# FLOOD INSURANCE STUDY

# PACIFIC COUNTY, WASHINGTON
## AND INCORPORATED AREAS

| COMMUNITY NAME | COMMUNITY NUMBER |
|---|---|
| ILWACO, TOWN OF | 530127 |
| LONG BEACH, TOWN OF | 530128 |
| PACIFIC COUNTY, UNINCORPORATED AREAS | 530126 |
| RAYMOND, CITY OF | 530129 |
| SHOALWATER BAY INDIAN TRIBE | 530341 |
| SOUTH BEND, CITY OF | 530130 |


PRELIMINARY:
AUGUST 30, 2013

Federal Emergency Management Agency

**FLOOD INSURANCE STUDY NUMBER**
**53049CV000A**

**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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**FLOOD INSURANCE STUDY**
**PACIFIC 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 Pacific County, Washington, including the Cities of Raymond and South Bend; the Towns of Ilwaco and Long Beach; the Shoalwater Bay Indian Tribe; and the Unincorporated Areas of Pacific County (referred to collectively herein as Pacific 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 Pacific County into a countywide format FIS. Information on the authority and acknowledgements for each of the previously printed FISs for communities within Pacific County was compiled, and is shown below.

| | |
|---|---|
| Ilwaco, Town of | The hydrologic and hydraulic analyses for the August 1978 study were performed by Tippetts-Abbett-McCarthy-Stratton, Engineers and Planners, for the Federal Insurance Administration (FIA), under Contract No. H-4022. This work was completed in April 1977 (Reference 1). |

| | |
|---|---|
| Raymond, City of | The hydrologic and hydraulic analyses for the January 1979 study were performed by CH2M HILL, Inc., for FIA, under Contract No. H-3815. This work was completed in January 1978 (Reference 2). |
| South Bend, City of | The hydrologic and hydraulic analyses for the May 1979 study were performed by CH2M HILL, Inc., for FIA, under Contract No. H-3815. This work was completed in January 1978 (Reference 3). |
| Pacific County, Unincorporated Areas | The hydrologic and hydraulic analyses for the September 27, 1985 study were performed by CH2M HILL, Inc., for the FEMA, under Contract No. H-3815. This work was completed in January 1976 and covered only major coastal and riverine flooding sources in Pacific County. Approximate flood boundaries for the Pacific Ocean, Willapa Bay, the Columbia River, the Naselle River, the South Fork Naselle River, and Salmon Creek were determined in November 1976, by Dewberry, Nealon, and Davis (Reference 4).<br><br>The FIS was extended under Contract No. EMW-C-0950 to include the Pacific Ocean coast from North Cove north to the county line. The analyses for this part of the study were performed by C2HM HILL, Inc., and were completed in September 1983. |

There are no previous FIS reports or FIRMs published for the Shoalwater Bay Indian Tribe and there is no previous FIS report published for the Town of Long Beach; therefore the previous authority and acknowledgment information for these communities are not included in this FIS. These communities may not appear in the Community Map History table (Section 6.0).

For this countywide FIS, new coastal engineering analyses were prepared by Strategic Alliance for Risk Reduction (STARR) under the contract to the Department of Homeland Security (DHS) and FEMA under Contract No. HSFEHQ-09-D-0370, Task Order Number HSFE10-11-J-0001. Work on the countywide report was completed in May 2013.

The orthophotography base mapping was acquired from the U.S. Geological Survey (USGS) and the Washington State Department of Ecology, at a scale of 1:24,000 from photography dated 2009 or later. The projection used for the basemap was produced in Washington State Plane FIPS South Zone 4602 (feet), and the horizontal datum used is the North American Datum 1983 (NAD83), Geodetic Reference System (GRS) 80 Spheroid. Differences in datum and spheroid used in the production of the 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 Pacific 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 | Final Meeting |
|---|---|---|
| Ilwaco, Town of | April 8, 1976 | July 6, 1977 |
| Raymond, City of | December 1976 | June 19, 1978 |
| South Bend, City of | December 1976 | June 26, 1978 |
| Pacific County, Unincorporated Areas | July 21, 1975 | March 10, 1976 |

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 Pacific 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 |
|---|---|
| Naselle River | At the confluence with Dell Creek to approximately 7,500 feet upstream of State Highway 4 |
| Salmon Creek | At the confluence with Naselle River to approximately 1,500 feet upstream of State Highway 4 |
| South Fork Naselle River | At the confluence with Naselle River to approximately 3.33 miles upstream of the confluence with Naselle River |
| Willapa River | USGS Gage No. 12-0115 to approximately 10,300 feet upstream of State Highway 6 |

No other freshwater flood sources exist which would normally fall within the scope of this FIS. Black Lake, in the northern part of the Town of Ilwaco, has an outlet at the city limit which discharges away from the community into Willapa Bay. Holman Lake and marshes on the west side of the Town of Ilwaco drain though natural channels leading to Baker Bay, in the southwest corner of the town. The small drainage area of an undeveloped nature produces no significant source of freshwater flooding. Area 25 feet above sea level, were excluded from the detailed area.

For this revision, STARR conducted over 38 miles of revised Coastal Hazard Analysis that included computing wave runup. STARR utilized 79 transects in this study. No new detailed riverine studies were conducted as part of this countywide FIS. For riverine areas, 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.

The floodplain mapping updates consisted of a mixture of redelineation and rectification (refinement) of existing flood boundaries based on the best topographic data and aerial photography available at the time of the study. Redelineation was limited to areas were new, quality topographic data was available and Base Flood Elevations were previously defined. Redelineation was completed on the detailed study areas of the Naselle River, Salmon Creek and South Fork Naselle River. The detailed study reaches along Ward, Wilson and Whitcomb Creeks near the City of Raymond and the Willapa River near Lebam are not covered by new topographic data and was converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new aerial photography.

Approximately 4.3 stream miles, including portions of Naselle River and Salmon Creek were studied with base level methods (Zone A).

The boundary of the 1-percent-annualchance flood for the South Fork Naselle River near its confluence with Cement Creek was refined by making adjustments to fit the floodplains to new aerial photography and the new topographic data. Those approximate method reaches not covered by new topographic data were converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new aerial photography to ensure that they overlay the water course they represent. These areas include portions of Salmon Creek and Willapa River.

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction. Approximate analyses were used to study those areas having a low development potential or minimal flooding hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and the communities.

No Letters of Map Revision (LOMRs) were incorporated as part of this study.

### 2.2 Community Description

Pacific County is located in southwestern portion of Washington. The County is bordered on the north by Grays Harbor County, WA; on the west by the Pacific Ocean; on the south by Clatsop County, OR; on the southeast by Wahkiakum County, WA; and on the east by Lewis County, WA. The County seat is located in the City of South Bend. In 1970, the population of Pacific County was 15,796. The 2010 population of Pacific County was reported to be 20,920 (Reference 5).

Pacific County is influenced by marine and continental weather patterns. The County is characterized by warm, dry summers and generally mild winters, although heavy rain and hail infrequently accompanies thunderstorm activity. General storms covering a large area usually occur in the winter months, and, to a lesser extent, during the fall and spring seasons. The average mean temperature ranges from 72 degrees Fahrenheit (ºF) in August to 32ºF in January. The highest recorded temperature was 102ºF in 1981. The lowest recorded temperature was 3ºF in 1983. Yearly precipitation averages approximately 85 inches, with the maximum monthly average occurring in January, with almost 14 inches of rain, and the minimum monthly average occurring in July, with 1.2 inches (Reference 6). About 60 percent of this precipitation occurs from November through February in moderate rains that may continue uninterrupted for several days.

A wind speed of 113 miles per hour (mph) is the highest recorded in Washington (Reference 7). It was recorded at North Head, WA two miles west of the Town of Ilwaco on January 29, 1921. Newspaper accounts indicate gusts from the southeast may have reached 150 mph (Reference 8). The strongest winds are associated with the more intense winter storms moving east across the ocean. Circulation of air around low atmospheric pressure centers results in a high frequency of strong southeasterly and southerly winds along the coast.

The dominant geologic features of Pacific County are the Willapa Bay estuary and its associated tidelands. The mean tidal range in Willapa Bay varies from 8.5 to 10.2 feet. The Columbia River estuary borders the County on the south. The mean tidal range along this shore varies from 7.6 to 7.9 feet.

The tidal range on the ocean is approximately 8.1 feet. Elevations range from sea level to over 2,800 feet in the Willapa Hills in the eastern portion of the County.

Vegetation varies from tidal flat and marshland grasses in the estuaries to forest stands of western hemlock, Douglas fir, and western red cedar. Forest land comprises 90 percent of the land area in Pacific County. The lower river valleys contain farm and pastureland.

Development in the County is restricted by the topography, which is quite steep throughout the County. Therefore, most of the development has occurred in the lower river valleys and along the Willapa Bay and ocean coastlines.

The Naselle River flows predominantly east to west through the central portion of Pacific County. At the Town of Naselle it turns northwest and joins Willapa Bay in the north.

Salmon Creek flows northwest along Highway 12 and joins Naselle River approximately 700 feet from the intersection of Highway 12 and Naselle River.

The South Fork Naselle River flows north to south on the east side of Highway 401 and joins the Naselle River near Naselle, WA.

The Willapa River flows predominantly east to west through the northern portion of the County and discharges into Willapa Bay northwest of the City of South Bend. The topography in the Willapa River watershed north of the City of South Bend is relatively flat and is characterized by several small streams and marsh areas.

## 2.3 Principal Flood Problems

Flooding in Pacific County occurs primarily during the winter months. In the coastal areas, the high spring tides and strong winds from winter storms that produce storm surges are responsible for coastal flooding. Heavy rains with some snowmelt produce the highest runoff flows in the winter. The storms that produce the storm surges also bring heavy rains, and, therefore, the high riverflows are held basically by tides, producing the greatest flooding at river mouths, which have cumulative water levels that are sufficient to create flood hazards in the adjacent communities.

High tidal waters can also enter communities through malfunctioning tide gates on the underground storm sewer system that drains either the Willapa or South Fork Willapa Rivers. These gates occasionally become blocked open with accumulated debris. Flooding is relieved as tidewaters recede and tide gates that hold back storm water runoff reopen.

