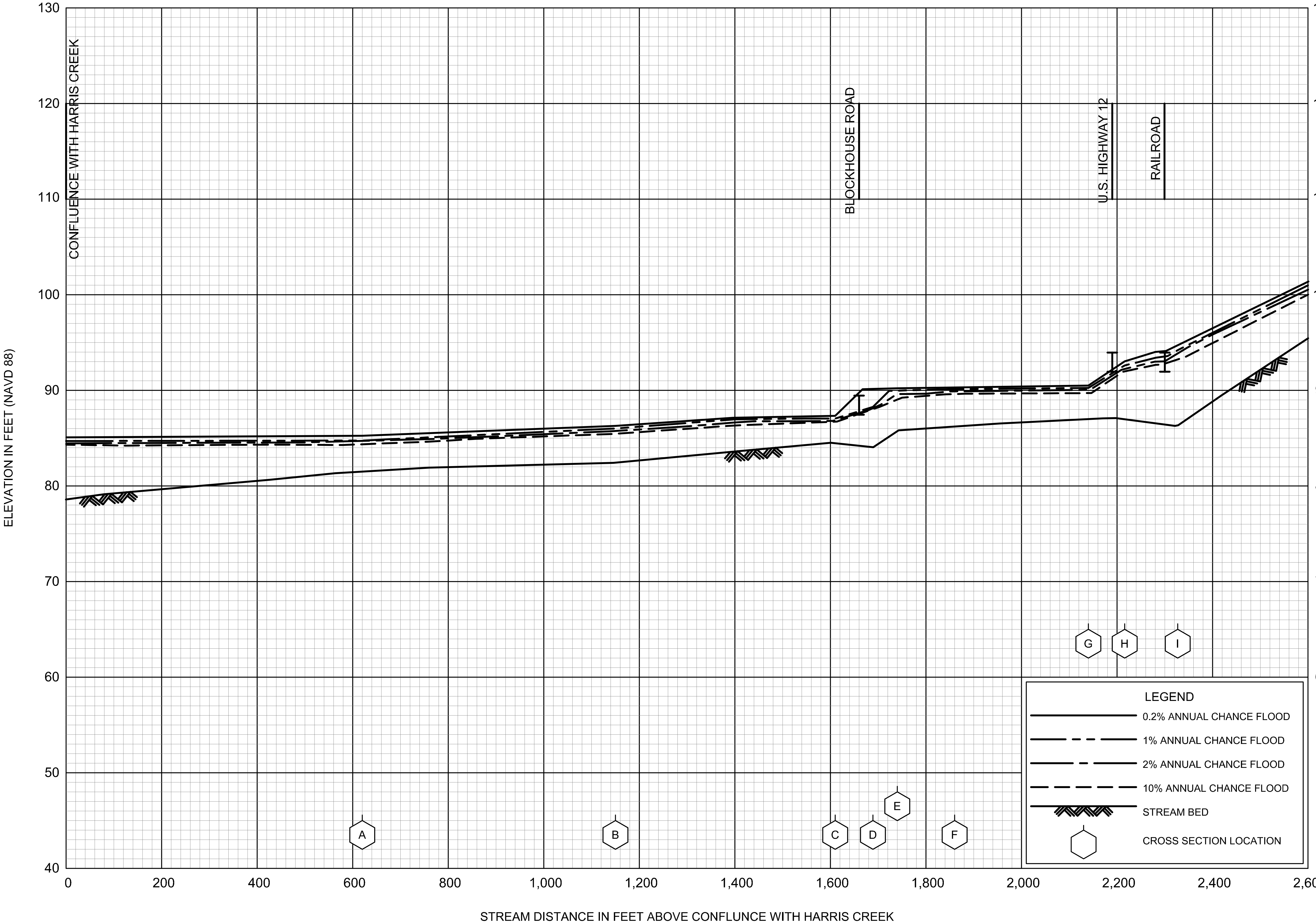
FLOOD PROFILES

NEWMAN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



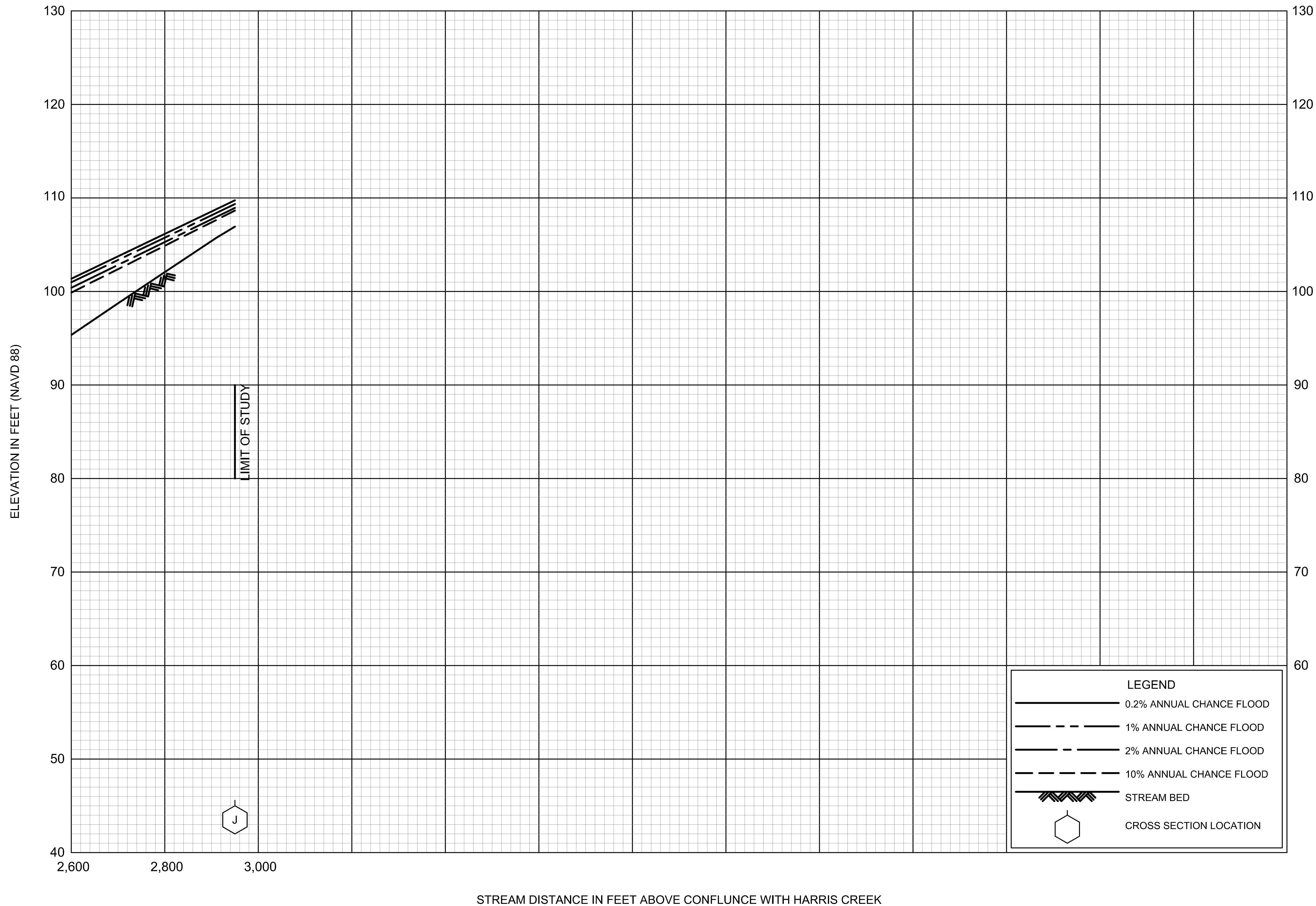
