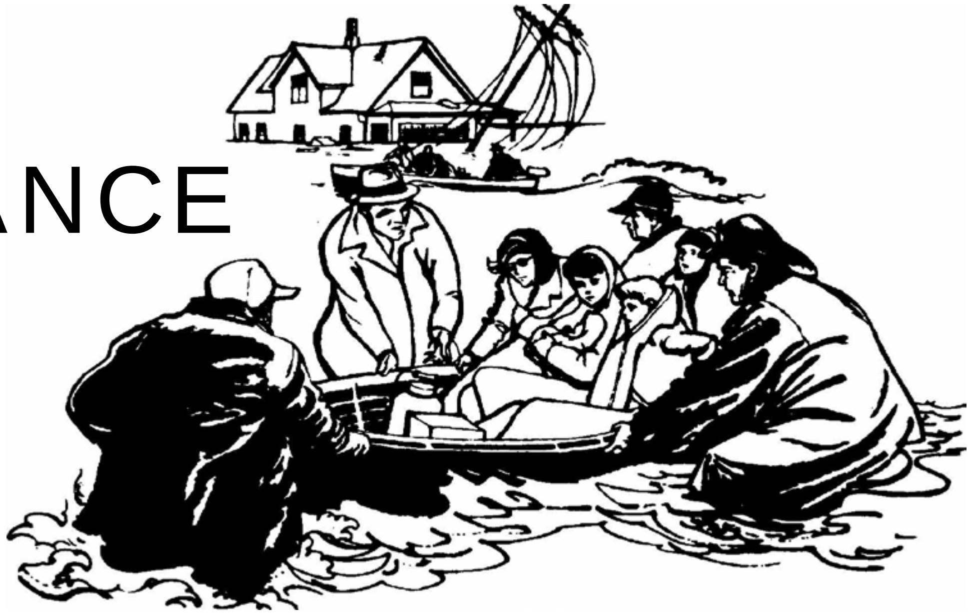
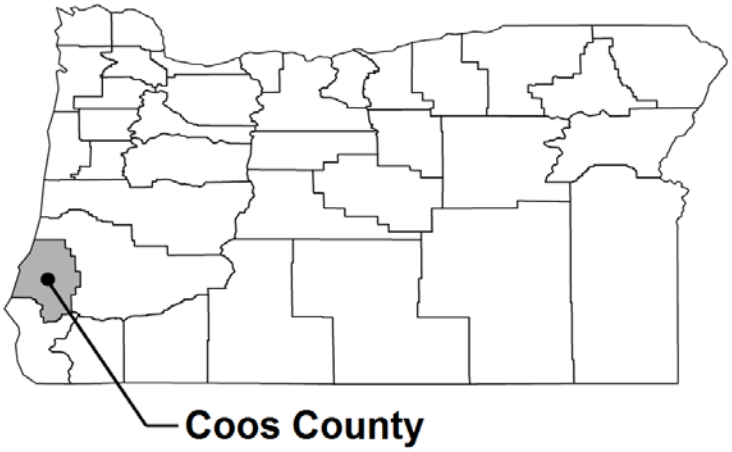
FLOOD INSURANCE STUDY



Volume 1 of 2

COOS COUNTY, OREGON
AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
BANDON, CITY OF	410043
CONFEDERATED TRIBES OF COOS, LOWER UMPQUA AND SIUSLAW	410292
COOS BAY, CITY OF	410044
COOS COUNTY (UNINCORPORATED AREAS)	410042
COQUILLE, CITY OF	410045
COQUILLE INDIAN TRIBE	410102
LAKESIDE, CITY OF	410278
MYRTLE POINT, CITY OF	410047
NORTH BEND, CITY OF	410048
POWERS, CITY OF	410049



REVISED:
DECEMBER 7, 2018

U.S. DEPARTMENT OF HOMELAND SECURITY

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
41011CV001C

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.

Initial Countywide FIS Effective Date: September 25, 2009

Revised Countywide FIS Date: March 17, 2014
December 7, 2018

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FLOOD INSURANCE STUDY
COOS COUNTY, OREGON AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Coos County, including the Cities of Bandon, Coos Bay, Coquille, Lakeside, Myrtle Point, North Bend and Powers; the unincorporated areas of Coos County (referred to collectively herein as Coos County); the Coquille Indian Tribe; and the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw; and 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.

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.

Pre-Countywide Analyses

Coos County Unincorporated Areas. Flood Hazard Boundary Maps for Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in September 1977 (community panel numbers 0001-0021).

City of Bandon. Flood Hazard Boundary Maps for City of Bandon, Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in December 1973 and revised in April 1976 (community panel numbers 410043A 01-03).

City of Coos Bay. Flood Hazard Boundary Maps for City of Coos Bay, Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in March 1977 (community panel numbers 410044 0001-0005).

City of Coquille. Flood Hazard Boundary Maps for City of Coquille, Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in November 1973 and revised October 1975.

City of Myrtle Point. Flood Hazard Boundary Maps for City of Myrtle Point, Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in November 1973 and revised December 1975.

City of North Bend. Flood Hazard Boundary Maps for City of North Bend, Coos County, Oregon, were produced by the U.S. Department of Housing and Urban Development in June 1974 (community panel numbers 410048A 01-03).

Coos County Unincorporated Areas. The detailed riverine and estuarine hydrologic and hydraulic analyses for this study were performed by CH2M Hill Northwest, Inc., for FEMA, under Contract No. EMW-C-0283. This work was completed in April 1982 and represents a portion of the original FIS performed for Coos County.

City of Bandon. The original FIS was revised to update coastal flood information from the south jetty to the southern city limit of Bandon. The work was performed by CH2M Hill, Inc., under FEMA Contract No. EMW-94-C-4526 and was completed in September 1995. Note that the present countywide update revises this area and supersedes this update.

Countywide Analyses

A countywide update and vertical datum conversion was performed by WEST Consultants, Inc., for FEMA, under Contract No. EMS-2001-CO-0068. This countywide update occurred under FEMA's Map Modernization program, the purpose of which was to create digital versions of the Flood Insurance Rate Maps (DFIRMs), create a single layout format for the entire area within the county, and compile a single FIS report that includes all FIS information and data for the entire county area. During this countywide update revised hydraulic data were incorporated for Pony Creek (in the cities of Coos Bay and North Bend). See Section 3.2 for more information about the hydraulic data revision for Pony Creek. Portions of Pony Creek, Coos Bay, and the Pacific Ocean flood zones were redelineated with 2 foot contours provided by the City of North Bend. Portions of the Pacific Ocean flood zones were also redelineated with LiDAR provided by NOAA. All other flood mapping was incorporated as-is from the original FIS. This update was completed in July 2008.

The present countywide update was performed by the Oregon Department of Geology and Mineral Industries (DOGAMI), for FEMA, under Contract No. EMS-2008-GR-0013. During this countywide update, revised detailed and approximate coastal hydrologic and hydraulic analyses were performed for the entire coastline. Revised approximate riverine hydrologic and hydraulic analyses were also performed for county where new, high quality topographic data (LiDAR) was available. Finally, revised mapping of detailed riverine and estuarine study areas (from original FIS) was performed by redelineating to LiDAR provided by the Oregon LiDAR Consortium. This redelineation work supersedes all similar work performed for the previous countywide analysis. This update was completed in March 2014.

Base map information shown on the Flood Insurance Rate Map (FIRM) was derived from LiDAR ground and first return digital elevation models produced at a scale of 1:2,300, from surveys conducted between June 8, 2008 and September 28, 2008. The projection used in the preparation of this map is Universal Transverse Mercator Zone 10 North, and the horizontal datum used is NAD 1983.

1.3 Coordination

An initial meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied or restudied. A final meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study.