Runoff and accumulation of precipitation are secondary source of flooding problems. The capacity of the present water drainage system is hampered by undersized culverts and conduits. During high tide periods, there is insufficient hydraulic gradient to allow precipitation runoff to drain into the river; so, it accumulates in low areas.

Major coastal and tidal floods, in order of highest water, have occurred in 1934, 1933, 1973, 1969, 1967, 1972, and 1960. The flood in 1934 is estimated as having a recurrence interval of 19 years, while the 1973 flood had a recurrence interval of 10 years.

Historically the highest flood levels along the lower reaches of the Columbia River have been due to combination of storm tides and winter freshets on the Columbia River.

Columbia River flow records at The Dalles, Oregon gaging station covers a period of 100 years. The largest Columbia River flows recorded there include 1,240,000 cubic feet per second (cfs) in 1894; 1,010,000 cfs in 1948; and 958,000 cfs in 1876. The river is subject to considerable regulation by many large reservoirs. During three of the larger observed river freshets, when flooding was evident at high tides, levels dropped below flood stage, during low tides downstream of River Mile 40, while remaining above flood stage upstream.

Table 3, “Major Floods Occurring on the Naselle and Willapa Rivers” lists several of the the largest documented floods on the Naselle and Willapa Rivers. Discharges for the Naselle River were recorded at USGS gage No. 12010000. Discharges for Willapa River were recorded at USGS gage No. 12013500.

**Table 3 – Major Floods Occurring on the Naselle and Willapa Rivers**

| | **DISCHARGE (cfs)[1]** | |
|---|---|---|
| **DATE** | **Naselle River** | **Willapa River** |
| January 22, 1935 | 11,100 | * |
| February 22, 1949 | 10,300 | 11,400 |
| November 20, 1962 | 10,500 | 11,200 |
| December 13, 1966 | 7,500 | 11,400 |

**Table 3 – Major Floods Occurring on the Naselle and Willapa Rivers (Continued)**

| | DISCHARGE (cfs)[1] | |
|---|---|---|
| **DATE** | **Naselle River** | **Willapa River** |
| January 9, 1990 | 9,350 | 11,700 |
| November 24, 1990 | 11,300 | 11,800 |
| December. 20, 1994 | 10,400 | 14,800 |
| March 18-19, 1997 | 12,600 | 12,100 |
| February 24, 1999 | * | 12,000 |
| December 15, 1999 | 9,390 | * |
| December 03, 2007 | 7,180 | 15,100 |
| January 7-8, 2009 | 13,500 | 13,000 |

* Data Not Available
[1] Reference 9

For much of December 1933, Pacific County was under siege of combined high winds, rainfall and tides. More than 20 consecutive days in December 1933, were marked by gale force winds with record rainfall for the period. Extensive property damage was reported (Reference 10). Wave action on Baker Bay eroded the Town of Ilwaco beachfront and washed out roads east of the town. On December 17, 1933, the maximum wind velocity was 70 mph; 2.63 inches of rainfall fell in 24 hours; and the highest tide in the 51 year period (1925-1976) at the Tongue Point gage near the City of Astoria, Oregon was recorded as 14.6 feet above Mean Lower Low Water (MLLW).

Ocean waves and tidal currents are eroding approximately 2.5 miles of the beach and undermining upland areas of Cape Shoalwater on the northwestern shore of Willapa Bay. The shoreline has moved north approximately 12,000 feet since 1887 and is expected to continue this trend. During the last 15 years, portions of the shoreline uplands after eroded at the rate of 150 feet per year. In addition to the land loss, numerous houses and roads have been destroyed and a portion of the main highway along Cape Shoalwater required relocations in the mid-1970’s (Reference 11).

At local requests, the feasibility of protecting Cape Shoalwater was investigated by the U.S. Army Corps of Engineers (USACE) in the late 1960’s and early 1970’s. Study findings indicated that any short-term emergency measures would cost millions of dollars to insure any degree of success. Furthermore, the success of any method of erosion control was problematical and a hydraulic model study would be advisable before actual expenditure of construction funds for navigation or erosion protection measures were undertaken. At present, no additional studies are being undertaken by USACE except for frequent condition surveys of Cape Shoalwater and the bar and entrance channel.

Storm tides have flooded homes in the low area near the Holman Lake drainage slough on the west side of the downtown area of the Town of Ilwaco. Personal interviews, records, and newspaper accounts (Reference 8) indicate that the worst wave conditions in Baker Bay were generated by the January 29, 1921 storm. Winds gusting to 150 mph from the southeast shifted to the southwest as the storm moved inland. Waves were about six feet high and caused damage along the waterfront and at the boat docks.

The most significant rain event Pacific County has seen to date occurred December 1-3, 2007. This three day severe storm event consisted of three separate storms that battered the County with snow, rain, and hurricane force winds. The first storm produced heavy snow throughout the state of Washington. On December 2nd, the snow changed to rain as the temperatures increased, accompanied by strong winds. On December 3rd, the most significant storm arrived; bringing hurricane force winds, record high temperatures, and record rainfall. Klipsan Beach (on the Long Beach Peninsula) recorded gusts of 102 mph while Naselle Ridge (mountain top) record gusts of 140 mph. Pacific County received $1,340,100 in Small Business Administration disaster loans (Reference 12). Power was out to much of the County and all major transportation routes were closed due to tree fall.

## 2.4 Flood Protection Measures

Flood protection measures at Tokeland, WA include a breakwater on the southwest shore of the peninsula and breakwater protecting the harbor. A breakwater was also constructed to protect the small boat harbor at the Town of Chinook. These areas are protected from wave action.

Some dikes have been built along the Willapa River. Elevations of levees on the Willapa River, in the Mailboat Slough area, west of the City of South Bend, have adequate 0.2-percent-annual-chance flood protection. Levees around the Willapa Harbor Airport provide 1-percent-annual-chance flood protection. Along the Ocean side of the North Beach Peninsula, a natural dune list has been built up by wind-blown sand. This offers 1-percent-annual-chance flood protection.

Some diking has been done along the on the Willapa River and South Fork Willapa River in the Cities of Raymond and South Bend. Inspection of the levees revealed that they are generally not substantial structures and are not high enough to provide more than minimal protection against the more frequent events.

The embankment for U.S. Highway 101 forms a dike which protects the eastern portion of the City of South Bend against the 10-percent-annual-chance high tide.

Most of the Town of Ilwaco waterfront consists of a large boat basin which will accommodate 1,000 sport and commercial fishing vessels. Raised breakwaters were constructed in conjunction with boat basin improvements in 1974. The breakwaters, constructed to elevation 14.0 feet MLLW (10.1 feet National Geodetic Vertical Datum of 1929 (NGVD29)), attenuate wave action, but wave overtopping would occur under assumed conditions of the 1-percent-annual-chance flood event. The overtopping would regenerate minor waves inside the basin.

Development in the floodplains of Pacific County is restricted by County zoning ordinance and the Washington State Shoreline Management Act of 1971.

## 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 Pacific 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

Water-surface profiles of Columbia River flood stages were obtained from the USACE, Portland District, which give elevations for 50-, 20-, 10-, 5-, 1-, and 0.2-percent-annual-chance flood frequencies (Reference 13). These profile plots end at Fort Stevens, Oregon, about four miles upstream of the Town of Ilwaco, so they were not used to establish flood elevations at the Town of Ilwaco. Profiles of observed floods during high and low tides show that tides control flood levels in the Town of Ilwaco regardless of flow rates in the Columbia River. Also maximum flood stages have occurred in the winter months on the lower reaches of the Columbia River (below River Mile 40).

On the Naselle River, three gaging stations were used for stream data, one located at Salmon Creek, the second located at South Fork Naselle River, and the third located near Naselle, WA on the river with data available for 46 years. The gaging station located on the South Fork Naselle River recorded date for a period of 11 years. Salmon Creek has stream data at its gaging station location for a period of 12 years. The gages for these sources were located at the upstream ends of the study areas. To obtain flows at the proper locations in the study areas, for sites on a gaged stream, not at a gage, the following formula was used:

$$Q_s = Q_g (A_s \div A_g)^a$$

$Q_s$ and $Q_g$ are flows at the site and gage; $A_s$ and $A_g$ are areas above the site and gage, and 'a' is the exponent taken from a USGS publication (Reference 14). The flows at the gage were computed by the log-Pearson Type III frequency analysis and were obtained from the USGS.

At Willapa River at the Lebam, WA (formerly known as Half Moon Creek), the floodflow was obtained from a weighted average of log-Pearson Type III frequency analysis of USGS records as recommended by the U.S. Water Resources Council (Reference 15) and regional techniques (Reference 14). There were no weighting factors given for the 10- or 0.2-percent-annual-chance flows, so they were taken directly from the frequency-discharge data supplied by the USGS. Flow upstream from the Lebam, WA was reduced by a drainage-area ration. The USGS gage used for this analysis was located on the Willapa River at Willapa, WA and data were available for a period of 21 years for this gage.

For the Willapa River, in the City of Raymond, the hydrologic analyses involved only an interpolation between the relationships established in the County's study's detailed examination of the Willapa and South Fork Willapa River reaches upstream and downstream of the city.

Countywide Analyses

No new hydrologic analyses were conducted as part of this countywide FIS.

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 4, "Summary of Discharges".