FLOOD PROFILES

ROUNDTREE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



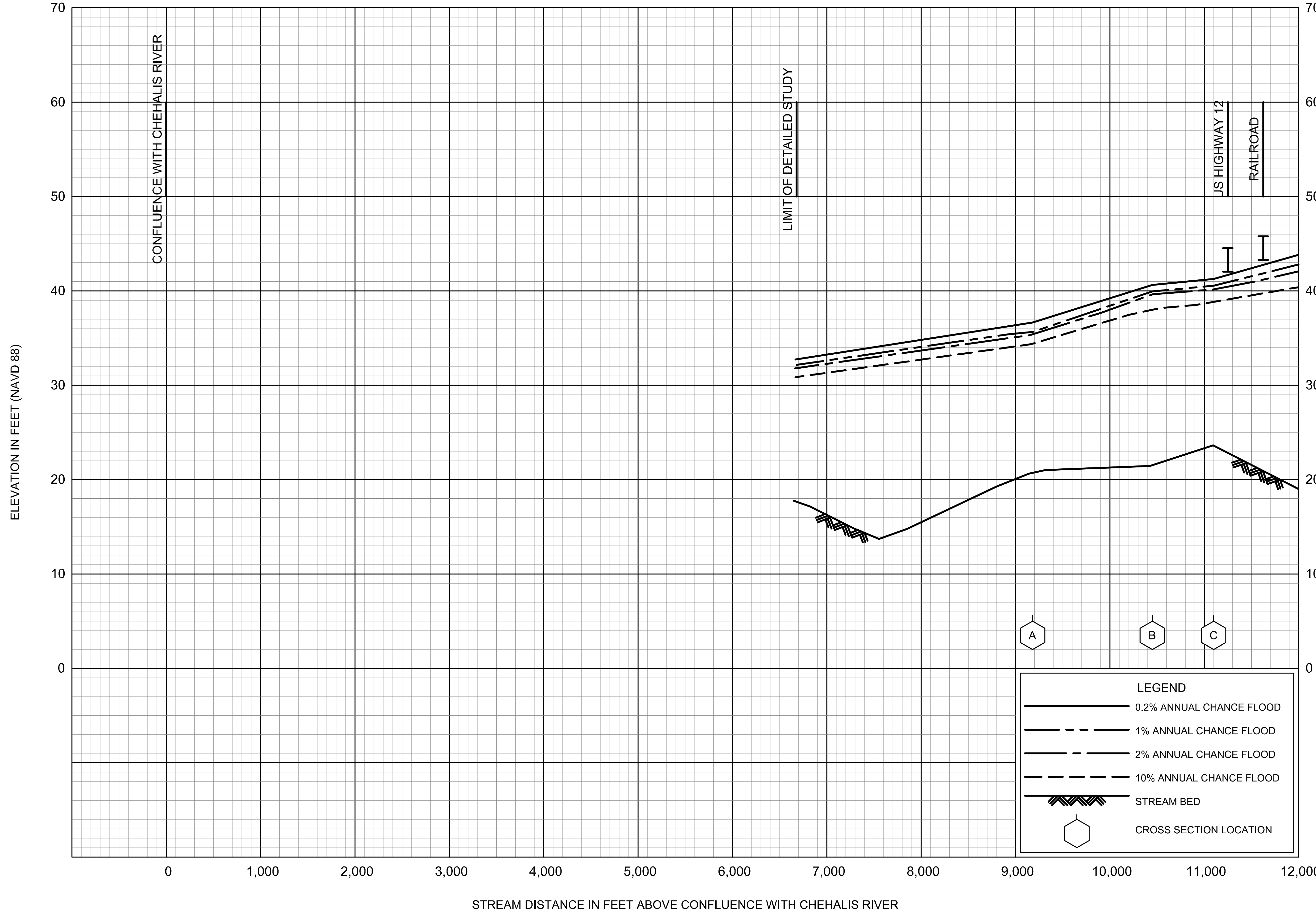
FLOOD PROFILES