The initial and final meeting dates for previous FIS reports for Coos County and its communities are listed in the following table:

Table 1. Initial, Intermediate, and Final CCO Meetings

Community	Initial CCO Date	Intermediate CCO Dates	Final CCO Meeting
Coos County (Unincorporated Areas)	May, 1979	--	November, 1980
Bandon, City of	May, 1979	March 22, 1983	August 23, 1983
Coos Bay, City of	May, 1979	--	August 24, 1983
Coquille, City of	May, 1979	--	July 20, 1983
Lakeside, City of	May, 1979	March 22, 1983	August 25, 1983
Myrtle Point, City of	May, 1979	--	December 4, 1980
North Bend, City of	May, 1979	--	August 24, 1983
Powers, City of	--[1]	--[1]	--[1]

[1] Information not available

Streams, lakes, estuarine and coastal areas requiring detailed study were identified at a meeting attended by the CH2M Hill Northwest, Inc., FEMA, and representatives of Coos County in May 1979. The U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (USACE), and the Coos-Curry Council of Governments were contacted for information used in the initial study.

Streams, lakes, estuarine and coastal areas requiring revision were identified at a meeting attended by the CH2M Hill Northwest, Inc., FEMA, and representatives of the City of Bandon on March 22, 1983. The USGS was contacted for hydrologic information. The USACE, the Bandon Historical Society, and the Port of Coquille were contacted for information on past flooding in the city.

An initial community coordination meeting for Coos County was held on March 14, 2006, to address the first-time countywide update and vertical datum conversion. This meeting was attended by representatives of the cities and county, State of Oregon, FEMA and WEST Consultants.

The results of the update were reviewed at the final Consultation Coordination Officers' meeting held on November 5, 2008, and attended by representatives of FEMA, the City of Coos Bay, the City of Coquille, the City of Lakeside, the City of Myrtle Point, the City of North Bend, Coos County, the Oregon Department of Land and Development (DLCD) and DOGAMI.

Present Countywide Update

The initial meeting was held on January 7, 2009, and attended by representatives of FEMA, Coos County, the City of Bandon, the City of Coos Bay, the City of North Bend, the City of Coquille, the Coquille Indian Tribe, DLCD, and DOGAMI.

The results of the study were reviewed at the final meeting held on June 7, 2011, and attended by representatives from the Coquille Indian Tribe, the Cities of Bandon, Coos Bay, Lakeside, Myrtle Point, and North Bend, and representatives from DOGAMI, STARR, DLCD, and FEMA. 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 Coos County, Oregon, including the incorporated communities listed in Section 1.1. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction through 1987, determined during scoping of the original FIS.

The following flooding sources were studied by detailed methods in this FIS report:

Table 2. Summary of Flooding Sources Studied by Detailed Methods

Flooding Source	Limits of Detailed Study
Tenmile Creek	From Lake Front Road bridge to Tenmile Lake within the City of Lakeside
Tenmile Lake	Within corporate limits (as of 1982) of the City of Lakeside
North Tenmile Lake	Within corporate limits (as of 1982) of the City of Lakeside
Millicoma River	From river mile (RM) 8.2 to the confluence of the East and West Forks Millicoma River
East Fork Millicoma River	From its confluence with West Fork Millicoma River to RM 10.7
West Fork Millicoma River	From its confluence with East Fork Millicoma River to RM 2.0
Coquille River	Within the corporate limits (as of 1982) of the City of Bandon, from RM 16 to RM 17 at Riverton, from RM 23 to RM 27.5 at the City of Coquille, and from RM 32 to RM 33 at Arago
South Fork Coquille River	From RM 36.4 to RM 38.4 at the City of Myrtle Point
Pony Creek	From the Virginia Avenue bridge in the City of North Bend to Ocean Boulevard in the City of Coos Bay
Cunningham Creek	Within corporate limits (as of 1982) of the City of Coquille
Calloway Creek	Within corporate limits (as of 1982) of the City of Coquille

Table 2. Summary of Flooding Sources Studied by Detailed Methods (continued)

Flooding Source	Limits of Detailed Study
Ferry Creek	From its confluence with Coquille River to upstream of Harlem Avenue within the City of Bandon
Coos River	From its confluence with Coos Bay to 2 miles upstream (area of tidal influence)
Cooston Channel	From its confluence with Coos Bay to its confluence with Coos River
Catching Slough	Within corporate limits (as of 1982) of the City of Coos Bay
Coos Bay	From its confluence with the Pacific Ocean to its confluence with Coos River and Cooston Channel
Isthmus Slough	From its confluence with Coos Bay to 0.3 miles upstream of Coos-Summer Lane bridge
Coalbank Slough	From its confluence with Isthmus Slough to Shinglehouse Road
Pony Slough	From its confluence with Coos Bay to its confluence with Pony Creek within the City of North Bend
Haynes Inlet	From its confluence with Coos Bay to its confluence with Larson and Palouse Sloughs
North Slough	From its confluence with Coos Bay to the Highway 101 bridge near North Bay Road at Hauser

Table 2. Summary of Flooding Sources Studied by Detailed Methods
(continued)

Flooding Source	Limits of Detailed Study
South Slough	From its confluence with Coos Bay to Valino Island

This revision used LiDAR to re-delineate Special Flood Hazard Areas (SFHAs) to the flood elevations determined by detailed methods in the original FIS. This approach was applied in all detailed study areas listed above.

The following flooding sources are studied by revised detailed methods in this FIS report:

Table 3. Summary of Flooding Sources Studied by Revised Detailed Methods

Flooding Source	Limits of Revised Detailed Study
Pacific Ocean	From the north jetty at Coos Bay to Sunset Bay, and from the south jetty at Coquille River to the southern extent of the City of Bandon Urban Growth Boundary

The limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

Approximate analyses were used to study those areas having low development potential or minimal flood hazards. These areas were adopted from previously effective flood hazard boundary maps (U.S. Department of Housing and Urban Development, 1977). The scope and methods of study were proposed to and agreed upon by FEMA, the communities, and the study contractor, DOGAMI.

The following flooding sources are studied by revised approximate methods in this FIS report:

Table 4. Summary of Flooding Sources Studied by
Revised Approximate Methods

Flooding Source
Pacific Ocean, excluding areas studied by revised detailed methods

Table 4. Summary of Flooding Sources Studied by Revised Approximate Methods (continued)

Flooding Source

Tenmile Creek Basin, including these tributaries and lakes:

Saunders Creek, Clear Lake, Saunders Lake, Eel Creek, Eel Lake, Tenmile Lake, North Tenmile Lake, Murphy Creek, Big Creek, Noble Creek, Alder Gulch, Benson Creek, Roberts Creek, Johnson Creek, Adams Creek, Shutter Creek

Lakes of the Oregon Dunes National Recreation Area:

Lyons Reservoir, Snag Lake, Sandpoint Lake, Spirit Lake, Horsfall Lake

Coos River Basin, including these tributaries and lakes:

Winchester Creek, John B Creek, Talbot Creek, Talbot Slough, Elliott Creek, Joe Ney Slough, North Fork Joe Ney Slough, South Fork Joe Ney Slough, Tarheel Creek, Fourth Creek, First Creek, Chickses Creek, Lower Empire Lake, Upper Empire Lake, North Slough, Palouse Slough, Palouse Creek, Larson Slough, Larson Creek, Kentuck Slough, Kentuck Creek, Mettman Creek, Willanch Slough, Willanch Creek, Johnston Creek, Coalbank Creek, C. A. Smith Reservoir, Noble Creek, Delmar Creek, Davis Slough, Upper Isthmus Slough, Ross Slough, Catching Slough, Catching Creek, Millicoma River, Marlow Creek, East Fork Millicoma River (Not Revised), Glenn Creek (Not Revised), West Fork Millicoma River, Elk Creek, South Fork Coos River, Williams River

Coquille River Basin, including these tributaries and lakes:

Ferry Creek, Fahy’s Creek, Fahy’s Lake, Sevenmile Creek, Bear Creek, Lampa Creek, Hatchet Slough, Beaver Creek, Fat Elk Creek, Calloway Creek, Cunningham Creek, Rink Creek, Fishtrap Creek, Hall Creek, North Fork Coquille River, East Fork Coquille River, Elk Creek, Brummit Creek (Not Revised), Middle Creek, Cherry Creek, Evans Creek, Woodward Creek, Catching Creek, Middle Fork Coquille River, Big Creek, Myrtle Creek, Rock Creek, Sandy Creek