**Table 4 – Summary of Discharges**

| | | **PEAK DISCHARGES (CFS)** | | | |
|---|---|---|---|---|---|
| **FLOODING SOURCE AND LOCATION** | **DRAINAGE AREA (SQ. MILES)** | **10%-ANNUAL-CHANCE** | **2%-ANNUAL-CHANCE** | **1%-ANNUAL-CHANCE** | **0.2%-ANNUAL-CHANCE** |
| COLUMBIA RIVER | | | | | |
| At Dalles, Oregon gaging station | 237,000 | * | * | 700,000** | * |
| NASELLE RIVER | | | | | |
| Near Naselle | 107.3 | 13,681 | 18,150 | 19,500 | 22,300 |
| At confluence with South Fork Naselle River | 81.2 | 11,530 | 14,280 | 15,340 | 17,540 |
| At confluence with Salmon Creek | 58.1 | 8,800 | 11,000 | 11,800 | 13,450 |

*Data Not Available
**Regulated by many large reservoirs

**Table 4 – 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 |
|---|---|---|---|---|---|
| SALMON CREEK | 18.3 | 2,670 | 3,290 | 3,620 | 4,180 |
| SOUTH FORK NASELLE RIVER | 19.6 | 3,480 | 4,000 | 4,310 | 5,620 |
| WILLAPA RIVER At Willapa | 36.2 | 4,124 | 5,040 | 5,460 | 6,170 |

The coastal stillwater elevations for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods have been determined and are summarized in Table 5, "Summary of Stillwater Elevations."

**Table 5 – Summary of Stillwater Elevations**

| FLOODING SOURCE AND LOCATION | ELEVATION (feet NAVD88) 10%-ANNUAL-CHANCE | 2%-ANNUAL-CHANCE | 1%-ANNUAL-CHANCE | 0.2%-ANNUAL-CHANCE |
|---|---|---|---|---|
| BAKER BAY | 9.5 | 9.8 | 9.9 | 10.0 |
| PACIFIC OCEAN | 9.7 | 10.3 | 10.5 | 11.0 |
| WILLAPA BAY | 9.4 | 10.1 | 10.3 | 10.6 |

## 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.

All elevations shown on the Flood Profiles and FIRM (Exhibits 1 and 2) are referenced to the North American Vertical Datum of 1988 (NAVD88).

Pre-countywide Analysis

In the Naselle area the underwater cross-sections were measured and estimated when the f low was approximately five percent of the 1-percent-annual-chance flow and the bottom was visible at most cross sections. Cross-sections were located at close intervals above and below the bridges that constrict the channel in order to compute the significant backwater effects of these structures.

Flood elevations in Pacific County are often raised by log jams at bridges.

Water-surface elevations of floods studied in detail were computed through use of the USACE HEC-2 step-backwater computer program (Reference 16).

Cross-sections for the Lebam, WA area were field surveyed and in the Naselle, WA study area were derived photogrammetrically (Reference 17).

The starting water surface elevations at the Lebam, WA were taken from the rating curve of the Willapa River at the Lebam gage. The starting water-surface elevation for the Naselle River was acquired from tidal information obtained in the lower Willapa Bay. The starting water surface elevations for the Salmon Creek and South Fork Naselle River were obtained from water-surface elevations on the Naselle River flood profiles.

The 1-percent-annual-chance flood elevations for the portions of the Willapa River, the Naselle River, Salmon Creek, and, the South Fork Naselle River which were studied by the approximate methods, were determined by extending the 1-percent-annual-chance profile using the slope of profile at the limit of detailed study.

The hydraulic analyses for the Cities of Raymond and South Bend study involved only an interpretation between the stage-frequency relationships of the Willapa and South Fork Willapa River reaches on either side of the corporate limits as determined in the Pacific County FIS. For both reaches, the 1-percent-annual-chance base flood elevation rounded to the nearest foot is the same. The stage-frequency relationship for this FIS is an interpolation between the high tide frequency analyses performed for the gages at the Willapa Harbor dock in the City of Raymond and at Toke Point, WA. The former gage has a record length of 21 years.

Countywide Analyses

No new detailed hydraulic analyses were conducted as part of this countywide FIS. However, this entire study was updated to the NAVD88.

Channel and overbank roughness factors (Manning's "n") 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 6, "Manning's "n" Values," shows the channel and overbank "n" values for the streams studied by detailed methods.

**Table 6 – Manning's "n" Values**

| Stream | Channel | Overbank |
|---|---|---|
| Naselle River | 0.035 – 0.038 | 0.040 – 0.072 |
| Salmon Creek | 0.035 – 0.038 | 0.040 – 0.072 |
| South Fork Naselle River | 0.035 – 0.038 | 0.040 – 0.072 |
| Willapa River | 0.035 – 0.038 | 0.040 – 0.072 |

As part of this countywide FIS, Naselle River, starting approximately 29,000 feet above the confluence with Dell Creek and extending to the upstream county boundary, and Salmon Creek starting approximately 1,500 feet upstream of State Highway 4 and extending to approximately 800 feet downstream of Tienhaara Road were studied with base level methods (Zone A). For these flooding sources, the 1-percent-annual-chance flood elevations were determined using the USACE HEC-RAS computer program (Reference 18). Peak flood discharges from the pre-countywide study were input into a HEC-RAS model that included cross sections extracted from LiDAR data collected by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 2009 (Reference 19) and by the USACE Portland District Columbia River in 2010 (Reference 20). Because this cross section information was not supplemented with field survey data and the models did not include bridge and culvert information, the resulting floodplain boundaries are considered approximate. Approximately 4.3 stream miles in Pacific County were analyzed using this approach.

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.

## 3.3 Wave Height Analysis

Pre-countywide Analysis

Flood damage in tidal and coastal areas is a result of high stillwater levels and wave action. The stillwater level is a result of astronomical tide, caused by gravitational effects of the sun and moon, and storm surge, rise in water levels due to wind stress and low atmospheric pressure. Wave action produces a rise in water level due to shoreward mass transport of the water, known as wave setup. In addition, wave runup after breaking produces flooding, and the energy of the wave would produce flooding, and the energy of the wave would produce damage above the stillwater level of the flood.

The astronomical tide height-frequency distribution was computed using hourly predicted tides. Predicted tides were calculated from tide tables (Reference 21).

Surface weather maps supplied by the National Weather Service (NWS), at 3-hour intervals for years 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.

Wave statistics for wind-generated waves were computed during the Sverdrup-Munk-Bretschneider procedure (Reference 22). The frequency distributions for 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 models. 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 probably of occurrence as the wind-generated waves (Reference 23). However, they are less likely to occur during high storm surges than are the wind-generated waves.

For the Tokeland, WA study area, the stillwater height-frequency curve was obtained by extending the five years of tide data at Toke Point, WA through correlation of monthly high waters with the long-term gage at Tongue Point (also known as Salt Creek State Park) near the City of Astoria, Oregon. Tide data at the Astoria gage were available for a period of 46 years. For the exposed southwest shoreline of Toke Point, wave setup was added to the tide heights. On the protected northeast shoreline only the stillwater level was used to draw the stage-frequency curve.

One the east shoreline of North Beach Peninsula, tide gage correction factors were used to adjust the combined astronomical tide and storm surge from the open coast.

For the Town of Ilwaco study area, the stillwater elevation-frequency relationship was established by analysis of an annual peak series for 51 years of recorded gage data. The gage is located at Tongue Point near the City of Astoria, Oregon. Factors published by the national Ocean Survey (Reference 21) were used to convert levels to NGVD29. The conversion factor, for the Town of Ilwaco, is +3.90.

At the Town of Chinook, the stillwater elevation was taken from the USACE flood profiles (Reference 24). This was added to the wave runup to calculate the high waters.

Shallow-water heights of local wind-generated waves in Baker Bay and resultant wave runup were determined in order to estimate onshore flood levels above the stillwater levels. Wave heights for Baker Bay were based on a computation of the effective fetch for irregular shorelines and the expected wind speeds associated with storm frequency. High winds from the south-southeast are frequent and generate waves which have the most effect on the waterfront. Based on past occurrences it is reasonable to expect high winds from that direction during severe storms associated with storm surge during the winter months when high tides and high river flows are coincident. Wave runups at the open shorelines and at the breakwaters were calculated. Breakwater overtopping rates and resultant wave transmission to the boat basin were also evaluated. Wave runup was added to stillwater levels for 10-, 2-, 1-, and 0.2-percent-annual-chance return periods.

Methods presented in the Shore Protection Manual were used for this analysis (Reference 22). Published accounts of storms and local personal interviews substantiate the results.

For the ocean coastline of North Beach Peninsula, 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 NWS program, SPLASH Part 2 (Reference 25), 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 from the Monthly Weather Review (Reference 26) 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 COAST computer model 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 direct ions for the various recurrence intervals were used to synthesize waves which were tracked from the deepwater locations to shore using wave refraction and shoaling program called WAVES 2. This program is a modified version of the WAVES program (Reference 27). The required data for this program were 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 22) were used to compute wave setup and wave runup. The appropriate value was added to the stillwater level to produce the water levels for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods.

The determination of the wave runup on the Pacific Ocean coast from the Town of North Cove north to the county line was based on the previous analysis for North Beach, WA and for the reaches of the Pacific Ocean coast studied for the Ocean Shores FIS (Reference 28).

The results of the USACE feasibility study for protecting Cape Shoalwater from erosion were presented in 1971 in Feasibility Report, Navigation and Beach Erosion, Willapa River and Harbor and Naselle River, Washington (Reference 29). In this report, the estimated location of the shore in 1980, 1985, and 1994 was presented. The 1944 shore location was the estimated northern limit of erosion. The report cautions: "However, a change in the complex natural forces causing the erosion could alter this estimate and erosion could continue."

The area between the shoreline shown on the map and the USACE 1994 estimated shoreline has been designated in this study as an erosion hazard area, as identified by the USACE and the community. The location of the shoreline as shown on the map is based on aerial photographs flown September 17, 1982. These photographs were used in preparing the topographic maps used in this FIS (Reference 30).

For coastal flooding areas studied by approximate methods, the elevations determined at the limit of detailed study were used to approximate 1-percent-annual-chance flood boundaries.

Countywide Analyses

Peaks-over-threshold (POT) analyses were performed on flood elevations (i.e., total water levels, TWLs) resulting from flood-producing events occurring over the period 1934 – 2010. The POT analyses were conducted at 79 cross-shore transects. The flood events were hindcast using state-of-the-art numerical modeling tools. The POT method consists of analyzing TWLs exceeding some high threshold, over the hindcast period. It is well known that exceedances over sufficiently high thresholds follow a generalized Pareto distribution, from which return periods can be inferred.