ROUNDTREE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



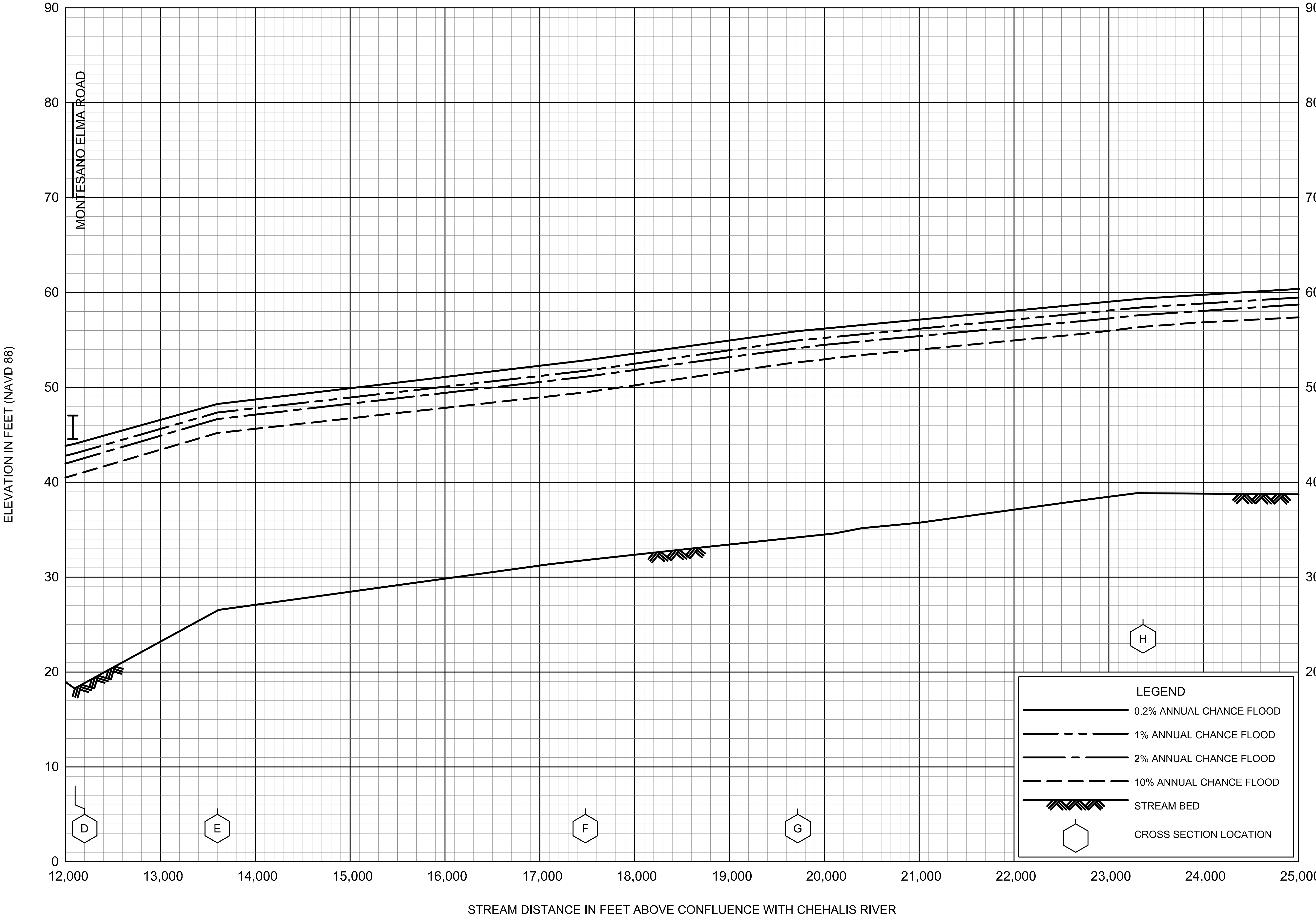
FLOOD PROFILES

SATSOP RