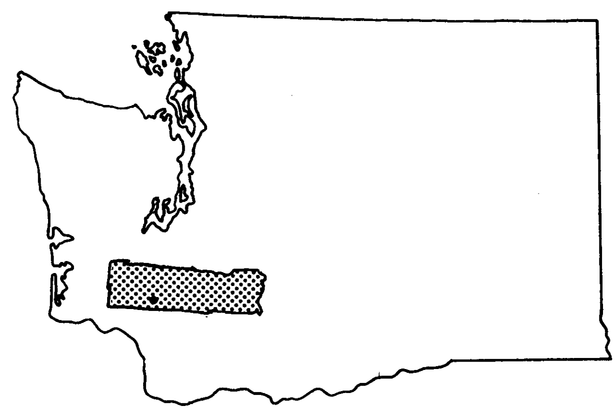
FLOOD INSURANCE STUDY



CITY OF TOLEDO, WASHINGTON
LEWIS COUNTY

MAY 1980

FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

COMMUNITY NUMBER - 530303

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PUBLISHED SEPARATELY:

FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the City of Toledo, Lewis County, Washington, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Toledo to the regular program of flood insurance by the Federal Insurance Administration. Further use of this information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

Streams selected for detailed analysis were identified in a meeting attended by representatives of the City of Toledo and the Federal Insurance Administration on April 13, 1976. A later meeting was attended by representatives of Lewis County, the study contractor, and the Federal Insurance Administration on July 6, 1976.

On May 17, 1979, the results of the study were reviewed at an interim technical meeting attended by representatives of the study contractor, the Federal Insurance Administration, and the City of Toledo.

The results of this study were reviewed at a final community coordination meeting held on November 27, 1979. Attending the meeting were representatives of the Federal Insurance Administration, the study contractor, and the city. This study incorporates all appropriate comments, and all problems have been resolved.

1.3 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by Tudor Engineering Company, for the Federal Insurance Administration, under Contract No. H-4025. This work, which was completed in June 1979, covered all significant flooding sources affecting the City of Toledo.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Toledo, Lewis County, Washington. The area of study is shown on the Vicinity Map (Figure 1).

Floods caused by the overflow of Cowlitz River were studied in detail. Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1984.