Flooding in Pacific County is governed by a combination of different physical processes. The severity of flooding experienced is dependent on the characteristics of waves arriving at the shoreline from distant storms, the magnitude of local storm winds, the tidal elevations coincident with storm conditions, et cetera. Flooding may also be driven by water level anomalies resulting from large freshwater flows or climate extremes due to global climate oscillations such as El Niño.

*Open Coast Model*

Two Steady-State Spectral Wave (STWAVE)-based wave models (Reference 31) were setup for the open coast. A total of 150 storm events were selected. These events were selected based on the wave heights and wave directions at the OWI GROW-FINE NEPAC output point. The selected events are the most likely to have produced the highest wave runup (i.e., TWL) events over the hindcast period. The STWAVE model was run for each of these events. The primary inputs for each event were water level, wind speed, wind direction and the wave spectra at the open ocean boundary. Model outputs (significant wave height, peak wave period, mean wave direction, etc.) were saved at locations along the 35 meter bathymetric contour. Detailed wave spectra were also saved for each event.

*Baker Bay Model*
In Baker Bay, a 50 meter resolution Cartesian grid was setup. The grid covers the Bay and the mouth of the Columbia River. A total of 359 potential flooding events were simulated. Of these, 208 events were selected based on the magnitude of the peak wind speeds, and another 151 events were selected based on water levels. The Simulating Waves Nearshore (SWAN) wave model (Reference 32) was run for each of these events. Each event simulation covered 6 hours of record before and after the peak of the event. The primary inputs at each time step were water level, wind speed and wind direction. Model outputs were saved at points along each transect.

*North Cove Model*
For North Cove, a variable resolution unstructured mesh was setup. The unstructured mesh allowed for accurate representation of the complex bathymetry in Willapa Bay while keeping computation time low. The SWAN wave model (Reference 32) for North Cove was run for the 150 open coast events. Each event simulation included 6 hours of record before and after the peak of the event. The primary inputs at each time step were water level, wind speed, wind direction, and waves coming into the model domain (i.e., the wave spectra at the ocean boundary). Model outputs were saved at points along each transect.

After field reconnaissance, the locations of transects used in nearshore hydraulic computations (i.e., wave setup, runup, overtopping, and erosion, where applicable) were finalized. A total of 79 transects were selected. The locations of transects were chosen so as to be reasonably representative of the bathymetric, topographic and land-use characteristics of segments of the coastline. Transect spacing is denser in areas with considerable alongshore variation in bathymetry, topography, or cultural characteristics.

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”.

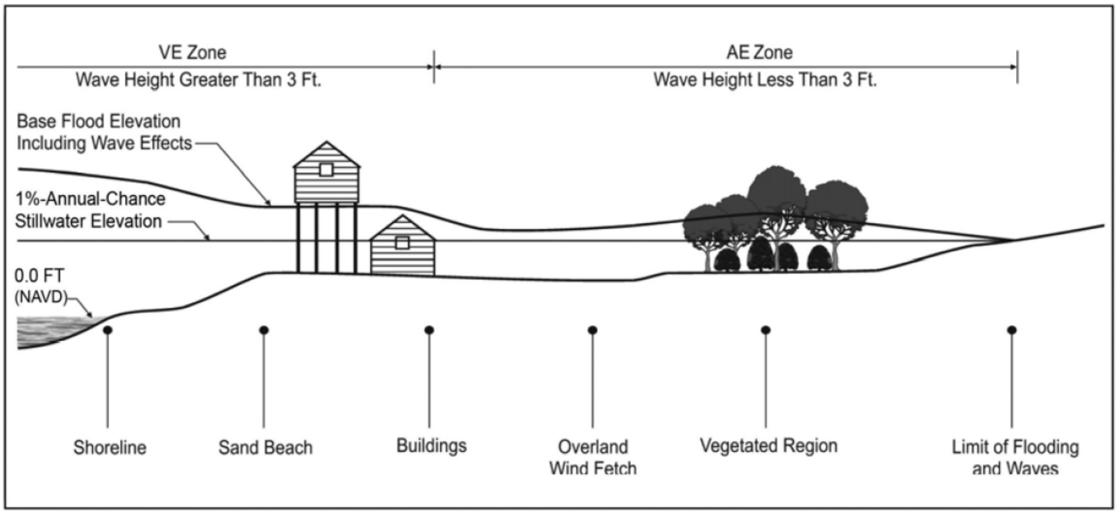


**Figure 1 – Transect Schematic**

The wave conditions saved at each transect, in conjunction with the water level coincident with the wave conditions, were used to compute wave runup on the transects. TWLs were computed at hourly intervals over the duration of each event. The definition of event duration was limited to 6 hours before and after the peak of the event. The maximum TWLs for each storm event were saved at each transect.

Transects were placed perpendicular to the mean shoreline or parallel to the mean direction of wave propagation. Figure 2, “Transect Location Map,” shows the location of the 79 transects along in Pacific County.

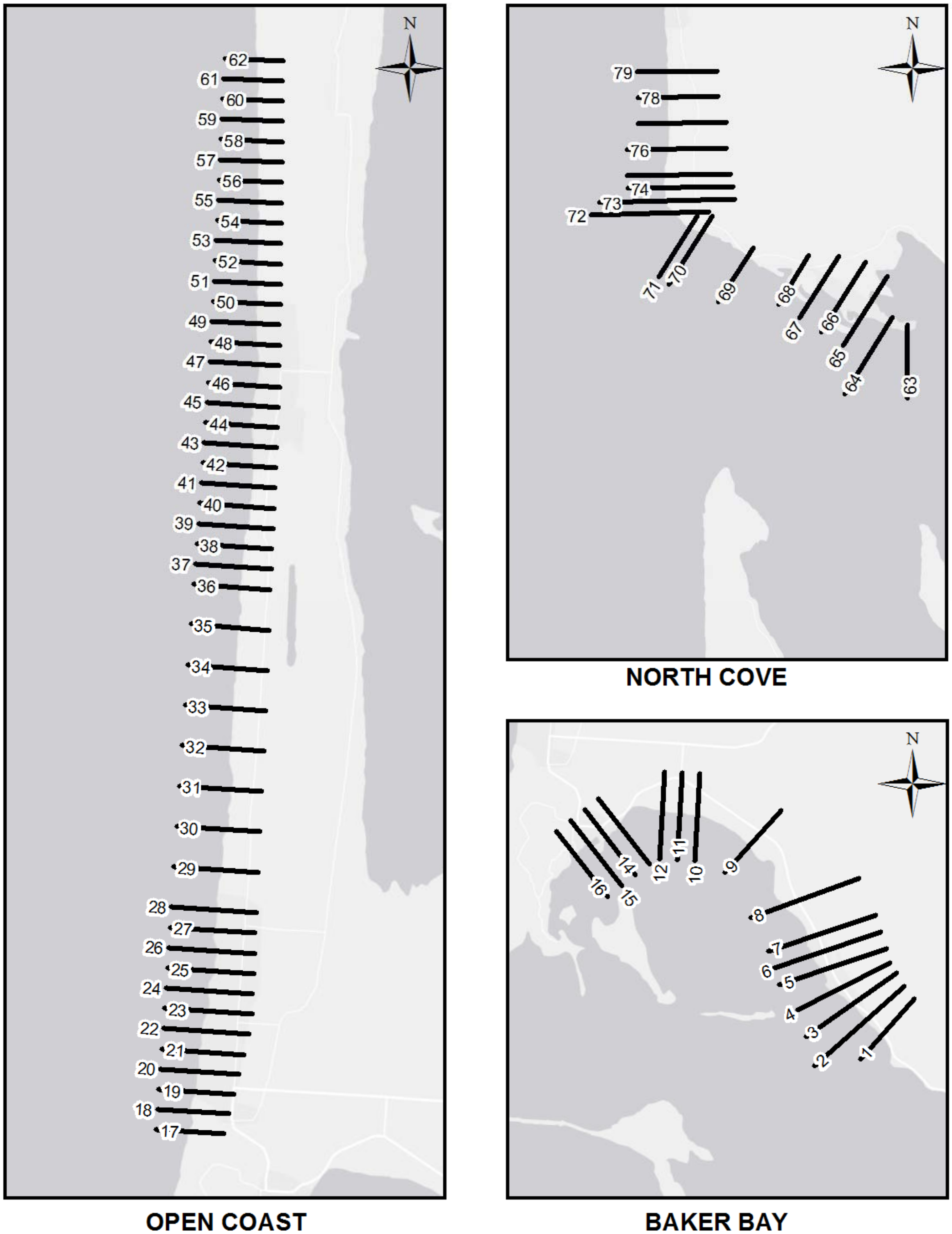


**Figure 2 – Transect Location Map**

The 1- and 0.2-percent-annual-chance total water levels for the Pacific Ocean, Baker Bay and North Cove are summarized in Table 7, "Transect Descriptions."