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



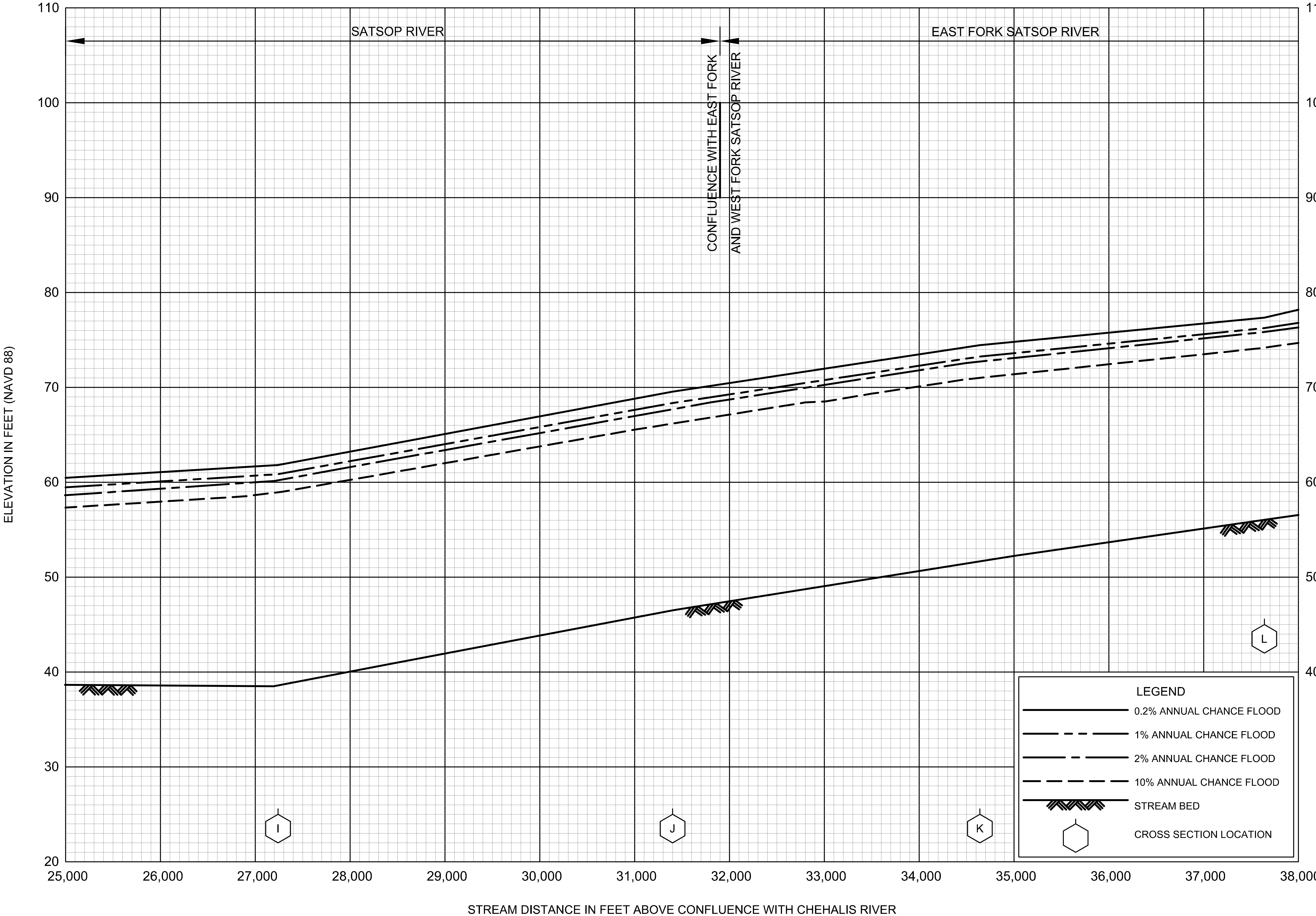
FLOOD PROFILES

SATSOP RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