Table 4. Summary of Flooding Sources Studied by Revised Approximate Methods (continued)

Flooding Source

New River Basin, including these tributaries and lakes:

> Fourmile Creek, Laurel Creek, Laurel Lake, Lost Lake, Davis Creek, Muddy Lake, Croft Lake, Conner Creek, Bethel Creek, New Lake, Butte Creek, Morton Creek

Threemile Creek

Twomile Creek

Cut Creek Basin, including Chrome Lake and Round Lake

Johnson Creek

Crooked Creek

China Creek Basin, including Bradley Lake

Twomile Creek Basin, including Lower and South Twomile Creeks

2.2 Community Description

Coos County is located in southwest Oregon. The county is bounded on the west by the Pacific Ocean, on the south by Curry County, and on the east and north by Douglas County. Coos County is about 66 miles long, 36 miles wide, and covers an area of 1,629 square miles. About one-third of the county is publicly owned. The U.S. Bureau of Land Management, the U.S. Forest Service, the U.S. Fish and Wildlife Service, and the Oregon State Land Board own most of the public lands (Sidor and Brown, 1967). Only about 1 percent of the area in the county has been urbanized or built up. The county was founded on December 22, 1853. According to the U.S. Census Bureau, Coos County's population was 63,043 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 60,273 (U.S. Department of Commerce, 2010). The Coos County economy is based on tourism, agriculture, forest products, and fishing (Coos County Emergency Management Department, 2005).

The Coquille River basin, with a drainage area of 1,058 square miles, covers most of the southern two-thirds of the county. Flow from the basin enters the Pacific Ocean at Bandon. Upstream at RM 36.3, about a mile south of Myrtle Point, the river branches into the South Fork and North Fork Coquille Rivers. The South Fork Coquille River has a drainage area of 598 square miles and a length of 62.8

miles. The North Fork Coquille River has a drainage area of 289 square miles and a length of 53.3 miles (Pacific Northwest River Basins Commission, 1968). Both forks begin in the Coast Range Mountains. The cities of Myrtle Point and Powers are located on the South Fork Coquille River, and the cities of Coquille and Bandon are located on the main stem of the Coquille River. Tidal influences extend as far upstream as Myrtle Point on the South Fork Coquille River. About 70% of the Coquille River basin is forested. Private industrial forest holdings make up 40% of the watershed. The remaining 30% of forested lands are federal, state, and county lands. (Coos County Emergency Management Department, 2005) Two federal agencies, the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS), administer the largest of these public holdings.

The Coos River basin, with a drainage area of 415 square miles covers most of the northeast corner of the county. The Coos River flows into Coos Bay at the City of Coos Bay. Upstream at RM 5.5, the Coos River branches into the Millicoma River and the South Fork Coos River. The Millicoma River has a drainage area of 151 square miles while the South Fork Coos River has a drainage area of 254 square miles. The Millicoma River branches into the East Fork and West Fork Millicoma Rivers at RM 8.1. Tidal influences extend upstream to Dellwood on the South Fork Coos River and to the confluence of the East and West Forks on the Millicoma River. The East Fork Millicoma River has a drainage area of 79 square miles and a length of 23.9 miles. The West Fork Millicoma River has a drainage area of 55 square miles and a length of 34.9 miles (Pacific Northwest River Basins Commission, 1968). About 80% of the Coos River basin is forested.

Coos Bay, located in the west-central part of Coos County, is the largest estuary in Oregon. The bay covers an area of about 17 square miles and drains a total of 605 square miles (Percy and Sutterlin, 1974). Tributaries such as the South Slough, North Slough, Larson and Palouse Creeks, Isthmus Slough, and Catching Slough account for 190 square miles of the drainage area. The Coos River accounts for the remaining 415 square miles. The Cities of Coos Bay and North Bend are located on the bay.

The original natural estuarine environments of Coos Bay have been altered by the community's dependence on wetland and estuarine resources and the need for flat, dry land. Diking, draining, and filling of marshes began in the 1870's to create the present city of Coos Bay, expand rail and road routes, and accommodate more ranches and homes. In 1970, when only 15% of the original marsh remained, state and federal laws slowed the conversion process (Coos County Emergency Management Department, 2005).

The eastern two-thirds of the Coos River basin is sparsely populated and made up of steep forested slopes. This area has been managed exclusively for time since the late 1800's. About 36,000 people live in the basin, with the bulk of the population clustered about the eastern half of the estuary and lower riverbanks. Until the late 1980's the area was heavily reliant on natural resource extraction, such as timber production, fishing, and agriculture. Many family wage jobs have been lost as these industries saw a decline in the availability of resources. The area is struggling with a transition to utilize other economic opportunities, such as tourism (Coos County Emergency Management Department, 2005).

The Tenmile Creek basin, with a drainage area of about 86 square miles, covers most of the northwest corner of the county. Tenmile Creek flows generally west for 5.1 miles from the outlet of Tenmile Lake at Lakeside to the Pacific Ocean. The drainage area above the outlet of Tenmile Lake is 70.6 square miles. This drainage area includes North Tenmile Lake which is connected to Tenmile Lake by a 0.4-mile-long canal. The drainage area above the outlet of North Tenmile Lake is 29.0 square miles. North Tenmile Lake and Tenmile Lake cover about 980 and 1,350 acres, respectively (Sidor and Brown, 1967). Most of the steep forested slopes in the upper basin are found in the Elliott State Forest, which is managed by the Oregon Department of Forestry (Coos County Emergency Management Department, 2005).

The native fishery in the Tenmile Creek basin was primarily Coho salmon, steelhead, and sea-run cutthroat trout. In the 1930's, yellow perch, small mouth bass, brown bullhead catfish and other non-native fish were introduced to the lakes. In 1996, the lakes in the Tenmile Creek basin were placed on the Department of Environmental Quality's list for water quality problems with bacteria, aquatic weeds, temperature, and algae (Coos County Emergency Management Department, 2005).

Coos County has a temperate marine climate with typically mild temperatures, wet winters, and dry summers. The average temperature in January is about 50°F and in July, about 60°F. The average annual temperature ranges from 50 to 54°F. The average yearly rainfall along the coast is about 60 inches. Further inland in the Coast Range, average yearly rainfall may reach 100 inches or more, depending on the location and elevation. Approximately 75 percent of the rainfall occurs from November through March. In coastal areas prevailing winds during March through October are from the northwest with an average speed of 17 miles per hour. During November through February, prevailing winds are from the southwest with an average speed of 15 miles per hour (Sidor and Brown, 1967).

The topography of Coos County is predominately steep and mountainous. The Coast Range Mountains begin near the coastline and rise to average peak elevations of 2,500 to 3,500 feet at the crest of the Coast Range. The Coast Range in Coos County is predominately composed on marine sedimentary rock with some igneous and metamorphic rock occurring in the southern end of the county. The sedimentary rock is composed of alluvium, siltstone, mudstone, sandstone, shale, and conglomerates. The igneous rock is composed of basalt, breccia, tuff, diorite, and peridotite. The metamorphic rock is composed of gneiss, schist, and serpentine. Soils in the county are generally clayey (Sidor and Brown, 1967).

Land located in the river valleys of Coos County is used predominately for agriculture.

City of Bandon

The City of Bandon is located on the Pacific Ocean at the mouth of the Coquille River in southwestern Coos County. Bandon is located 23 miles southwest of Coos Bay along U.S. Highway 101, 27 miles north of Port Orford along U.S. Highway 101, and 18 miles southwest of Coquille along State Highway 42S. The city was incorporated in 1891. According to the U.S. Census Bureau, the population of Bandon was 3,066 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 2,215 (U.S. Department of Commerce, 2010).