**Table 7 – Transect Descriptions**

| | | ELEVATION (feet NAVD88) | |
|---|---|---|---|
| **Transect** | **Description** | **1-Percent-Annual-Chance Total Water Level** | **0.2-Percent-Annual-Chance Total Water Level** |
| BAKER BAY | | | |
| 1 | Starts at the Baker Bay shoreline near the southern terminus of Chinook Park Road. | 10.1 | 10.2 |
| 2 | Starts at the Baker Bay shoreline approximately 470 feet west of the intersection of Chinook Park Road and Highway 101. | 10.5 | 11.0 |
| 3 | Starts at the Baker Bay shoreline approximately 280 feet southwest of the intersection of Houtchen Street and Highway 101. | 10.8 | 11.3 |
| 4 | Starts at the Baker Bay shoreline approximately 460 feet southwest of the intersection of Portland Street East and Water Street. | 9.9 | 10.0 |
| 5 | Starts at the Baker Bay shoreline approximately 1,040 feet southwest of the intersection of Cherry Street West and Highway 101. | 9.9 | 10.0 |
| 6 | Starts at the Baker Bay shoreline approximately 1,200 feet southwest of the intersection of Washington Street West and Highway 101. | 9.9 | 10.0 |
| 7 | Starts at the Baker Bay shoreline approximately 1,000 feet southwest of the intersection of Bayview Street and Highway 101. | 10.2 | 10.3 |
| 8 | Starts at the Baker Bay shoreline approximately 4,940 feet south of the intersection of Stringtown Road and Highway 101. | 10.0 | 10.0 |
| 9 | Starts at the Baker Bay shoreline approximately 2,140 feet southwest of the intersection of Black Tail Lane and Highway 101. | 10.6 | 11.6 |
| 10 | Starts at the Baker Bay shoreline approximately 2,220 feet southwest of the intersection of Dehnert Lane and Highway 101. | 10.8 | 11.2 |
| 11 | Starts at the Baker Bay shoreline approximately 1,760 feet south of the intersection of Rochelle Way and Captain Robert Gray Drive. | 11.1 | 11.8 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| BAKER BAY (Continued) | | | |
| 12 | Starts at the Baker Bay shoreline approximately 2,310 feet southwest of the intersection of Stringtown Road and Captain Robert Gray Drive. | 11.0 | 11.8 |
| 13 | Starts at the Baker Bay shoreline approximately 700 feet southeast of the intersection of Iris Northeast and Cooks Hill Road. | 11.1 | 12.1 |
| 14 | Starts at the Baker Bay shoreline approximately 1,560 feet southeast of the intersection of Elizabeth Avenue Southeast and Lake Street Southeast. | 10.9 | 12.1 |
| 15 | Starts at the Baker Bay shoreline approximately 400 feet east of the intersection of Howerton Avenue and Robert Gray Drive. | 10.5 | 11.0 |
| 16 | Starts at the Baker Bay shoreline approximately 960 feet east of the intersection of Klahanee Drive Southwest and Highway 100. | 11.2 | 12.3 |
| PACIFIC OCEAN | | | |
| 17 | Starts at the Pacific Ocean shoreline approximately 2,820 feet west of the intersection of Willows Road and G Street. | 18.2 | 18.6 |
| 18 | Starts at the Pacific Ocean shoreline approximately 3,040 feet west of the intersection of 32nd Street and K Place. | 17.9 | 18.4 |
| 19 | Starts at the Pacific Ocean shoreline approximately 2,660 feet west of the intersection of 38th Place and J Place. | 18.6 | 18.9 |
| 20 | Starts at the Pacific Ocean shoreline approximately 2,800 feet west of the intersection of 44th Place and K Place. | 18.7 | 19.0 |
| 21 | Starts at the Pacific Ocean shoreline approximately 2,680 feet west of the intersection of 51st Street and K Place. | 18.8 | 19.1 |
| 22 | Starts at the Pacific Ocean shoreline approximately 2,660 feet west of the intersection of 13th Street South and Boulevard Avenue. | 18.9 | 19.3 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| PACIFIC OCEAN (Continued) | | | |
| 23 | Starts at the Pacific Ocean shoreline approximately 2,690 feet west of the intersection of Ocean Beach Boulevard and 7th Street Southwest | 19.0 | 19.3 |
| 24 | Starts at the Pacific Ocean shoreline approximately 2,660 feet west of the intersection of 3rd Street Northeast and Boulevard Street North. | 19.1 | 19.4 |
| 25 | Starts at the Pacific Ocean shoreline approximately 2,650 feet west of the intersection of 9th Street North and Boulevard Street North. | 19.1 | 19.4 |
| 26 | Starts at the Pacific Ocean shoreline approximately 2,070 feet west of the intersection of Shoreview Drive North and 14th Street Northwest. | 18.6 | 19.0 |
| 27 | Starts at the Pacific Ocean shoreline approximately 2,680 feet west of the intersection of 19th Street North and Boulevard Street North. | 19.1 | 19.3 |
| 28 | Starts at the Pacific Ocean shoreline approximately 2,690 feet west of the intersection of 26th Street North and Pacific Way. | 19.5 | 19.8 |
| 29 | Starts at the Pacific Ocean shoreline approximately 2,750 feet west of the intersection of 107th Lane and Pacific Way. | 18.9 | 19.2 |
| 30 | Starts at the Pacific Ocean shoreline approximately 2,420 feet west of the intersection of 120th Place and Pacific Way. | 18.8 | 19.2 |
| 31 | Starts at the Pacific Ocean shoreline approximately 2,500 feet northwest of the intersection of Cranberry Road and N Alley. | 19.3 | 19.6 |
| 32 | Starts at the Pacific Ocean shoreline approximately 2,550 feet west of the intersection of 144th Lane and Pacific Way. | 19.3 | 19.7 |
| 33 | Starts at the Pacific Ocean shoreline approximately 1,170 feet west of the intersection of J Place and 156th Place. | 19.0 | 19.6 |
| 34 | Starts at the Pacific Ocean shoreline approximately 1,802 feet west of the intersection of 171st Place and 170th Place. | 18.6 | 19.0 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| PACIFIC OCEAN (Continued) | | | |
| 35 | Starts at the Pacific Ocean shoreline approximately 1,950 feet west of the intersection of 184th Place and Pacific Way. | 18.5 | 19.1 |
| 36 | Starts at the Pacific Ocean shoreline approximately 770 feet west of the intersection of K Place and 195th Street. | 18.2 | 18.7 |
| 37 | Starts at the Pacific Ocean shoreline approximately 1,950 feet west of the intersection of 291st Lane and Pacific Way. | 18.6 | 19.1 |
| 38 | Starts at the Pacific Ocean shoreline approximately 1,780 feet west of the intersection of 207th Street and Pacific Way. | 18.4 | 18.9 |
| 39 | Starts at the Pacific Ocean shoreline approximately 1,360 feet west of the intersection of 213th Place and Pacific Way. | 18.5 | 19.1 |
| 40 | Starts at the Pacific Ocean shoreline approximately 1,450 feet west of the intersection of 218th Lane and Pacific Way. | 18.6 | 19.2 |
| 41 | Starts at the Pacific Ocean shoreline approximately 1,340 feet west of the intersection of 225th street and Pacific Way. | 18.4 | 19.0 |
| 42 | Starts at the Pacific Ocean shoreline approximately 1,550 feet west of the intersection of 232nd Lane and Pacific Way. | 18.4 | 19.0 |
| 43 | Starts at the Pacific Ocean shoreline approximately 930 feet southwest of the intersection of 240th Street and J Place. | 18.4 | 19.1 |
| 44 | Starts at the Pacific Ocean shoreline approximately 1,500 feet southwest of the intersection of 247th Place and J Place. | 18.3 | 18.9 |
| 45 | Starts at the Pacific Ocean shoreline approximately 1,440 feet northwest of the intersection of J Place and 247th Place. | 18.6 | 19.1 |
| 46 | Starts at the Pacific Ocean shoreline approximately 2,000 feet west of the intersection of Park Avenue and 256th Place. | 18.6 | 19.1 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| PACIFIC OCEAN (Continued) | | | |
| 47 | Starts at the Pacific Ocean shoreline approximately 1,900 feet west of the intersection of Park Avenue and 262nd Place. | 18.5 | 19.0 |
| 48 | Starts at the Pacific Ocean shoreline approximately 1,690 feet southwest of the intersection of I Lane and 273rd Lane. | 18.3 | 18.8 |
| 49 | Starts at the Pacific Ocean shoreline approximately 1,520 feet southwest of the intersection of I Lane and 280th Street. | 18.2 | 18.7 |
| 50 | Starts at the Pacific Ocean shoreline approximately 980 feet west of the northern terminus of I Lane. | 18.0 | 18.5 |
| 51 | Starts at the Pacific Ocean shoreline approximately 1,040 feet southwest of the intersection of H Street and Joe Johns Road. | 18.5 | 19.0 |
| 52 | Starts at the Pacific Ocean shoreline approximately 770 feet west of the intersection of H Street and 295th Street. | 18.3 | 18.8 |
| 53 | Starts at the Pacific Ocean shoreline approximately 940 feet west of the intersection of H Street and 300th Street. | 18.1 | 18.6 |
| 54 | Starts at the Pacific Ocean shoreline approximately 630 feet west of the intersection of G Street and 306th Place. | 18.2 | 18.7 |
| 55 | Starts at the Pacific Ocean shoreline approximately 700 feet west of the intersection of G Street and 313th Place. | 18.2 | 18.6 |
| 56 | Starts at the Pacific Ocean shoreline approximately 702 feet west of the intersection of G Street and 318th Place. | 18.1 | 18.6 |
| 57 | Starts at the Pacific Ocean shoreline approximately 900 feet southwest of the southern intersection of G Place and G Street. | 18.0 | 18.4 |
| 58 | Starts at the Pacific Ocean shoreline approximately 720 feet west of the northern intersection of G Place and G Street. | 17.8 | 18.2 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| PACIFIC OCEAN (Continued) | | | |
| 59 | Starts at the Pacific Ocean shoreline approximately 770 feet west of the intersection of 338th Place and G Street. | 17.9 | 18.3 |
| 60 | Starts at the Pacific Ocean shoreline approximately 950 feet west of the southern intersection of G Street and F Place. | 18.0 | 18.4 |
| 61 | Starts at the Pacific Ocean shoreline approximately 1,850 feet southwest of the intersection of 357th Street and G Street. | 17.9 | 18.3 |
| 62 | Starts at the Pacific Ocean shoreline approximately 800 feet west of the intersection of 357th Street and G Street. | 17.8 | 18.2 |
| NORTH COVE | | | |
| 63 | Starts at the North Cove shoreline just east of the mouth of Wilson Creek. | 10.6 | 11.0 |
| 64 | Starts at the North Cove shoreline approximately 150 feet northwest of 3rd Street. | 11.3 | 11.8 |
| 65 | Starts at the North Cove shoreline approximately 300 feet southeast of Alder Street. | 11.6 | 12.1 |
| 66 | Starts at the North Cove shoreline approximately 1,300 feet northwest of Sunset Lane. | 11.4 | 11.8 |
| 67 | Starts at the North Cove Shoreline approximately 430 feet west of Dexter Drive. | 13.0 | 13.0 |
| 68 | Starts at the North Cove shoreline approximately 800 feet east of Eagle Hill Road. | 18.2 | 18.5 |
| 69 | Starts at the North Cove shoreline approximately 4,150 feet southeast of Smith Anderson Road. | 17.9 | 18.2 |
| 70 | Starts at the North Cove shoreline near the intersection of Sea Mobile Road and Old State Route 105. | 19.5 | 20.0 |
| 71 | Starts at the North Cove shoreline near Willow Street. | 19.1 | 19.7 |
| 72 | Starts at the Pacific Ocean shoreline near Whipple Avenue. | 20.4 | 21.1 |