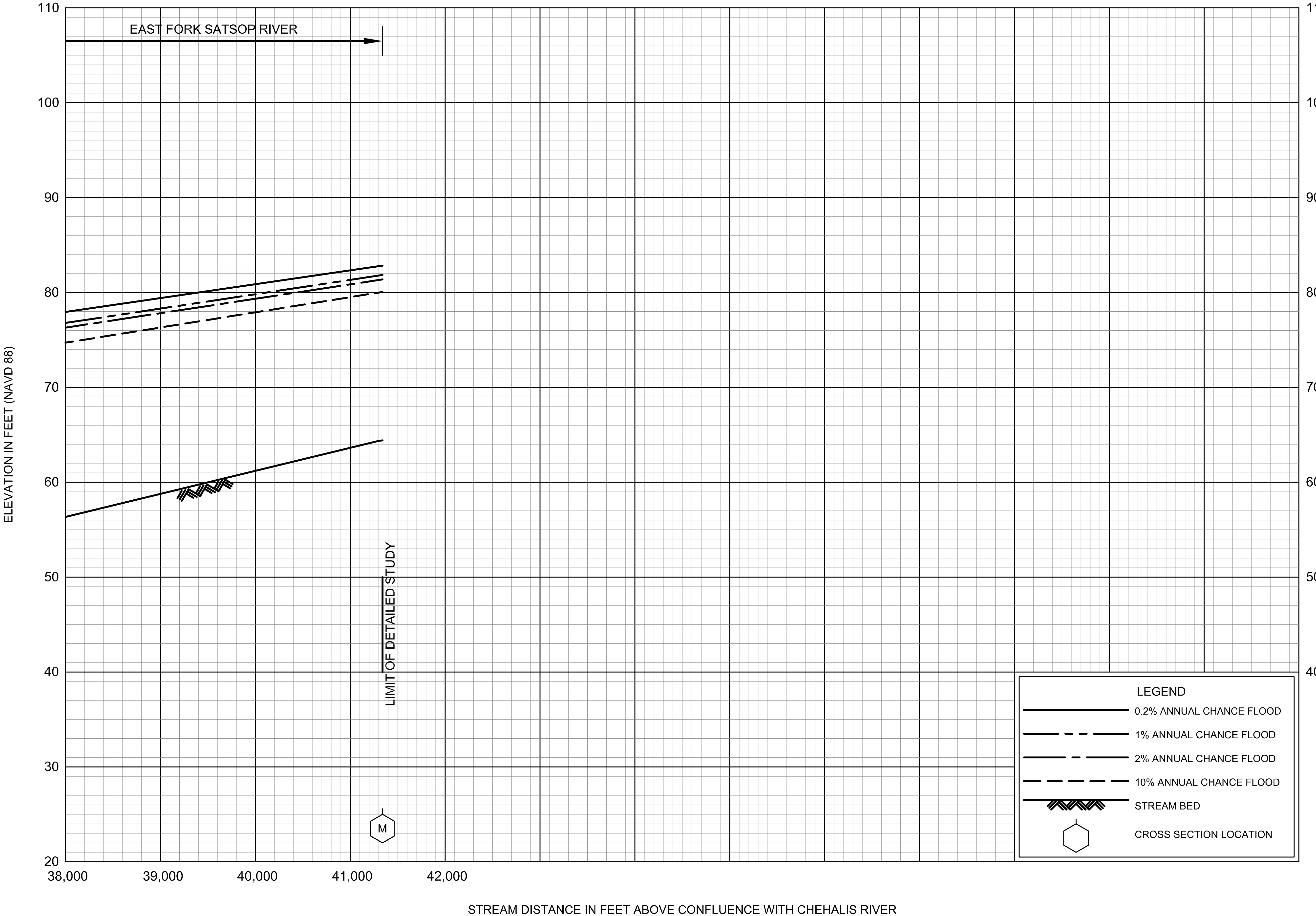
FLOOD PROFILES

SATSOP RIVER-EAST FORK SATSOP RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