The Coquille River flows through the northwestern corner of Bandon and empties into the Pacific Ocean. Most of the city is located on a high bluff overlooking the ocean and river estuary. The Coquille River is 99 miles long from the beginning of the South Fork Coquille River to the Pacific Ocean, and drains an area of 1,058 square miles covering most of the southern two-thirds of Coos County (City of Bandon, 1977). The average annual precipitation over the Coquille River basin is 66 inches (Beaulieu and Hughes, 1975).

Ferry Creek flows through the southeast corner of Bandon to the Coquille River. Ferry Creek is 3.8 miles long and drains an area of 5.2 square miles.

The corporate limits of Bandon enclose 3.2 square miles. Most of this area is lightly developed. The two most densely developed areas are along U.S. Highway 101 and near Harbor Lights High School. All of the flood plain areas studied are lightly developed and predominantly residential areas, except for the old downtown area between U.S. Highway 101 and the Coquille River. Development within the old downtown area is mainly commercial, with some industrial development, including a fish processing plant and a lumber mill.

The average annual rainfall at Bandon is approximately 60 inches. The mean temperature in January is approximately 50° F, and in July, approximately 60° F. From May through August, the prevailing winds are from the northwest, while the prevailing winds in winter are from the southwest. Winter winds are usually less than those experienced during the summer except during an occasional winter storm (Coos County Emergency Management Department, 2005).

Soils in the City of Bandon are predominantly sandy loams. The coastal cliffs and offshore rocks are a mixture of sandstone, siltstone, volcanic rock, chert, and blue schist. In undeveloped areas of Bandon south of the Coquille River estuary, vegetation includes salal, wild rhododendron, pine, cypress, and gorse. The Bandon tidal marsh covers approximately 25 percent of the Coquille River estuary (City of Bandon, 1978).

Bandon is served by U.S. Highway 101 and State Highway 42S.

City of Coos Bay

The City of Coos Bay is located in western Coos County at the southern end of a peninsula that extends north into the Coos Bay estuary. The City of Coos Bay is located approximately 4 miles east of the Pacific Ocean, approximately 27 miles south of Reedsport, and approximately 17 miles north of Coquille. The City of Coos Bay is bounded by the City of North Bend to the north, the Coos Bay estuary to the east and west, and Coos County to the south. The city covers 16.1 square miles. The city was incorporated in 1874. According to the U.S. Census Bureau, the population of Coos Bay was 15,967 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 15,076 (U.S. Department of Commerce, 2010).

The downtown area of the City of Coos Bay is located on Isthmus Slough, which enters the Coos Bay estuary near the intersection of Date Avenue and Front Street. Coalbank Slough follows the southeast corporate limits and enters Isthmus Slough east of the intersection of Hall Avenue and Front Street. Isthmus Slough and Coalbank Slough drain an area of 33.3 square miles south of the bay.

The Coos River, the major tributary of Coos Bay, flows into the bay through the Marshfield and Cooston Channels east and north of the developed portion of the City of Coos Bay. The Coos River drains an area of 415 square miles and has several forks including the Millicoma River, the East and West Fork Millicoma Rivers, the South Fork Coos River, and the Williams River. Catching Slough also flows into Coos Bay through the Marshfield Channel and has a drainage area of 25.2 square miles above the southern corporate limits of the City of Coos Bay.

Pony Creek has its headwaters in the hills southwest of the City of Coos Bay and flows north to the Coos Bay estuary. Pony Creek drains the central portion of the peninsula on which Coos Bay and North Bend are located. The creek has a length of 5.6 miles and a drainage area of 6.4 square miles above Virginia Avenue in North Bend. The Coos Bay North Bend Water Board operates two dams on Pony Creek for municipal water supplies. The drainage area above the upper dam is 2.9 square miles, while the drainage area above the lower dam is 3.9 square miles. At normal winter pool elevation, the storage volume in the reservoir behind the upper dam is 2,090 acre-feet, and the storage volume in the reservoir behind the lower dam is 123 acre-feet (CH2M HILL, 1978).

Blossom Creek has its headwaters in the hills between the Pony Creek basin and downtown Coos Bay, and drains an area of 1.0 square mile above 10th Street. At 10th Street, Blossom Creek enters the Mill Slough Box, a major storm sewer that drains several smaller systems in downtown Coos Bay and then discharges into Isthmus Slough 3,200 feet downstream of 10th Street.

Average annual precipitation at Coos Bay is approximately 60 inches. The majority of the rainfall occurs from November through March (Erichsen et al., 1966). In January, the coldest month, the mean temperature is approximately 46.6°F, and in July, the warmest month, the mean temperature is approximately 59.0°F. From May through August, prevailing winds are from the northwest, while in winter prevailing winds are from the southwest. Winter winds are usually milder than those during the summer, except during an occasional winter storm.

Soils in Coos Bay are predominantly sandy loams. In areas affected by tidal action along the bay, Coalbank and Isthmus Slough, and Pony Creek, the soils range from silty clay loams to sandy loams (U.S. Department of Agriculture, 1975). Most of Coos Bay is underlain by either coarse- to fine-grained sandstone of the Coaledo formation or Quartenary marine terrace deposits (Beaulieu and Hughes, 1975).

Most of the developed part of the City of Coos Bay that was formerly known as Eastside is underlain by the Bastendorff Formation consisting of shale and siltstone with minor sandstone interbeds (City of Eastside, 1978). A substantial amount of land north and west of the developed area has been, and will continue to be, filled with dredged material. Soils are predominantly silt loams where no fill has been placed.

A large portion of all land within the Coos Bay corporate limits is undeveloped or open lands including rights-of-way, city parks, and land owned by the Coos Bay-North Bend Water Board. Most residential areas are centered around downtown Coos Bay, in the Empire area, and along major arterials such as Southwest Boulevard, Ocean Boulevard, and Newmark Street (Coos Bay City Council, 1981). Development in areas affected by flooding is predominantly commercial and industrial with only limited residential areas affected.

Coos Bay is served by U.S. Highway 101 and the Southern Pacific Railroad.

City of Coquille

The City of Coquille is located in western Oregon, in the south-central portion of Coos County. The closest incorporated community is the City of Myrtle Point, located 9 miles to the south along State Highway 42. The coastal community of Coos Bay is located approximately 18 miles to the north and is connected to Coquille by a branch line of the Southern Pacific Railroad. State Highways 42 and 42S are the major routes between the coast, Coquille, and inland areas. The city is bounded by the unincorporated areas of Coos County. The city was incorporated in 1885. According to the U.S. Census Bureau, the population of Coquille was 3,866 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 4,121 (U.S. Department of Commerce, 2010).

The Coquille River forms the southwest boundary of Coquille and extends approximately 99 river miles inland from the coastal community of Bandon to the headwaters of the South Fork Coquille River. It drains a total of 1,058 square miles. Coquille occupies an area of high ground on the east bank of the river, between RM 23 and RM 25. Above the State Highway 42S bridge in Coquille, the Coquille River has a drainage area of 930 square miles. The Coquille River has two major tributaries, the North Fork Coquille River and the South Fork Coquille River that meet about 12 miles upstream of Coquille, near Myrtle Point. The North Fork Coquille River drains approximately 288 square miles, while the South Fork Coquille River drains 591 square miles (Pacific Northwest River Basins Commission, 1968). Tidal influences extend as far upstream as Myrtle Point on the South Fork Coquille River.

Cunningham Creek flows southwest through the City of Coquille to its confluence with the Coquille River at RM 24.0. The Cunningham Creek floodplain divides the developed portion of Coquille into two distinct areas that are joined by State Highway 42 (West Central Boulevard). Total drainage area of the Cunningham Creek basin at its confluence with the Coquille River is 14.2 square miles. Calloway Creek is a tributary of Cunningham Creek and has a drainage area of 2.7 square miles above its confluence with Cunningham Creek. Calloway Creek and Cunningham Creek share the flood plain for about 1,500 feet north of West Central Boulevard.