**Table 7 – Transect Descriptions (Continued)**

| Transect | Description | ELEVATION (feet NAVD88) 1-Percent-Annual-Chance Total Water Level | 0.2-Percent-Annual-Chance Total Water Level |
|---|---|---|---|
| PACIFIC OCEAN (Continued) | | | |
| 73 | Starts at the Pacific Ocean shoreline near Warrenton Cannery Road. | 20.2 | 21.1 |
| 74 | Starts at the Pacific Ocean shoreline approximately 1,300 feet north of Warrenton Cannery Road. | 20.0 | 21.2 |
| 75 | Starts at the Pacific Ocean shoreline approximately 3,000 feet north of Warrenton Cannery Road. | 19.0 | 19.6 |
| 76 | Starts at the Pacific Ocean shoreline approximately 1,800 feet south of Midway Beach Road. | 19.0 | 19.4 |
| 77 | Starts at the Pacific Ocean shoreline approximately 1,400 feet north of Midway Beach Road. | 17.9 | 18.4 |
| 78 | Starts at the Pacific Ocean shoreline approximately 4,400 feet south of Cranberry Beach Road. | 17.9 | 18.4 |
| 79 | Approximately 1,120 feet south of Cranberry Beach Road. | 18.1 | 18.6 |

The 10-, 2-, 1-, and 0.2-percent-annual-chance stillwater elevations and base flood elevations for the transects along Baker Bay, the Pacific Ocean, and Willapa Bay are summarized in Table 8, "Transect Data Table."

**Table 8 – Transect Data Table**

| Flooding Source | STILLWATER FLOOD ELEVATION (feet NAVD88) 10-Percent-Annual-Chance | 2-Percent-Annual-Chance | 1-Percent-Annual-Chance | 0.2-Percent-Annual-Chance | Base Flood Elevation (feet NAVD88) |
|---|---|---|---|---|---|
| Baker Bay | | | | | |
| Transect 1 | 9.5 | 9.8 | 9.9 | 10.0 | 10.1 |
| Transect 2 | 9.5 | 9.8 | 9.9 | 10.0 | 10.5 |
| Transect 3 | 9.5 | 9.8 | 9.9 | 10.0 | 10.8 |
| Transect 4 | 9.5 | 9.8 | 9.9 | 10.0 | 9.9 |
| Transect 5 | 9.5 | 9.8 | 9.9 | 10.0 | 9.9 |
| Transect 6 | 9.5 | 9.8 | 9.9 | 10.0 | 9.9 |
| Transect 7 | 9.5 | 9.8 | 9.9 | 10.0 | 10.2 |
| Transect 8 | 9.5 | 9.8 | 9.9 | 10.0 | 10.0 |
| Transect 9 | 9.5 | 9.8 | 9.9 | 10.0 | 10.6 |

### Table 9 – Transect Data Table (Continued)

| Flooding Source | STILLWATER FLOOD ELEVATION (feet NAVD88) 10-Percent-Annual-Chance | 2-Percent-Annual-Chance | 1-Percent-Annual-Chance | 0.2-Percent-Annual-Chance | Base Flood Elevation (feet NAVD88) |
|---|---|---|---|---|---|
| Baker Bay (Continued) | | | | | |
| Transect 10 | 9.5 | 9.8 | 9.9 | 10.0 | 10.8 |
| Transect 11 | 9.5 | 9.8 | 9.9 | 10.0 | 11.1 |
| Transect 12 | 9.5 | 9.8 | 9.9 | 10.0 | 11.0 |
| Transect 13 | 9.5 | 9.8 | 9.9 | 10.0 | 11.1 |
| Transect 14 | 9.5 | 9.8 | 9.9 | 10.0 | 10.9 |
| Transect 15 | 9.5 | 9.8 | 9.9 | 10.0 | 10.5 |
| Transect 16 | 9.5 | 9.8 | 9.9 | 10.0 | 11.2 |
| Pacific Ocean | | | | | |
| Transect 17 | 9.7 | 10.3 | 10.5 | 11.0 | 18.2 |
| Transect 18 | 9.7 | 10.3 | 10.5 | 11.0 | 17.9 |
| Transect 19 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 20 | 9.7 | 10.3 | 10.5 | 11.0 | 18.7 |
| Transect 21 | 9.7 | 10.3 | 10.5 | 11.0 | 18.8 |
| Transect 22 | 9.7 | 10.3 | 10.5 | 11.0 | 18.9 |
| Transect 23 | 9.7 | 10.3 | 10.5 | 11.0 | 19.0 |
| Transect 24 | 9.7 | 10.3 | 10.5 | 11.0 | 19.1 |
| Transect 25 | 9.7 | 10.3 | 10.5 | 11.0 | 19.1 |
| Transect 26 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 27 | 9.7 | 10.3 | 10.5 | 11.0 | 19.1 |
| Transect 28 | 9.7 | 10.3 | 10.5 | 11.0 | 19.5 |
| Transect 29 | 9.7 | 10.3 | 10.5 | 11.0 | 18.9 |
| Transect 30 | 9.7 | 10.3 | 10.5 | 11.0 | 18.8 |
| Transect 31 | 9.7 | 10.3 | 10.5 | 11.0 | 19.3 |
| Transect 32 | 9.7 | 10.3 | 10.5 | 11.0 | 19.3 |
| Transect 33 | 9.7 | 10.3 | 10.5 | 11.0 | 19.0 |
| Transect 34 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 35 | 9.7 | 10.3 | 10.5 | 11.0 | 18.5 |
| Transect 36 | 9.7 | 10.3 | 10.5 | 11.0 | 18.2 |
| Transect 37 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 38 | 9.7 | 10.3 | 10.5 | 11.0 | 18.4 |
| Transect 39 | 9.7 | 10.3 | 10.5 | 11.0 | 18.5 |
| Transect 40 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 41 | 9.7 | 10.3 | 10.5 | 11.0 | 18.4 |
| Transect 42 | 9.7 | 10.3 | 10.5 | 11.0 | 18.4 |
| Transect 43 | 9.7 | 10.3 | 10.5 | 11.0 | 18.4 |
| Transect 44 | 9.7 | 10.3 | 10.5 | 11.0 | 18.3 |
| Transect 45 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 46 | 9.7 | 10.3 | 10.5 | 11.0 | 18.6 |
| Transect 47 | 9.7 | 10.3 | 10.5 | 11.0 | 18.5 |
| Transect 48 | 9.7 | 10.3 | 10.5 | 11.0 | 18.3 |
| Transect 49 | 9.7 | 10.3 | 10.5 | 11.0 | 18.2 |

**Table 9 – Transect Data Table (Continued)**

**STILLWATER FLOOD ELEVATION (feet NAVD88)**

| **Flooding Source** | **10-Percent-Annual-Chance** | **2-Percent-Annual-Chance** | **1-Percent-Annual-Chance** | **0.2-Percent-Annual-Chance** | **Base Flood Elevation (feet NAVD88)** |
|---|---|---|---|---|---|
| Pacific Ocean (Continued) | | | | | |
| Transect 50 | 9.7 | 10.3 | 10.5 | 11.0 | 18.0 |
| Transect 51 | 9.7 | 10.3 | 10.5 | 11.0 | 18.5 |
| Transect 52 | 9.7 | 10.3 | 10.5 | 11.0 | 18.3 |
| Transect 53 | 9.7 | 10.3 | 10.5 | 11.0 | 18.1 |
| Transect 54 | 9.7 | 10.3 | 10.5 | 11.0 | 18.2 |
| Transect 55 | 9.7 | 10.3 | 10.5 | 11.0 | 18.2 |
| Transect 56 | 9.7 | 10.3 | 10.5 | 11.0 | 18.1 |
| Transect 57 | 9.7 | 10.3 | 10.5 | 11.0 | 18.0 |
| Transect 58 | 9.7 | 10.3 | 10.5 | 11.0 | 17.8 |
| Transect 59 | 9.7 | 10.3 | 10.5 | 11.0 | 17.9 |
| Transect 60 | 9.7 | 10.3 | 10.5 | 11.0 | 18.0 |
| Transect 61 | 9.7 | 10.3 | 10.5 | 11.0 | 17.9 |
| Transect 62 | 9.7 | 10.3 | 10.5 | 11.0 | 17.8 |
| Willapa Bay | | | | | |
| Transect 63 | 9.4 | 10.1 | 10.3 | 10.6 | 10.6 |
| Transect 64 | 9.4 | 10.1 | 10.3 | 10.6 | 11.3 |
| Transect 65 | 9.4 | 10.1 | 10.3 | 10.6 | 11.6 |
| Transect 66 | 9.4 | 10.1 | 10.3 | 10.6 | 11.4 |
| Transect 67 | 9.4 | 10.1 | 10.3 | 10.6 | 13.0 |
| Transect 68 | 9.4 | 10.1 | 10.3 | 10.6 | 18.2 |
| Transect 69 | 9.4 | 10.1 | 10.3 | 10.6 | 17.9 |
| Transect 70 | 9.4 | 10.1 | 10.3 | 10.6 | 19.5 |
| Transect 71 | 9.4 | 10.1 | 10.3 | 10.6 | 19.1 |
| Pacific Ocean | | | | | |
| Transect 72 | 9.7 | 10.3 | 10.5 | 11.0 | 20.2 |
| Transect 73 | 9.7 | 10.3 | 10.5 | 11.0 | 20.2 |
| Transect 74 | 9.7 | 10.3 | 10.5 | 11.0 | 20.0 |
| Transect 75 | 9.7 | 10.3 | 10.5 | 11.0 | 19.0 |
| Transect 76 | 9.7 | 10.3 | 10.5 | 11.0 | 19.0 |
| Transect 77 | 9.7 | 10.3 | 10.5 | 11.0 | 17.9 |
| Transect 78 | 9.7 | 10.3 | 10.5 | 11.0 | 17.9 |
| Transect 79 | 9.7 | 10.3 | 10.5 | 11.0 | 18.1 |

### 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 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. The datum conversion factor from NGVD29 to NAVD88 in Pacific County for Naselle River is **+3.120** feet. The data points used to determine the conversion are listed in Table 10, “Vertical Datum Conversion for Naselle River”.