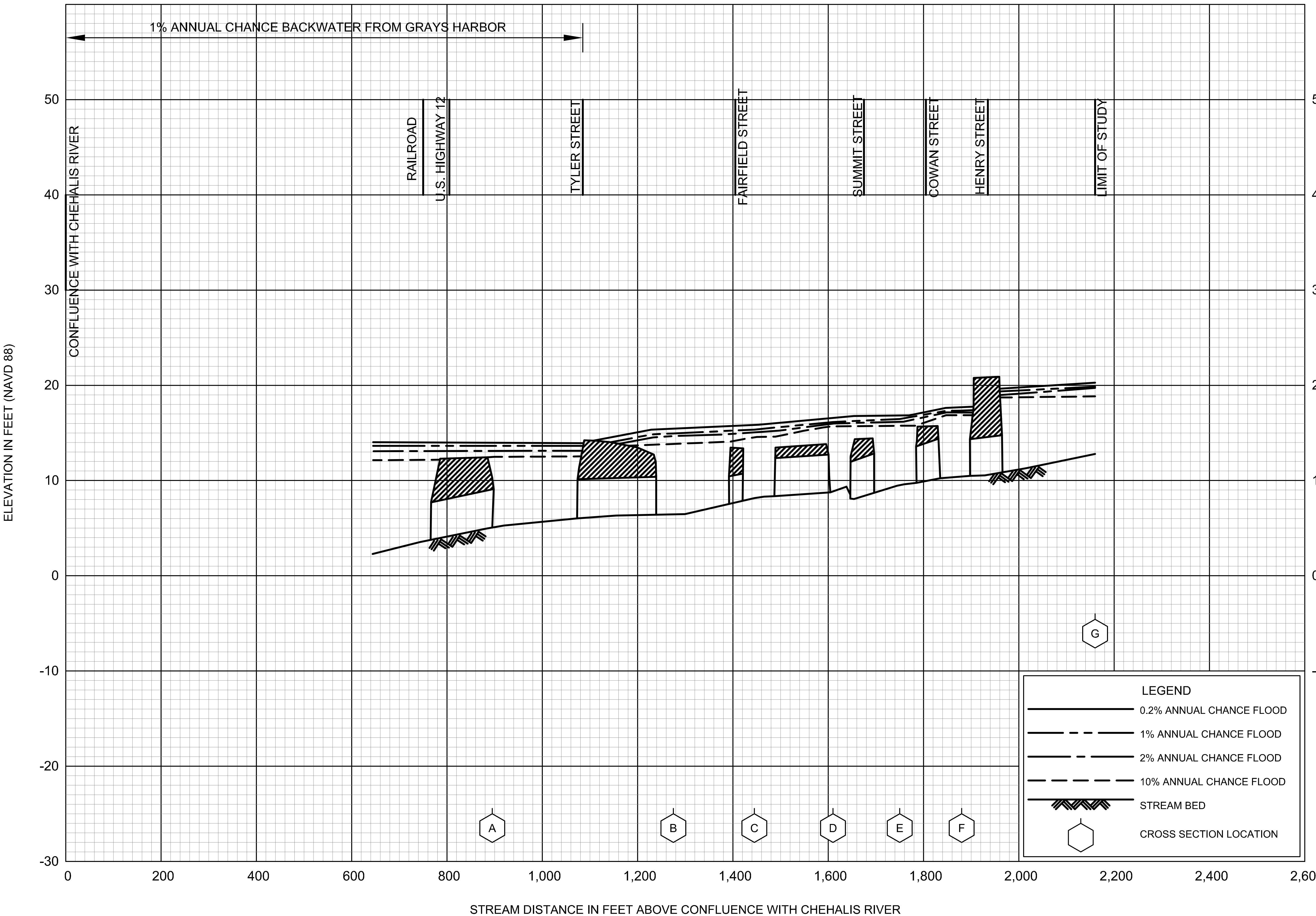
FLOOD PROFILES

SATSOP RIVER-EAST FORK SATSOP RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