2.2 Community Description

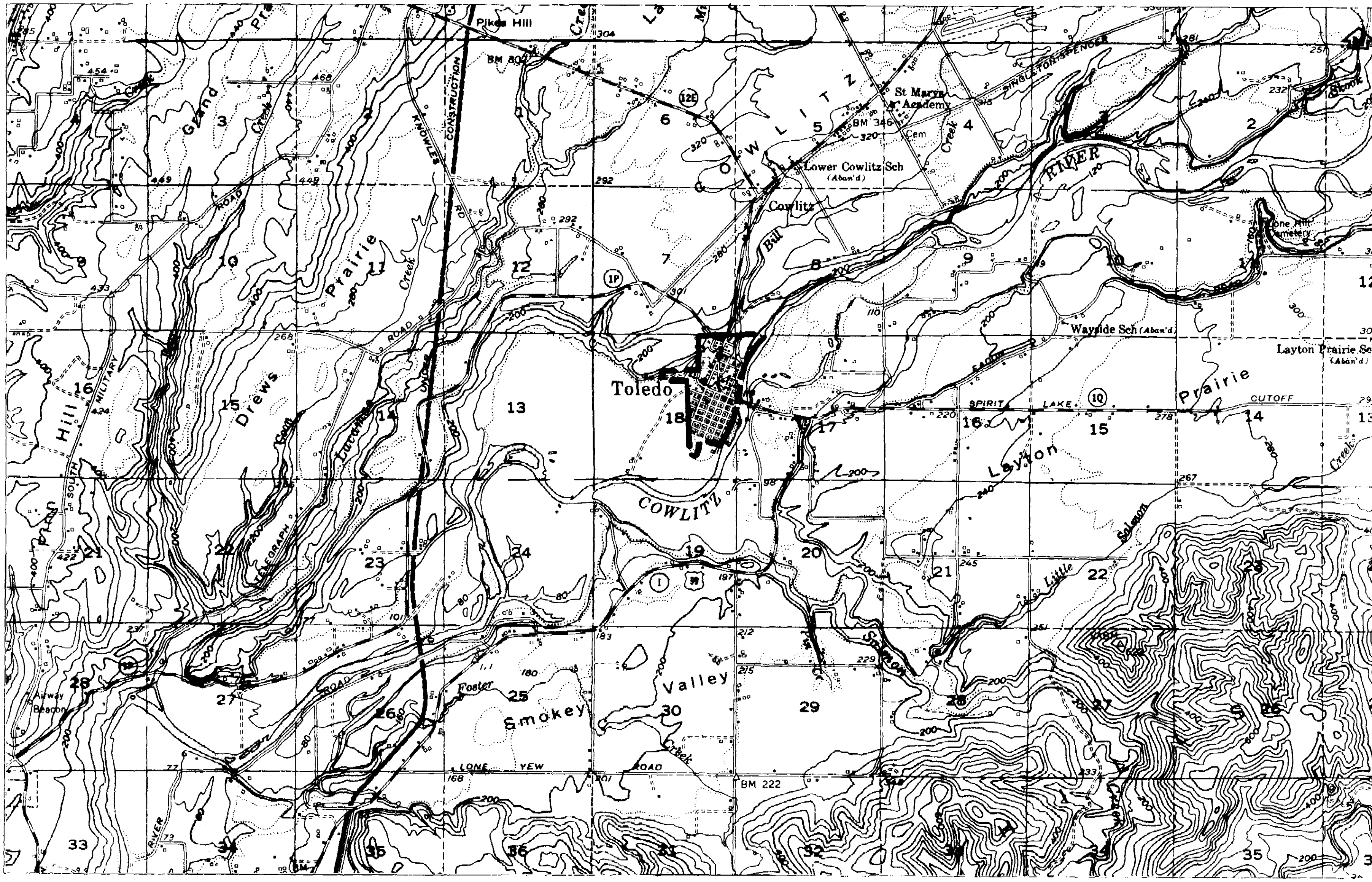
The City of Toledo is located in southwestern Lewis County, in southwestern Washington. It is located on the north bank of the Cowlitz River, approximately 34 miles upstream from its mouth and approximately 16 miles upstream from the City of Castle Rock. The city is located approximately 2 miles east of Interstate Highway 5, approximately 84 miles southwest of the City of Seattle, and approximately 20 miles southeast of the City of Chehalis, the county seat. Toledo is bordered on all sides by unincorporated areas of southwestern Lewis County.

Toledo and the former community of Cowlitz Landing, located approximately 0.5 mile downstream from Toledo, were important transportation centers during the early settlement of Washington. From 1863 to 1917, steamers from Portland came up the Cowlitz River bringing manufactured goods and taking farm products. Toledo represented the navigable limit for streams of that era and so became a natural site for a town. In 1892, the town was incorporated (Reference 1).

The city has experienced irregular population growth since the turn of the century. From a population of 285 in 1900, the city grew to 530 in 1930, then dropped to 499 by 1960 (Reference 2). The 1978 estimated population was 673 (Reference 3).

The economy of Toledo is based on logging and milling activities in the surrounding area, as well as farming. The town represents one of the commercial and residential centers for southwestern Lewis County. A considerable portion of the city's population is comprised of retired people from throughout the state. Most of the land within the corporate limits, including the flood plain, is used for residential or commercial purposes; however, some areas of the flood plain are used for pasture and croplands. Two areas, one north of the high school and the other east of Bill Creek, are open space.

Toledo has a mid-latitude, marine climate typified by dry, cool summers and mild, wet, and cloudy winters. The average annual precipitation is approximately 46 inches, with most of this occurring from September to April. The growing season usually extends from



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Federal Insurance Administration

CITY OF TOLEDO, WA
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VICINITY MAP

FIGURE 1

April to October. The average minimum temperature for January is 29°F, while the average maximum temperature for July is 77°F. The average annual snowfall is light. Snow seldom remains on the ground longer than one week or reaches a depth in excess of 8 to 12 inches (Reference 4).