Total land area within the corporate limits of Coquille is 2.7 square miles. About 60 percent of the city is undeveloped. Approximately one-third of this undeveloped land is in the flood plain (City of Coquille and Coos-Curry Council of Governments, 1978a). Existing development in the City of Coquille has occurred mainly on the terraced area northeast of the Coquille River. Approximately two-thirds of the developed land is currently used for residential purposes. Commercial development, consisting almost entirely of service-oriented business, is concentrated in the central business district. At present, commercial development is expanding eastward along West Central Boulevard. Lands developed for industrial purposes are primarily outside the corporate limits and, in most cases, are near the river. Little development has occurred within the Coquille River and Cunningham Creek flood plains because of a lack of roadway access and the need for extensive fill.

The Coquille River valley is a productive agricultural area that also supports dairy and beef production. With the exception of the river valley, much of the land surrounding Coquille is hilly and wooded.

Annual precipitation at Coquille averages 55.2 inches (City of Coquille and Coos-Curry Council of Governments, 1978a). Rainfall is heaviest in December and January, when a series of frontal storms frequently pass through the area. These storms are formed when cold, polar air from the Aleutian region merges with the warm air of the Central Pacific. On average, only about 4 percent of the total annual rainfall occurs in June, July, and August. The average annual temperature in Coquille is approximately 50 to 55°F.

Most of Coquille is underlain by Quaternary fluvial terrace deposits. Flood plain areas along Cunningham Creek and the Coquille River are underlain by unconsolidated deposits of sand, silt, clay, and mud (City of Coquille and Coos-Curry Council of Governments, 1978b).

City of Lakeside

The City of Lakeside is located in the northwestern corner of Coos County on Tenmile and North Tenmile Lakes. Lakeside is approximately 15 miles north of Coos Bay, 15 miles south of Reedsport, and 3 miles west of the Pacific Ocean. The city was incorporated in 1974. According to the 2010 U.S. Census, the population of Lakeside was 1,699 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 1,437 (U.S. Department of Commerce, 2010).

The southwest corner of North Tenmile Lake, the west end of Tenmile Lake, and 1.2 miles of Tenmile Creek are within the city limits of Lakeside. North Tenmile Lake and Tenmile Lake cover approximately 980 acres and 1,350 acres, respectively (Sidor and Brown, 1967). The drainage area above the North Tenmile Lake outlet near the North Lake Road Bridge is 29.0 square miles. North Tenmile Lake drains into Tenmile Lake through a 0.4-mile-long canal. The drainage area above the Tenmile Lake outlet and near the Hilltop Drive Bridge is 70.6 square miles. Tenmile Creek flows west from Tenmile Lake for 5.1 river miles before entering the Pacific Ocean. Above the Wildwood Drive Bridge and the confluence of Tenmile and Eel Creeks, Tenmile Creek drains an area of 97 square miles.

Several recreation areas border Lakeside: William M. Tugman State Park is to the north, and the Oregon Dunes National Recreation Area and the Siuslaw National Forest are to the west. Both Tenmile Lake and North Tenmile Lake are known for their sports fishing. U.S. Highway 101 and the Port of Coos Bay Railway serve the area, and Lakeside Municipal Airport is located in Lakeside.

The City of Lakeside covers 2.3 square miles. Development is primarily residential with most commercial development located along North 8th and South 8th Streets. Development in the flood plain includes a tourist resort on North Tenmile Lake, several residences along Tenmile Creek, and the city's sewage treatment plant.

Average annual precipitation at Lakeside is approximately 70 inches (Pacific Northwest River Basins Commission, 1969). Approximately 80 percent of the rainfall occurs between October and March. January is the coldest month, with an average temperature of approximately 45°F. August is the warmest month, with an average temperature of approximately 60°F. The predominant soil type found in Lakeside is composed of loamy sand, sand, and fine sand formed in wind-deposited material. Gravelly loams and silty loams formed from weathered sedimentary rock occur around Tenmile and North Tenmile Lakes (U.S. Department of Agriculture, 1975).

City of Myrtle Point

The City of Myrtle Point is located in the south-central portion of Coos County. The closest incorporated community is the City of Coquille, located 9 miles to the north along State Highway 42. The coastal community of Coos Bay is located approximately 27 miles to the north and is connected to Myrtle Point by a branch line of the Southern Pacific Railroad. The city is bounded by the unincorporated areas of Coos County. The city was incorporated in 1887. According to the U.S. Census Bureau, the population of Myrtle Point was 2,514 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 2,712 (U.S. Department of Commerce, 2010).

The South Fork Coquille River flows along the western boundary of Myrtle Point. The City of Myrtle Point occupies an area of high ground on the east bank of the South Fork Coquille River, between RM 37.0 and RM 38.0 (Pacific Northwest River Basins Commission, 1968). The confluence of the South Fork Coquille River and the North Fork Coquille River is at RM 36.4, a short distance downstream of Myrtle Point. State Highway 42 is the major highway between the coast, Myrtle Point, and inland areas. A bridge, roadway, and overflow bridge have been constructed across the South Fork and its floodplain at Spruce Street (RM 37.4) to serve access to a secondary highway to Bandon.

Total land area within the corporate limits of Myrtle Point is 1.6 square miles. The majority of residential and commercial development in the City of Myrtle Point is located on a plateau some 75 feet above the river valley. Scattered residential and industrial development exists within and along the fringes of the floodplain boundary. Commercial development includes a wide spectrum of retail- and service-oriented businesses centered along State Highway 42 and Spruce and Maple Streets. Limited light industrial development exists close to the Southern Pacific Railroad tracks along the western edge of the city.

The Coquille River valley is a productive agricultural area that also supports dairy and beef production. With the exception of the river valley, much of the land surrounding Myrtle Point is hilly and wooded.

Annual precipitation at Myrtle Point averages 56 inches. Rainfall is heaviest in December and January, when a series of frontal storms frequently pass through the area. On average, only about 4 percent of the total annual rainfall is received in June, July, and August. The average daily temperature in Myrtle Point is 62°F. Temperature extremes have been recorded as low as 0°F in winter and over 100°F in summer (City of Myrtle Point and Coos-Curry Council of Governments, 1979).

Sandstone, basalt, poorly sorted gravel, sand, silt, and clay are the predominate rock and soil types found in the area (Beaulieu and Hughes, 1975).

City of North Bend

The City of North Bend is located in western Coos County. The city lies on the northern end of a peninsula that extends north into Coos Bay estuary. North Bend is located approximately 2 miles west of the Pacific Ocean, approximately 25 miles south of Reedsport, and approximately 19 miles north of Coquille. North Bend is bounded by Coos Bay to the north and east, and by the City of Coos Bay to the south and west. The City of North Bend covers 5.1 square miles. The elevation in North Bend varies below sea level in the bay to approximately 160 feet at the western city limits. The city was incorporated in 1903. According to the U.S. Census Bureau, the population of North Bend was 9,695 in 2010 (U.S. Department of Commerce, 2010). In 1990, the population was 9,614 (U.S. Department of Commerce, 2010). The economy of North Bend is based on shipping, retail trade, and tourism.

Pony Creek flows north through the center of North Bend to the Coos Bay estuary, and drains the central portion of the peninsula on which the Cities of Coos Bay and North Bend are located. The creek has a length of 5.6 miles and a drainage area of 6.4 square miles above Virginia Avenue. As previously mentioned, the Coos Bay-North Bend Water Board operates two dams on Pony Creek for municipal water supplies.

The average annual rainfall at North Bend is 61.2 inches (Pacific Northwest River Basins Commission, 1968). The mean temperature in January, the coldest month, is approximately 46.6°F and in July, the warmest month, the mean temperature is approximately 59.0°F. In winter, the prevailing winds are from the southwest, while from May through August, the prevailing winds are from the northwest. Winter winds are usually milder than those during the summer except during an occasional winter storm.

Development in the floodplain is clustered around the Pony Creek and includes a shopping mall on Virginia Avenue and several businesses along Broadway Avenue. Some residential developments are also in the floodplain.