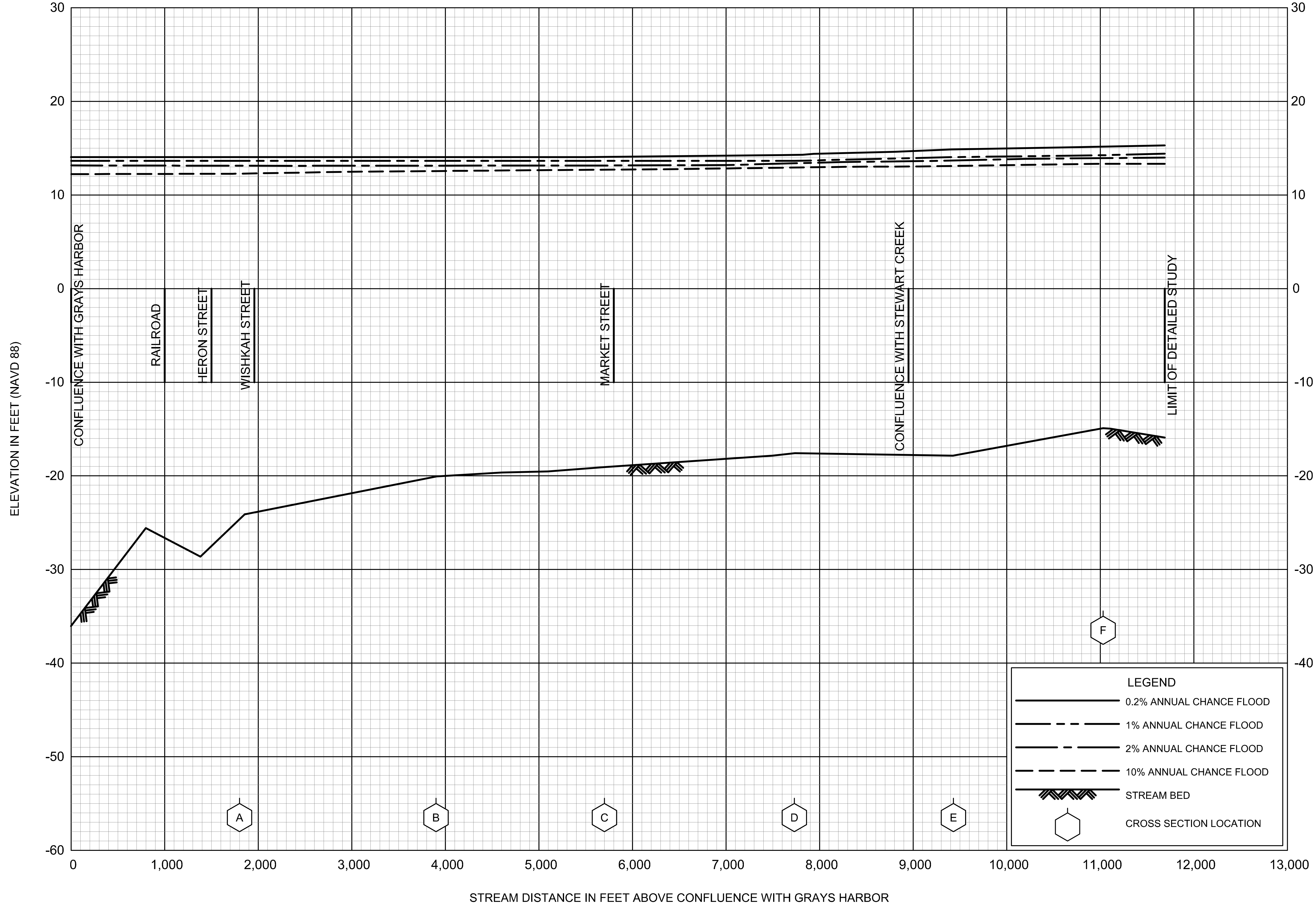
FLOOD PROFILES

WILSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



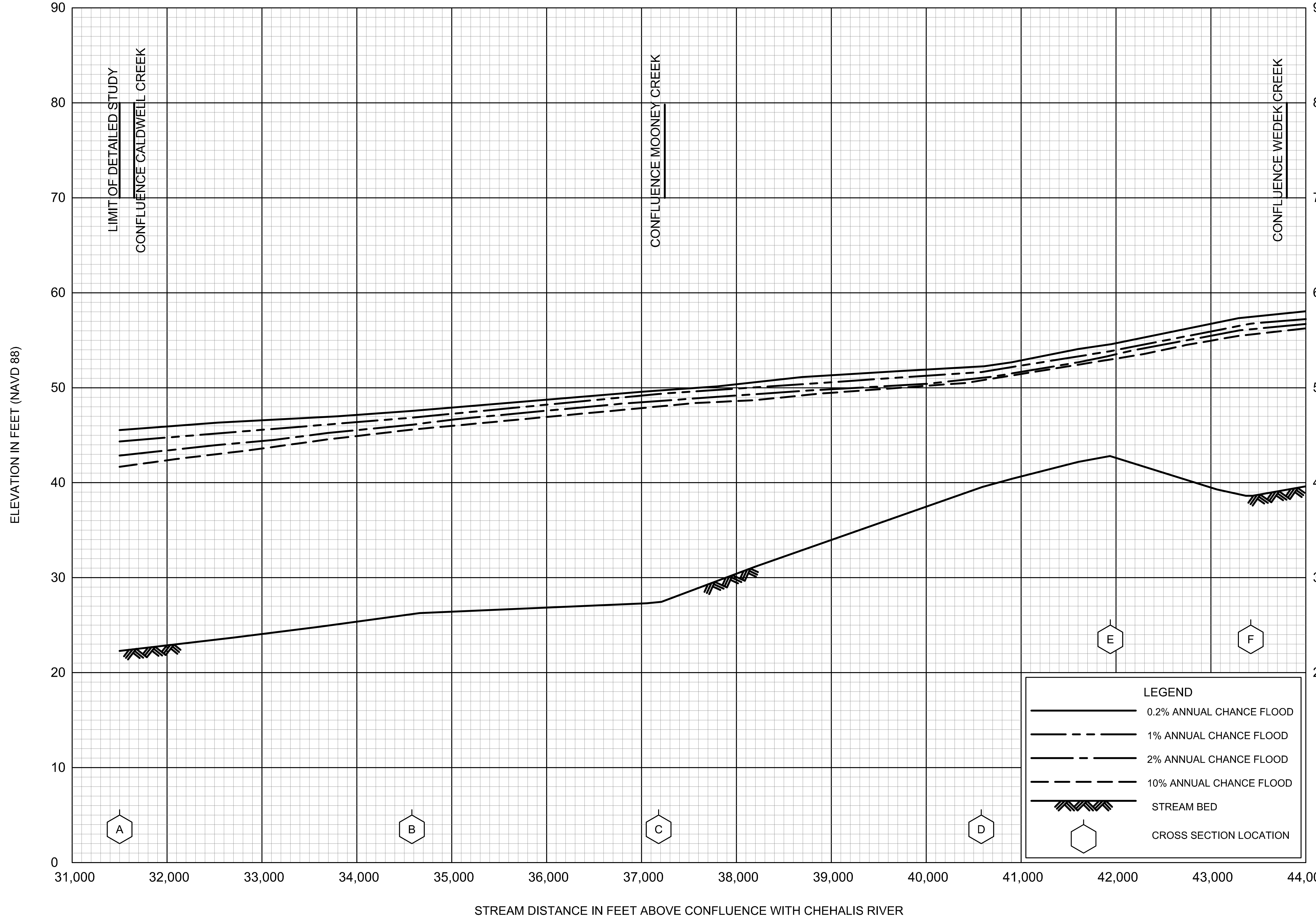
FLOOD PROFILES

WISHKAH RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