The Cowlitz River, together with its tributaries upstream of Toledo, including Bill Creek, drains an area of 1461 square miles. The headwaters of Cowlitz River are located on the steep, densely forested slopes of Mount Rainier, which has an elevation of over 14,000 feet. Approximately 83 percent of the watershed is forested with evergreen trees of various stages of growth. Most of the remainder is natural prairie north of Toledo. A small segment in the high mountains is classified as Alpine zone. Through Toledo, the channel bottom elevation of the Cowlitz River drops from 88 feet to 85 feet, creating an average gradient of 2.5 feet per mile. Ground elevations vary from 92 feet within the southeastern part of the city to over 200 feet in the northeastern section.

2.3 Principal Flood Problems

The major flood season in the Cowlitz River basin extends from late fall through winter. There have been instances, however, when less significant floods have occurred in the spring. Major floods usually result from a combination of intense rainfall and resultant snowmelt after the watershed has been saturated by prior rainfall.

The largest flood recorded on the Cowlitz River occurred in December 1933. The peak discharge at the Castle Rock gage was calculated at 139,000 cubic feet per second (cfs), a 500-year recurrence interval event with the current flood-control structures. The flood destroyed farms, buildings, and many livestock. A loss of $160,812 was estimated by residents of the area. Two other large floods have occurred since the area was settled. The worst was probably in 1867, when the former community of Cowlitz Landing was almost entirely washed away. In 1906, the water was also very high, perhaps due to backwater behind the fill for the old Olequa Bridge (Reference 1).

Other major floods on the Cowlitz River occurred in December 1946, December 1964, January 1972, and December 1975 (a 100-year event). The most recent flood occurred in December 1977.

At Toledo, the 1946 and 1964 floods were approximately 4 feet lower than the 1933 flood. The peak discharge of the 1977 flood measured 86,500 cfs at the Castle Rock gage (Reference 5). At Toledo, the computed 100-year flood has a discharge of 69,600 cfs, while the 500-year flood has a discharge of 94,700 cfs.

Flood durations in the middle Cowlitz River are now fairly short. Before the construction of the Mossyrock and Mayfield Dams, known major floods remained above bankfull for periods of 3 to 5 days (Reference 6). Water level changes have been significantly affected by the two reservoirs, (Riffe Lake and Mayfield Reservoirs), behind the dams. A time-of-rise of 20 and 22 hours was recorded for the floods of December 1975 and December 1977, respectively. During the 1975 flood, the average rate-of-rise was 0.30 foot per hour, while the maximum rise in 1 hour was 0.50 foot.

2.4 Flood Protection Measures

The City of Toledo is regulated under State flood plain management regulations of the Washington State Flood Control Zone Acts of 1935, 1960, and 1969 and the Washington Water Resources Act of 1971, including shoreline management. Under Chapter 86.16 of the Revised Code of Washington, the Cowlitz River and its tributaries are in Flood Control Zone 14. Toledo has no additional building and development regulations related to flood hazards.

Two projects lessen the impact of flooding on Cowlitz River through the study reach. Riffe Lake (Mossyrock Dam) at River Mile 65 (operated since 1968) and, to a lesser extent, Mayfield Reservoir (Mayfield Dam) at River Mile 52 (operated since 1962) provide a combined usable flood storage capacity of 1.3 million acre-feet. Both projects, owned and operated by the City of Tacoma under a Federal Power Commission license, attempt to control the 100-year flood at Toledo in coordination with the U.S. Army Corps of Engineers, Portland District. These structures, however, have no effect on the 500-year event.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled 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 which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

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

Flood frequency data for Cowlitz River were based on operating criteria for Mayfield and Mossyrock Dams and discharge records at the following streamflow gaging stations operated by the U.S. Geological Survey:

Stream and Gage No.	Location	Period of Record
Cowlitz River at Castle Rock (No. 14-2430), approximately 25 miles from Toledo	A Street Bridge in Castle Rock	1926 to Present
Cowlitz River Below Mayfield Dam (No. 14-2380- approximately 20 miles upstream from Toledo	1.4 Miles Downstream From Mayfield Dam	1934 to present
Cowlitz River Near Randle (No. 14-2334) approximately 50 miles upstream from Toledo	0.5 Mile Downstream of Cispus River confluence	1947 to Present

Analyses of data for the unregulated gage at Randle (No. 14-2334) were performed in accordance with the standard log-Pearson Type III method as outlined by the U.S. Water Resources Council (Reference 7). Discharges directly below Mayfield Dam were based on Mayfield Dam operational criteria and a cumulative frequency curve developed by the U.S. Army Corps of Engineers in Portland, Oregon, during February 1972. Discharges at Toledo were based on Mayfield Dam releases, computed hydrographs for Salmon Creek, confluent with the Cowlitz River downstream from Toledo (Reference 8), and local runoff.

Hydrographs for the ungaged area were derived using data obtained from gage nos. 14-2430 and 14-2380, a rainfall-runoff computer model (Reference 8) incorporating 24-hour storm precipitation, and the U.S. Soil Conservation Service unit hydrograph methods (Reference 9). The 24-hour storm precipitation for the 10-, 50-, and 100-year storm frequencies were obtained by extending the National Weather Service frequency curve on normal distribution probability paper. The time distribution was based on the National Weather Service rain gage records at Cinnebar and Castle Rock (Reference 10).

Peak discharge-drainage area relationships for the Cowlitz River are shown in Table 1.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Cowlitz River At Toledo	1,461	49,000	60,000	69,600	94,700

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Water-surface elevations for the Cowlitz River were computed through use of the U.S. Army Corps of Engineers HEC-2 step-backwater computer program (Reference 11).

Cross sections for the backwater analysis of the Cowlitz River were obtained from aerial photographs (Reference 12) and topographic maps (Reference 13), with below-water data taken from field surveys.

All bridges were surveyed to obtain elevation data and structural geometry.

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 Flood Boundary and Floodway Map (Exhibit 2).

Channel and overbank roughness factors (Manning's "n") are based on field inspections which were undertaken at each cross section location. Values of channel roughness coefficients ranged from 0.035 to 0.040, while the overbank coefficients ranged from 0.090 to 0.120.

Starting water-surface elevations for the step-backwater computations were determined by the slope-area method.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

The hydraulic analyses for this study assume unobstructed flow. The flood elevations are considered valid only if bridges remain unobstructed.

The study contractor has determined that some areas shown on the Federal Insurance Administration's Flood Hazard Boundary Map (Reference 14) are areas of minimal flooding; therefore, they were not delineated on the maps.

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

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage State and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Insurance Administration as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:4800, with a contour interval of 4 feet (Reference 13).

In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown.

Flood boundaries for the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2).

Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

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

The floodway developed in this study was initially computed on the basis of equal conveyance reduction from each side of the flood plain. Further refinements were made using field observations, hydraulic principles, and topographic maps (Reference 13). The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood boundaries are close together, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