Soils in North Bend are predominantly sands and sandy loams. In areas affected by tidal action along the bay and Pony Creek, the soils range from silty clay loams to sandy loams (U.S. Department of Agriculture, 1975). Most of North Bend is underlain by coarse- to fine-grained sandstone of the Coaledo formation (Beaulieu and Hughes, 1975).

North Bend is served by U.S. Highway 101, the Union Pacific Railroad, and is the site of the Southwest Oregon Regional Airport.

City of Powers

The City of Powers is located in southern Coos County. The closest incorporated community is the City of Myrtle Point, located 21 miles to the north along State Highway 42. The coastal community of Coos Bay is located approximately 42 miles to the north. The city is bounded by the unincorporated areas of Coos County. The city was incorporated in 1945. According to the U.S. Census Bureau, the population of Powers was 689 in 2010 (U.S. Department of Commerce, 2010). Total land area within the corporate limits of Powers is approximately 416 acres.

The South Fork Coquille River flows through the center of Powers. Powers is located 28 miles upstream of the confluence of the South and North Forks of the Coquille River. Although the City of Powers participates in the National Flood Insurance Program, a Flood Insurance Study had not been previously developed.

2.3 Principal Flood Problems

Riverine and Estuarine

Most flooding in Coos County occurs on the Coquille River and its tributaries. The Coquille River at Coquille and the South Fork Coquille River at Myrtle Point typically exceed flood stage at least once each winter. Most other rivers and streams in the county flood less frequently. Riverine flooding usually occurs from November through February when storms moving inland off the Pacific Ocean cause heavy rainfall.

In the lower reaches of the Coquille River, higher than normal tides combining with high runoff can cause extensive flooding. Storm runoff is high because of moderately steep to steep terrain and the characteristic low soil permeability in the upper Coquille River valley. A natural constriction in the Coquille River valley downstream of Riverton and tidal influences control the flood elevations at the City of Coquille. The river valley at Coquille is flooded an average of 3 months each year (City of Coquille and Coos-Curry Council of Governments, 1978a). Natural levees along the riverbanks result in poor drainage from overbank areas as floodwaters recede. The worst flooding occurs when high tides combine with high runoff and onshore winds during major winter storms.

Flood stage at Coquille is 21 feet while the flood stage at Myrtle Point is 33 feet (National Oceanic and Atmospheric Administration [NOAA], 2010). Extreme riverine floods have occurred in February 1890, December 1955, December 1964, and November 1996. Major flooding occurred in the Coquille River valley in December 1951, January 1953, November 1953, January 1971, January 1974, December 1980, December 1981, January 1995, and December 2005.

The largest observed flood in the basin, in February 1890, crested at 23 feet at the State Highway 42S Bridge in Coquille. In both December 1955 and December

1964, the river crested at 21.1 feet at Coquille with an estimated discharge of 120,000 cubic feet per second (cfs) (City of Myrtle Point and Coos-Curry Council of Governments, 1979). The estimated return period for both the 1955 and 1964 floods is 200 years. During floods of this magnitude, an estimated 300,000 acre-feet of water covers the Coquille River flood plain to an average depth of 15 feet. Damages to the Coquille River basin during the December 1964 flood totaled $3.1 million. About one-half of the damages were agricultural (USACE, 1969). Flooding in the Coquille River basin during the February 1999 flood totaled $5 million in crop damage (Coos County Emergency Management Department, 2005).

Flood stage in the Myrtle Point area is higher than in the areas downstream because of a natural constriction in the flood plain immediately downstream of the confluence of the North and South Forks of the Coquille River. In December 1964, the Spruce Street Bridge staff gage at Myrtle Point, indicated that the South Fork Coquille River crested at approximately 11 feet above flood stage (bankfull discharge) (City of Myrtle Point, 1964) with an estimated discharge of 100,000 cfs. This flow has a return period greater than 500 years. Stream Gage No. 14325000 on the South Fork Coquille River at Powers recorded a peak flow of 48,900 cfs. This flow has a return period of about 500 years.

Flooding on the North Fork Coquille River is often affected by backwater from the South Fork Coquille River. However, a localized storm system could cause flooding on the North Fork with resulting water-surface elevations that are not significantly affected by South Fork flows. During the December 1964 flood, the North Fork Coquille River near Myrtle Point (Stream Gage No. 14327000) peaked at 38,400 cfs. This flow has a return interval of 55 years (Beaulieu and Hughes, 1975).

Flooding on Cunningham Creek and Calloway Creek is affected by backwater from the Coquille River, During the December 1964 flood, flow from Cunningham and Calloway Creeks was 1 to 1.5 feet deep over West Central Boulevard in the City of Coquille.

Most flooding on Ferry Creek, located within the corporate limits of Bandon, results from high tides and storm surge in the Coquille River estuary backing up flow in the creek. During the 1955 flood, there were 18 inches of water in the Bandon Cheese Cooperative building on the west bank of Ferry Creek between U.S. Highway 101 and 3rd Street E. In December 1981, the creek overflowed near the intersection of 3rd Street E. and Grand Avenue. Water was 18 inches deep in one building southeast of the intersection. The overflow traveled down 3rd Street E. and Fillmore Avenue to the Coquille River estuary.

In December 1964, the flow at the only stream gage in the Coos River basin, No. 14324500, on the West Fork Millicoma River near Allegany, peaked at 5,560 cfs. This flow has a return period of only two years. The peak recorded flow at the

Allegany gage was 8,100 cfs in November 1960. This flow has a return period of about 8 years.

Until 1980, the flood plain along Pony Creek, located in the cities of North Bend and Coos Bay, had not been developed. As development occurs in this area, the potential for flood damage could increase substantially. In December 1980, water levels almost reached the Woodland Medical Village on Pony Creek east of Broadway Avenue after a period of heavy rainfall. The peak flow recorded at USGS Stream-Gage No. 14324580 below the lower Pony Creek dam for December 1980 was 73 cfs. The peak flow of record at the gage was 181 cfs in December 1981.

Flooding on North Tenmile Lake, Tenmile Lake, and Tenmile Creek in Lakeside usually occurs from October through March, during periods of heavy rainfall. Major floods in Lakeside typically have occurred in December or January. The largest recorded flood on Tenmile Creek came in December 1964 during a period of extensive flooding throughout western Oregon. The peak recorded flow at the USGS gage, Number 14323200, Tenmile Creek near Lakeside, was 3,330 cfs. This flow has a return frequency of approximately 36 years. The maximum elevation of Tenmile Lake during the 1964 flood was 18.8 feet measured at a staff gage maintained by the USGS near the outlet of Tenmile Lake. This elevation has a return frequency of approximately 17 years. East of South 8th Street, floodwaters almost reached North Lake Avenue. The Lakeside Division of Bohemia Lumber Company was flooded. West of North 6th Street floodwaters reached the second step of the Northlake Resort grocery store.

In January 1953, before the Tenmile Creek stream gage and Tenmile Lake staff gage were installed, Tenmile Lake reached an elevation of 19.8 feet. This elevation has a return frequency of approximately 53 years. Other major floods have occurred in 1969, 1977, and 1982 as a result of heavy rainfall. Flooding in December 1982 was close to what would be expected during the 1-percent-annual-chance event.

There is limited development along the shoreline of the Coos Bay estuary except in the incorporated areas of Coos Bay and North Bend, and in the unincorporated communities of Barview, Charleston, and Glasgow. Flooding in Coos Bay is most likely to occur from November through March, when rainfall is greatest and major storms are most likely to occur. In the past, most severe flooding in the City of Coos Bay has been caused by high tides in the Coos Bay estuary occurring during periods of high rainfall and runoff. In December 1964, a high tide of 6.1 feet combined with strong southerly winds to flood Bayshore Drive and several homes along Front Street to a depth of 6 inches. In December 1965, high water flooded the lobby of the Fitzpatrick Building, the basement of the old City Hall, and the intersection of South Broadway and Hall Avenue. In January 1966, December 1967, December 1968, December 1969, and December 1972, high tides of approximately 6 feet caused flooding along South Broadway and U.S.