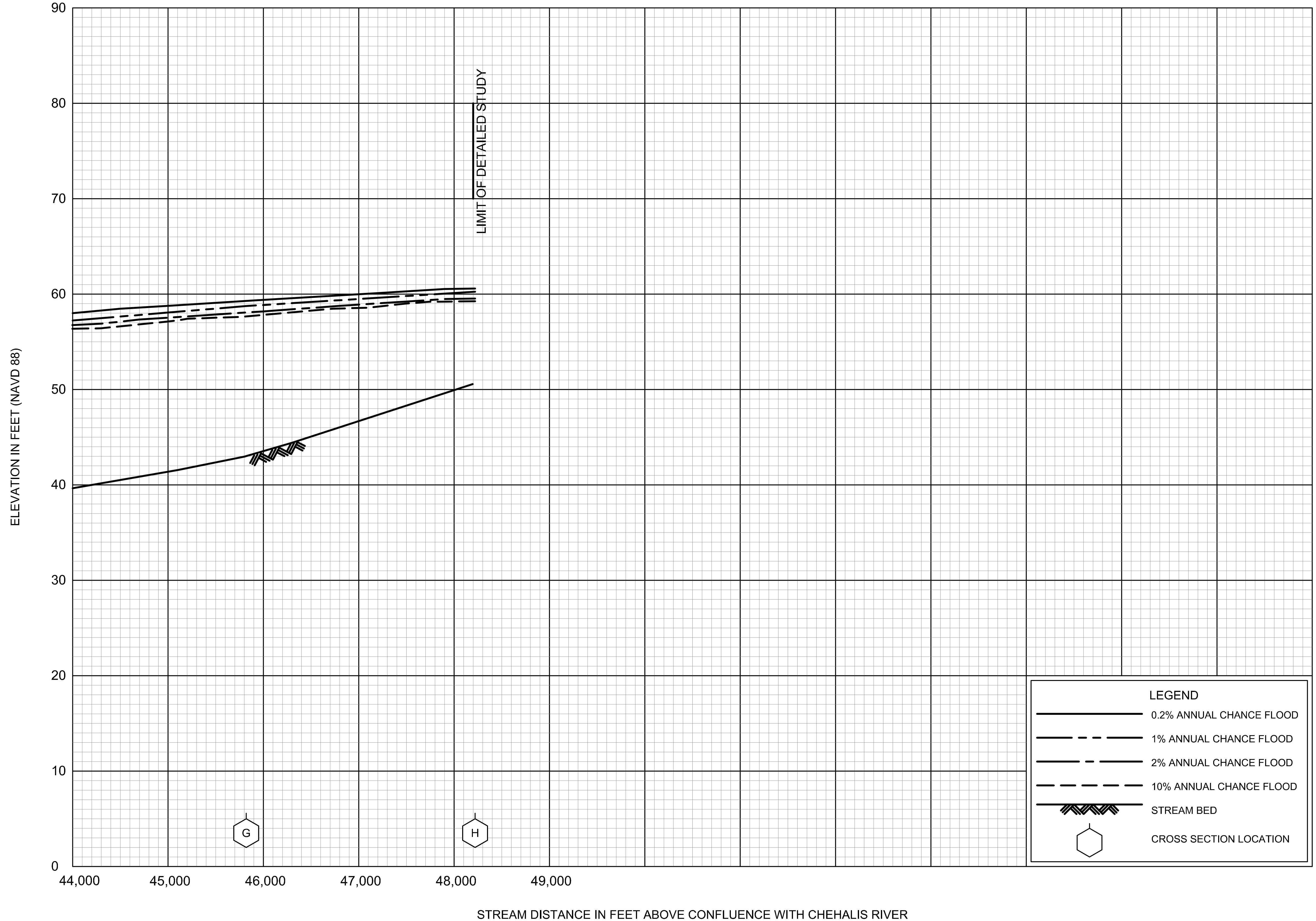
FLOOD PROFILES

WYNOOCHEE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS



FLOOD PROFILES

WYNOOCHEE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAYS HARBOR COUNTY, WA

AND INCORPORATED AREAS