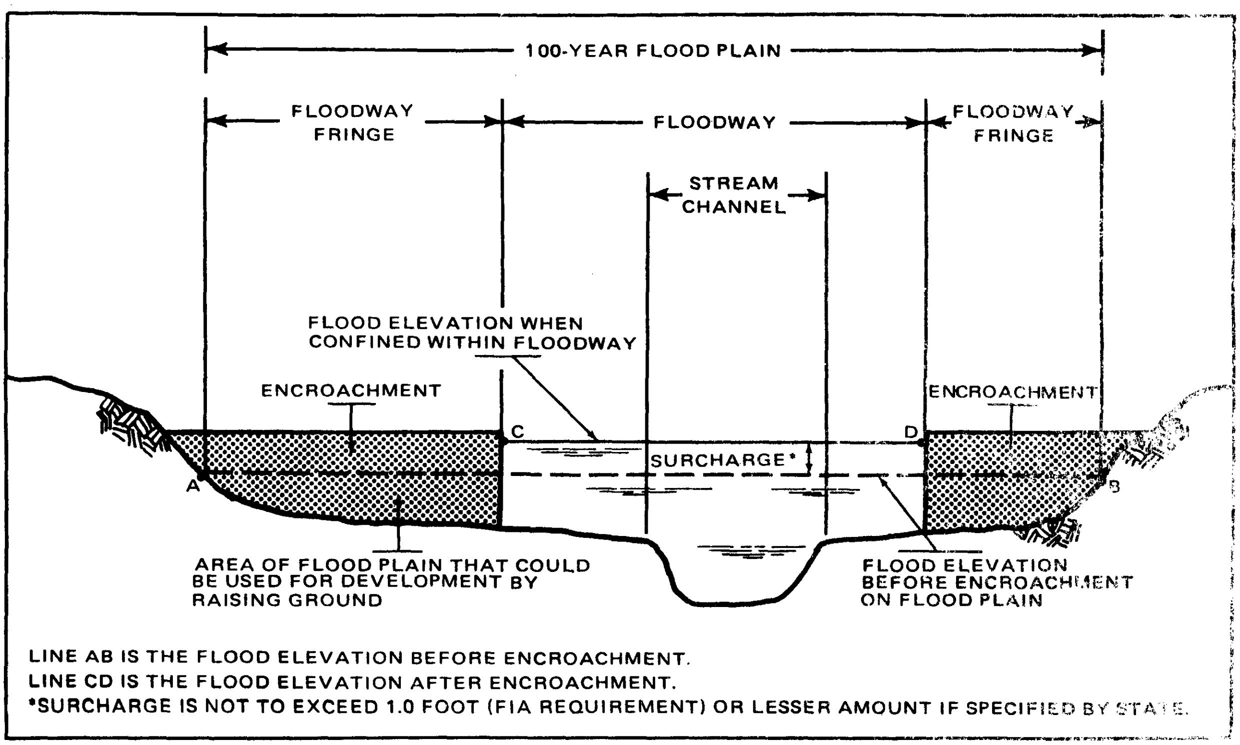

Figure 2. Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Cowlitz River								
A	34.228	727/65[2]	7,270	9.6	101.0	101.0	102.0	1.0
B	34.367	728[3]	9,020	7.7	102.6	102.6	103.3	0.7
C	34.774	1,281/18[2]	13,390	5.2	106.7	106.7	107.1	0.4

[1] Miles Above Mouth [2] Width/Width Within Corporate Limits [3] Floodway Lies Entirely Outside Corporate Limits

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FLOODWAY DATA

COWLITZ RIVER

TABLE 2

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Insurance Administration has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Toledo.

5.1 Reach Determinations

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

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The location of the reach determined for the flooding source of the City of Toledo is shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the Federal Insurance Administration device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

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

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Cowlitz River							
Reach 1	0001	-2.7	-1.2	2.5	025	A5	Varies - See Map

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

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CITY OF TOLEDO, WA
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FLOOD INSURANCE ZONE DATA

COWLITZ RIVER

TABLE 3

5.3 Flood Insurance Zones

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

Zone A5:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas are subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

The flood elevation differences, Flood Hazard Factors, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Toledo is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Insurance Administration.

6.0 OTHER STUDIES

The U.S. Army Corps of Engineers, Portland District, published a report entitled, Special Flood Hazard Information, Cowlitz River, in the Vicinity of Toledo, Washington, in November 1971 (Reference 6). Included in that study was the Cowlitz River through Toledo. The flood profiles obtained in the U.S. Army Corps of Engineers study differed slightly from those of this Flood Insurance Study. The hydrological determinations used to obtain the U.S. Army Corps of Engineers profiles were minimal, whereas the profiles of this study were obtained using detailed hydrological analyses.

The Federal Insurance Administration previously published a Flood Hazard Boundary Map for the City of Toledo (Reference 14). This Flood Insurance Study is more detailed, and, thus, supersedes that map.