Highway 101. In January 1973, several businesses along Front Street and North Bayshore were flooded. Development in Eastside, North Bend, Barview, and Glasglow has generally occurred in areas unaffected by flooding. Flooding in Charleston has reached some of the lower-lying commercial areas in the past when storm surge combined with high tides.

Coastal

The Coos County shoreline is the product of a variety of processes that have helped shape the morphology of the beaches and shorelines over the past several thousand years. These include the effects from great earthquakes associated with the Cascadia subduction zone that produced giant tsunamis that inundated significant areas of the coast as well as having lowered the coastal land elevations, thereby initiating a new sequence of shoreline evolution. More recent effects are due to humans, including the construction of the jetties at the mouth of the Coquille and Coos estuaries, and indirectly through the introduction of non-native dune grasses that have stabilized significant stretches of the coast, enhancing the growth of dunes and dramatically changing the character of the coast.

Beach morphodynamics along the Bandon shoreline today is a function of the response of the coast to the most recent Cascadia subduction zone earthquake (1700), with the coast now being emergent due to tectonic uplift, and human effects associated with the construction of the Coquille jetties. The primary sediment sources for the Bandon beaches are fine sands that are carried down the Coquille River and gravels (sand to pebbles) supplied by the erosion of Blacklock Point, located to the north of Cape Blanco in northern Curry County. Sand has also been lost from this stretch of shore due to Aeolian processes that have carried the finer sand inland where it has accumulated and formed dunes, a loss that is particularly significant south of Bradley Lake near Bandon where a field of dunes has formed. Sand dunes have also accumulated at the back of the beach along the length of the New River Spit, a ridge of foredunes that separates the ocean beach from the channel of the river.

Erosion of Blacklock Point north of Cape Arago is actively contributing coarser sediments to the beach system. Analyses of changes in the position of the bluff-top using historical aerial photos indicate that the bluffs along Blacklock Point are eroding at rates of ~0.09 m per year (Komar et al., 2001). These coarser sediments move along the shore in a predominantly northward direction, where they have mixed with the finer sands contributed by the Coquille River, producing a longshore variation in beach sediment grain-sizes along this shore. Pebbles dominate the beach sediments along the southern portion of the New River Spit, while the sand content decreases away from the Coquille River southward toward the southern end of the New River Spit; this southward decrease of sand in the beach reflects both the increasing distance away from the Coquille River, its source, as well as the loss of the sand inland to form dunes. The general patterns of sediment movement identified by Komar et al. (2001) does not reflect any prevailing net longshore sediment transport in any one particular direction, since within the “pocket beach” littoral cells of the Oregon coast the net transport is effectively zero (Komar, 1997). Nevertheless, sand and gravel derived from the mixing of these two sediment sources has enabled the New River Spit to prograde as the mouth of the river has slowly migrated to the north in recent decades, and with the elevations of the foredunes having increased with time, aided by the introduction of European dune grass. Over approximately 1.5 km near the tip of the Spit nearest the present day position of the river’s mouth, the beach is characterized by intermittent clumps of low dunes, separated by zones where winter storm waves actively wash over the Spit. With increasing distance southward, the dunes become progressively higher and more effective at preventing overwash during storms.

In the north along the Bandon bluffs, the beach and shoreline is considered to be stable and appears geomorphically to be unchanged from photographs taken in the early 1900s. The bluffs are covered by dense vegetation, mainly impenetrable brush, such as salal and gorse, and have not been subject to wave-induced toe erosion during the 140 years of settlement of Bandon (Komar et al., 1991).

The Bandon jetties were constructed in the late 1800s at the mouth of the Coquille River, and this locally resulted in significant changes in the shorelines. Construction of the jetties was initiated in December 1883 and the response of the shoreline is documented in Figure 1, derived from periodic surveys undertaken by USACE (Komar et al., 1976). As can be seen in Figure 1, the shoreline response in 1884 indicates rapid accretion that took place south of the jetty. This occurred as a sand spit that grew northward where it became attached to the south jetty. East of the spit, the northward advance of the spit effectively trapped a low area within the accreted land, forming a lagoon shown in the 1891 survey that still exists today (Figure 1). Aside from the build-up of sand south of the south Coquille jetty, sand also began to aggrade in the north adjacent to the north jetty. Based on this evidence and from similar studies undertaken elsewhere on the coast, this type of response demonstrates the existence of a seasonally reversing longshore sediment transport, northward during the winter and to the south in the summer, but with the long-term net transport being effectively zero (Komar et al., 1976).

The shoreline adjacent to the Coquille jetties have been broadly stable for some decades, although the dunes and low lying land characteristic of this area remain susceptible to both dune erosion and flooding from extreme ocean waves coupled with high tides (Figures 2 and 3). Figure 4 is an historical 1939 aerial photo of the ‘triangle’ adjacent to the jetties. Included in the figure is a dashed line that demarcates blowouts in the foredune that is likely to have been caused by a recent major storm(s), possible an event in January 1939 (Figure 4). Evidence for the blowouts includes significant amounts of logs and flotsam that have been carried well inland from the coast. The January 1939 storm resulted in extensive erosion elsewhere on the Oregon coast and is thought to be one of the most significant events to affect the coast in historical times (Dr. Paul Komar, Emeritus Professor, Oregon State University, December 2009). According to Dr. Komar, the 1939 aerial photographs were flown by USACE to document the effects of the storm, and is the first coastwide suite of aerial photographs of the Oregon coast. A comparison of the shoreline mapped in 1939 with the 2009 shoreline indicates little difference in the general position, reaffirming the fact that there has been little net change in the position of the shoreline over the past 70 years.

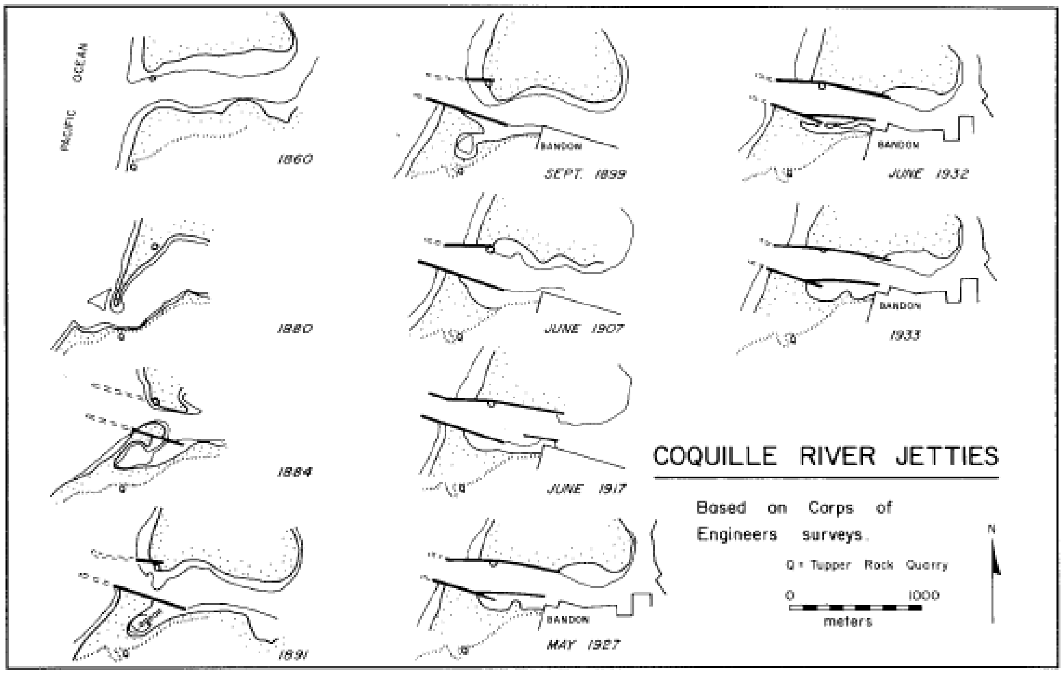


Figure 1 - USACE Coquille River Survey Lines at Bandon
Survey line drawings prepared by USACE prior to and during construction of the Coquille jetties adjacent to Bandon (Komar et al., 1991).