**Table 10 – Vertical Datum Conversion for Naselle River**

| Location | Longitude (Decimal Degrees) | Latitude (Decimal Degrees) | Conversion from NGVD29 to NAVD88 (foot) |
|---|---|---|---|
| Upstream | 46.373 | 123.761 | 3.100 |
| Midpoint | 46.375 | 123.797 | 3.110 |
| Downstream | 46.368 | 123.821 | 3.159 |
| | | **AVERAGE** | **Feet +3.120** |

NAVD88 = NGVD29 + 3.120 feet

The datum conversion factor from NGVD29 to NAVD88 for Salmon Creek is **+3.100** feet. The data points used to determine the conversion are listed in Table 11, “Vertical Datum Conversion for Salmon Creek”.

**Table 11 – Vertical Datum Conversion for Salmon Creek**

| Location | Longitude (Decimal Degrees) | Latitude (Decimal Degrees) | Conversion from NGVD29 to NAVD88 (foot) |
|---|---|---|---|
| Upstream | 46.358 | 123.760 | 3.100 |
| Midpoint | 46.361 | 123.770 | 3.104 |
| Downstream | 46.367 | 123.783 | 3.107 |
| | | **AVERAGE** | **Feet +3.100** |

NAVD88 = NGVD29 + 3.100 feet

The datum conversion factor from NGVD29 to NAVD88 for South Fork Naselle River is **+3.130** feet. The data points used to determine the conversion are listed in Table 12, “Vertical Datum Conversion for South Fork Naselle River”.

**Table 12 – Vertical Datum Conversion for South Fork Naselle River**

| Location | Longitude (Decimal Degrees) | Latitude (Decimal Degrees) | Conversion from NGVD29 to NAVD88 (foot) |
|---|---|---|---|
| Upstream | 46.337 | 123.804 | 3.150 |
| Midpoint | 46.367 | 123.783 | 3.107 |
| Downstream | 46.365 | 123.809 | 3.133 |
| | | **AVERAGE** | **Feet +3.130** |

NAVD88 = NGVD29 + 3.130 feet

The datum conversion factor from NGVD29 to NAVD88 for Willapa River is **+3.380** feet. The data points used to determine the conversion are listed in Table 13, "Vertical Datum Conversion for Willapa River".

**Table 13 – Vertical Datum Conversion for Willapa River**

| Location | Longitude (Decimal Degrees) | Latitude (Decimal Degrees) | Conversion from NGVD29 to NAVD88 (foot) |
|---|---|---|---|
| Upstream | 123.804 | 46.337 | 3.383 |
| Midpoint | 123.783 | 46.367 | 3.379 |
| Downstream | 123.821 | 46.368 | 3.386 |
| | | **AVERAGE** | **Feet +3.380** |

NAVD88 = NGVD29 + 3.380 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 (+3.380 foot) 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.

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. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data. Due to beach erosion and accretion, the flood boundaries may change in the future.

This countywide FIS combined the FIRMs for Pacific 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. 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.

As part of this countywide FIS, 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.

Pre-Countywide Analysis

For riverine study area along the Willapa River, the boundaries were interpolated using topographic maps at a scale of 1:62,500 with a contour interval of 80 feet for Lebam, WA (Reference 33).

Flood boundaries for areas studied by approximate methods were delineated using topographic maps at a scale of 1:24,000 with a contour interval of 25 feet (Reference 34).

Countywide Analysis

For coastal areas studied in detail, engineering data and statistical analyses established BFEs throughout the study area. The typical flood hazard zone designations in coastal areas are: zones VE, AE, AH, AO, and X (along with the appropriate flood elevation or flood depth). The criteria for zone VE designation includes: 1) Wherever the profile (or the eroded profile, where erosion is appropriate) is 3 feet or more below the Total Water Level (TWL). 2) The area landward of the crest of an overtopped barrier, where the TWL exceeds the barrier crest elevation by 3 feet or more. 3) The high-velocity flow zone landward of an overtopped barrier. 4) Wherever wave heights are 3 feet or more in inundated upland areas. 5) The landward toe of the primary frontal dune (PFD).

Output from wave runup computations were mapped along each coastal transect. The 1- and 0.2-percent-annual-chance floodplain boundaries for Pacific County were delineated using standard GIS utilities. Floodplain boundaries were manually drawn on 2-foot topographic contours derived from LIDAR data collected by DOGAMI in 2009 (Reference 19) and the USACE Portland District in 2010 (Reference 20). Aerial imagery and land use data assisted in the development of these features. Gutter lines were used to separate flood zones and model results between transects. A limit of moderate wave action (LiMWA) was also delineated for all areas subject to significant wave attach in accordance with FEMA Procedure Memorandum No. 50 – *Policy and Procedures for Identifying and mapping Areas Subject to Wave Heights Greater than 1.5 feet as an Informational Layer* (Reference 35).

For riverine areas, 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. The floodplain mapping updates consisted of a mixture of redelineation and rectification (refinement) of existing flood boundaries based on the best topographic data and aerial photography available at the time of the study.

Redelineation was limited to areas were new, quality topographic data was available and Base Flood Elevations were previously defined. This topographic data included Light Detection and Ranging (LiDAR) derived digital elevation models (DEMs) collected by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 2009 (Reference 19) and data collected by the USACE Portland District Columbia River in

2010 (Reference 20). Both datasets are considered accurate enough to support a contour interval of two feet. The redelineation process updates the floodplain extents based on the new topographic data, but does not make changes to the Base Flood Elevations or the engineering models used to develop those elevations. Redelineation was completed on the detailed study areas of the Nasselle River, Salmon Creek and South Fork Naselle River.

The detailed study reaches along Ward, Wilson and Whitcomb Creeks near the City of Raymond and the Willapa River near Lebam are not covered by new topographic data and was converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new aerial photography.

For portions of the Naselle River and Salmon studied by new approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2). The boundary of the 1-percent-annual-chance floodplain was delineated using digital terrain models developed from DOGAMI in 2009 (Reference 19) and the USACE Portland District Columbia River in 2010 (Reference 20). The boundary of the 1-percent-annual-chance flood for the South Fork Naselle River near its confluence with Cement Creek was refined by making adjustments to fit the floodplains to new aerial photography and the new topographic data.

Those approximate method reaches not covered by new topographic data were converted to digital format by digitizing the effective FIRMs and refined by making small adjustments to fit the floodplains to new aerial photography to ensure that they overlay the water course they represent. These areas include Salmon Creek from approximately 800 feet downstream of Tienhaara Road to the upstream county boundary and just upstream and just downstream of the detailed study of the Willapa River near Lebam.

In accordance with FEMA Procedure Memorandum 36 (Reference 36), 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.

## 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 study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 14, "Floodway Data Table"). 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 is shown.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage and heightens potentials flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 14, "Floodway Data Table". To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

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 1-percent-annual-chance 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 3, "Floodway Schematic".

No floodways were computed for portions of South Fork Naselle River and Willapa River, near the Cities of Raymond and South Bend, because the major flooding is due to the combined effects of storm surge and astronomical tide. No floodways were computed in tidal areas, as well as the Columbia River.

### 4.3 Base Flood Elevations

Areas within the community studied by detailed engineering methods 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 normal 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 11). 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.