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

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Insurance and Mitigation Division, Federal Emergency Management Agency, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

8.0 BIBLIOGRAPHY AND REFERENCES

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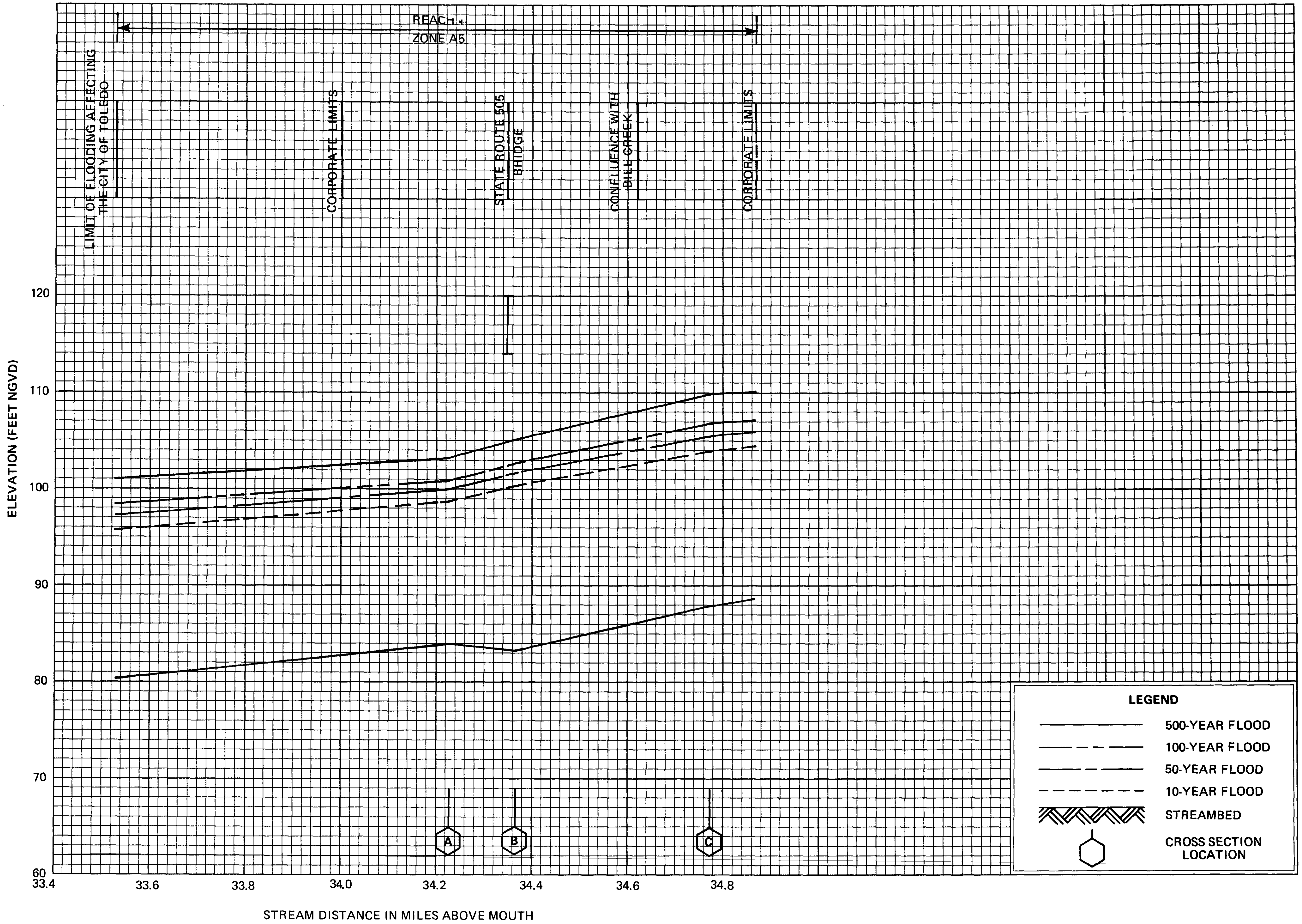

FLOOD PROFILES

COWLITZ RIVER

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

CITY OF TOLEDO, WA
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