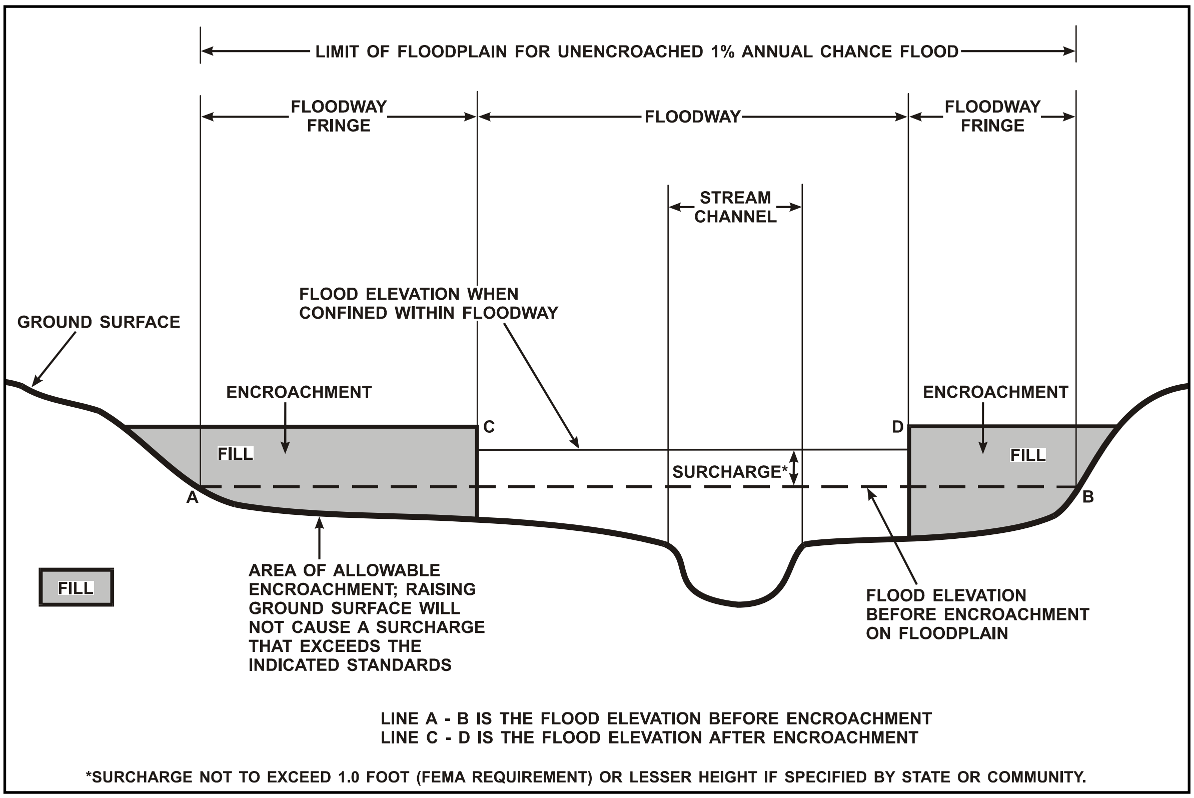


**Figure 3 – Floodway Schematic**

| 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) |
| Naselle River | | | | | | | | |
| A | 0 | 2,349 | 15,530 | 1.3 | 15.6 | 15.6 | 16.6 | 1.0 |
| B | 3,990 | 1,321 | 9,321 | 2.1 | 16.5 | 16.5 | 17.5 | 1.0 |
| C | 7,990 | 2,480 | 15,644 | 1.2 | 17.2 | 17.2 | 18.2 | 1.0 |
| D | 8,360 | 298 | 3,291 | 5.9 | 17.3 | 17.3 | 18.3 | 1.0 |
| E | 9,180 | 2,618 | 21,822 | 0.8 | 18.2 | 18.2 | 19.1 | 0.9 |
| F | 14,200 | 1,443[2] | 15,447 | 1.0 | 18.4 | 18.4 | 19.4 | 1.0 |
| G | 16,740 | 580[2] | 4,084 | 3.8 | 18.7 | 18.7 | 19.7 | 1.0 |
| H | 18,800 | 329 | 3,427 | 4.5 | 22.0 | 22.0 | 22.0 | 0.0 |
| I | 21,330 | 100 | 2,055 | 5.7 | 25.1 | 25.1 | 26.1 | 1.0 |
| J | 23,160 | 900 | 5,561 | 2.1 | 27.3 | 27.3 | 27.9 | 0.6 |
| K | 25,470 | 181* | 1,822 | 6.5 | 28.8 | 28.8 | 29.4 | 0.6 |
| L | 27,650 | 165 | 1,825 | 6.5 | 32.6 | 32.6 | 33.4 | 0.8 |
| M | 28,850 | 87 | 1,059 | 11.1 | 34.4 | 34.4 | 35.0 | 0.6 |

[1] Feet above Confluence with Dell Creek

[2] Width ignores reductions due to islands in floodway

* Mapped Floodway width does not match model

TABLE 13

**FEDERAL EMERGENCY MANAGEMENT AGENCY**

**PACIFIC COUNTY, WA**

**AND INCORPORATED AREAS**

**FLOODWAY DATA**

**NASELLE 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) |
| Salmon Creek | | | | | | | | |
| A | 200 | 155 | 1,083 | 3.3 | 23.7 | 23.7 | 24.7 | 1.0 |
| B | 1,090 | 100 | 857 | 4.2 | 24.1 | 24.1 | 25.1 | 1.0 |
| C | 1,350 | 70 | 822 | 4.4 | 24.3 | 24.3 | 25.3 | 1.0 |
| D | 2,770 | 72* | 537 | 6.7 | 25.9 | 25.9 | 26.7 | 0.8 |
| E | 4,720 | 69 | 559 | 6.5 | 30.4 | 30.4 | 31.4 | 1.0 |
| F | 6,610 | 56* | 592 | 6.1 | 36.4 | 36.4 | 36.4 | 0.0 |
| G | 8,110 | 87 | 609 | 5.9 | 40.2 | 40.2 | 41.0 | 0.8 |
| H | 8,820 | 56 | 478 | 7.6 | 41.5 | 41.5 | 42.4 | 0.9 |
| I | 11,100 | 43 | 403 | 9.0 | 47.7 | 47.7 | 48.6 | 0.9 |
| J | 11,520 | 40 | 491 | 7.4 | 49.9 | 49.9 | 50.5 | 0.6 |
| K | 12,600 | 111 | 820 | 4.4 | 52.9 | 52.9 | 53.3 | 0.4 |

[1] Feet above Confluence with the Naselle River

* Mapped Floodway width does not match model

TABLE 13

**FEDERAL EMERGENCY MANAGEMENT AGENCY**

**PACIFIC COUNTY, WA**

**AND INCORPORATED AREAS**

**FLOODWAY DATA**

**SALMON 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) |
| South Fork Naselle River | | | | | | | | |
| A | 300 | 58 | 842 | 5.1 | 18.1 | 18.1 | 19.1 | 1.0 |
| B | 1,570 | 1,078 | 5,969 | 0.7 | 19.1 | 19.1 | 20.0 | 0.9 |
| C | 2,710 | 730 | 2,108 | 2.0 | 19.1 | 19.1 | 20.0 | 0.9 |
| D | 5,010 | 240 | 986 | 4.4 | 20.1 | 20.1 | 21.1 | 1.0 |
| E | 6,560 | 652 | 2,064 | 2.1 | 22.3 | 22.3 | 23.3 | 1.0 |
| F | 7,940 | 264 | 1,574 | 2.7 | 24.1 | 24.1 | 24.5 | 0.4 |
| G | 8,320 | 378 | 1,719 | 2.5 | 24.4 | 24.4 | 24.8 | 0.4 |
| H | 9,420 | 325 | 827 | 5.2 | 25.2 | 25.2 | 25.9 | 0.7 |
| I | 10,850 | 120 | 824 | 5.2 | 29.2 | 29.2 | 29.2 | 0.0 |
| J | 12,370 | 297 | 675 | 6.4 | 32.5 | 32.5 | 32.5 | 0.0 |
| K | 12,640 | 433 | 1,196 | 3.6 | 34.4 | 34.4 | 34.6 | 0.2 |
| L | 14,170 | 160 | 539 | 8.0 | 37.9 | 37.9 | 38.5 | 0.6 |
| M | 15,570 | 104 | 611 | 7.0 | 42.0 | 42.0 | 42.4 | 0.4 |
| N | 16,300 | 71 | 573 | 7.5 | 44.7 | 44.7 | 45.6 | 0.9 |
| O | 17,600 | 90 | 646 | 6.7 | 50.5 | 50.5 | 51.2 | 0.7 |

[1] Feet above Confluence with the Naselle River

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

**PACIFIC COUNTY, WA**

**AND INCORPORATED AREAS**

## FLOODWAY DATA

## SOUTH FORK NASELLE 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) |
| Willapa River | | | | | | | | |
| A | 0 | 400 | 2,461 | 2.2 | 176.1 | 176.1 | 176.1 | 0.0 |
| B | 750 | 144 | 1,661 | 3.3 | 176.1 | 176.1 | 176.2 | 0.1 |
| C | 980 | 144 | 1,662 | 3.3 | 176.2 | 176.2 | 176.2 | 0.0 |
| D | 1,760 | 92 | 805 | 6.8 | 176.4 | 176.4 | 176.4 | 0.0 |
| E | 1,960 | 94 | 839 | 6.5 | 176.7 | 176.7 | 176.7 | 0.0 |
| F | 2,910 | 58 | 697 | 7.8 | 177.8 | 177.8 | 177.8 | 0.0 |
| G | 3,830 | 220 | 2,745 | 2.0 | 179.3 | 179.3 | 179.3 | 0.0 |
| H | 5,070 | 60 | 844 | 6.5 | 179.3 | 179.3 | 179.3 | 0.0 |
| I | 5,620 | 86 | 722 | 7.6 | 179.8 | 179.8 | 179.8 | 0.0 |
| J | 7,090 | 77 | 974 | 5.6 | 181.2 | 181.2 | 181.2 | 0.0 |
| K | 8,190 | 78 | 563 | 9.7 | 182.0 | 182.0 | 182.0 | 0.0 |
| L | 9,750 | 128 | 875 | 6.2 | 184.9 | 184.9 | 184.9 | 0.0 |
| M | 10,670 | 104 | 822 | 6.6 | 185.8 | 185.8 | 185.8 | 0.0 |
| N | 11,760 | 160 | 1,396 | 3.9 | 186.8 | 186.8 | 186.8 | 0.0 |
| O | 12,090 | 140 | 1,348 | 4.0 | 187.4 | 187.4 | 187.4 | 0.0 |

[1] Feet above U.S. Geological Survey Gage No. 12-0115

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

**PACIFIC COUNTY, WA**

**AND INCORPORATED AREAS**

**FLOODWAY DATA**

**WILLAPA RIVER**

## 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 BFEs (1-percent-annual-chance) 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 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 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.

## 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 Pacific 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 14, "Community Map History."

| COMMUNITY NAME | INITIAL IDENTIFICATION | FLOOD HAZARD BOUNDARY MAP REVISIONS DATE | FIRM EFFECTIVE DATE | FIRM REVISIONS DATE |
|---|---|---|---|---|
| Ilwaco, Town of | May 24, 1974 | January 16, 1976 | February 1, 1979 | |
| Long Beach, Town of | May 24, 1974 | January 9, 1976<br>April 25, 1978 | August 1, 1979 | |
| Raymond, City of | May 31, 1974 | February 7, 1975 | July 16, 1979 | |
| Shoalwater Bay Indian Tribe* | October 25, 1974 | None | January 5, 1978 | September 27, 1985 |
| South Bend, City of | June 28, 1974 | January 30, 1976 | November 15, 1979 | |
| Pacific County Unincorporated Areas | October 25, 1974 | None | January 5, 1978 | September 27, 1985 |

* Dates for this community were taken from Pacific County (Unincorporated Areas)

TABLE 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

**PACIFIC 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 reports for the adjacent Washington Counties of Grays Harbor and Wahkiakum are currently underway.

Countywide FIS reports for Clatsop County, OR (2010) and Lewis County, WA (2006) have already gone effective (References 37 and 38).

## 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.

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