Figure 2 - December 22, 2000 Coastal Flooding Debris at Bandon
High wave runup and overtopping during a major storm (December 22, 2000) near the south Coquille jetty at Bandon carried logs onto the main parking lot, adjacent to a public restroom (Photo courtesy of Dr. J. Marra, pers. comm., May 2010).

Figure 3 - December 22, 2000 Wave Runup at Bandon
Wave overtopping during a major storm (22 December, 2000) surrounds the restroom and covers the parking lot adjacent to the south Coquille jetty at Bandon (Photos courtesy of Dr. J. Marra, pers. comm., May 2010).

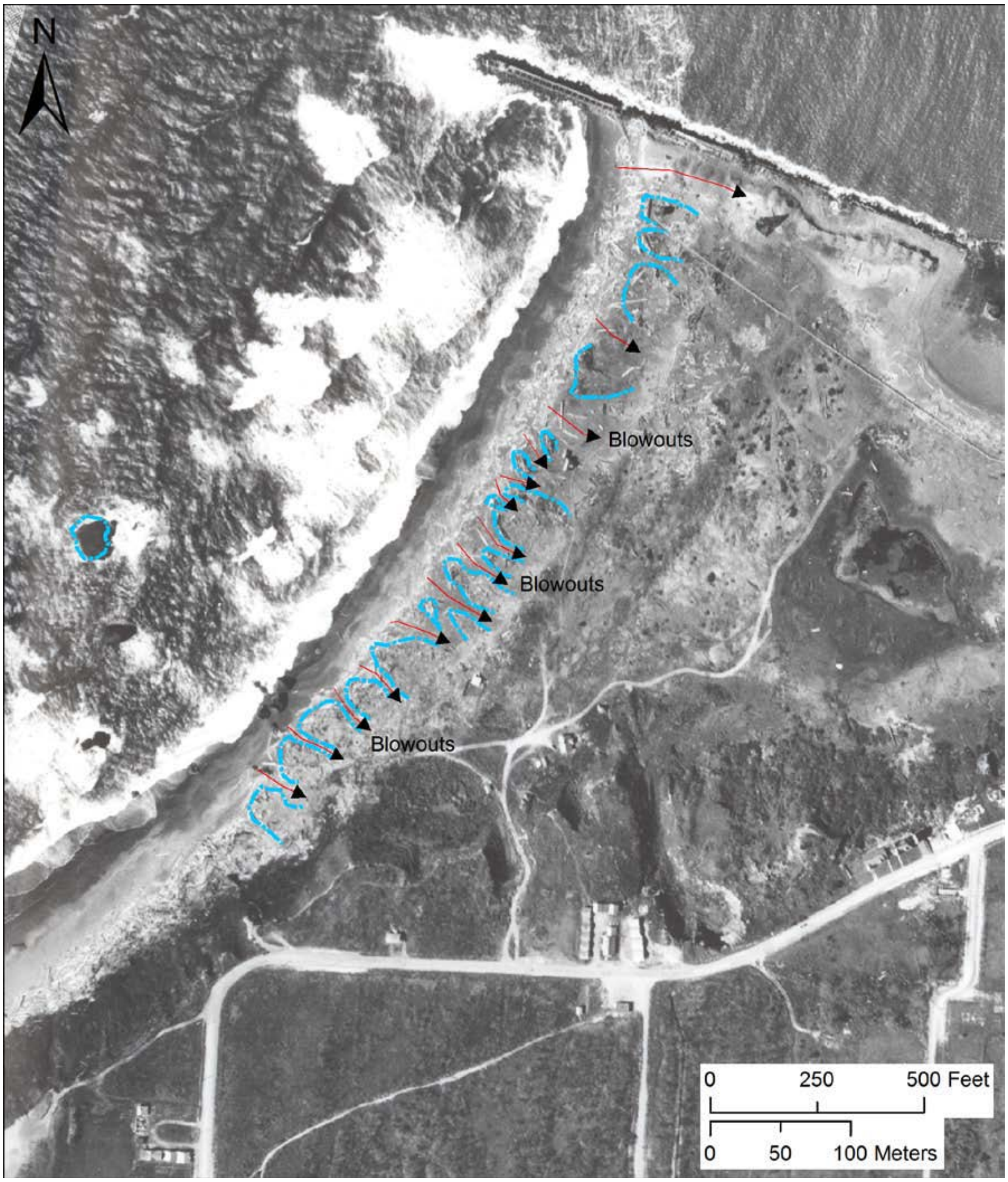


Figure 4 - 1939 Aerial Photo of Wave Blowouts at Bandon
1939 aerial photograph of the Bandon 'triangle' adjacent to the Coquille jetties showing evidence of blowouts in the developing foredune that likely occurred during a major storm in January 1939.

As part of the revised FIS undertaken in Bandon, CH2MHILL (1996) compiled a history of past flood events. These are summarized in Table 5, while Figures 2 and 3 highlight the effects of several recent storms along the Bandon 'triangle'. For example, one local resident described one storm between 1945 and 1977, which generated ocean flooding near the Bandon triangle that reached an estimated 5.6 m (NAVD88) elevation at the shore.

Table 5. History of Coastal Flooding Events at South Jetty Area of Bandon, Oregon (CH2MHILL, 1998)

Date	Comments	(Note 1) Observed Tide Level (ft. NGVD)	(Note 2) Estimated Return-Period of Tide Level (yrs)
2/9/60	Beach erosion at foot of South Jetty with drift logs 1-2 ft. dia. and stumps (est. from photos) washed est. 200' into parking lot.	NHT	---
11/20/60	62 mph southwest winds at Bandon with high tides and surf. No reported flooding, but flood damage at Newport and Tillamook.	NHT	---
10/12/62	Columbus Day wind storm "hurricane-like" winds caused much wind damage but no reported flooding.	5.45	2
1/18/64	Stormy SW wind. Seafoam 2-3 ft. deep drifted into parking lot at S. Jetty.	NHT	---
12/1/67 – 12/2/67	Very high tides and "ferocious" winds wash logs into S. Jetty parking lot and jetty access road. 10.1 ft tide (no datum reported) associated with flooding.	NHT	---
1/17/73	S. Jetty Road and top of S. Jetty littered with stumps 2-3 ft. dia. and 1 ft. (est.) logs. Sand deposited on S. Jetty Road.	6.05	< 1
11/9/75	Worst windstorm since 10/12/62. 145 mph gusts at C. Blanco. 100 mph W-NW gusts Bandon airport. No flooding mentioned.	MD	---
10/28/77	Highest waves in years. "Water surged 9.5 feet (?) instead of normal 1 foot in Bandon Harbor." Drift logs 1-2 ft. dia. washed into S. Jetty parking lot approximately 200 feet.	4.63	< 1
12/13/77	Foam and sheets of water surge over foot of S. Jetty.	NHT	---
2/7/78	3 ft. dia. drift logs and sand on S. Jetty Road from high tide and breaking waves	6.25	18
11/22/79	2-3 ft. diameter stumps and sand washed onto S. Jetty Road. High waves reported.	NHT	---
11/13/81 - 11/14/81	Est. 100 mph gusts at Bandon. Much wind damage. No reported flooding.	5.91	7
1/28/83 - 1/29/83 (dates approx.)	Waves wash across S. Jetty Road opposite Bandon lighthouse into freshwater pond. Coos County in process of placing rock along road shoulder to prevent further damage.	6.90	141
11/22/88	High tides and waves scattered foam over S. Jetty parking lot.	5.24	1.1
1/29/90	62-98 mph wind gusts. Driftwood tossed into S. Jetty parking lot. "[Significant] waves measured at 26 feet " at wave buoy 5 miles off Bandon's Bar.	NHT	---

Table 5. History of Coastal Flooding Events at South Jetty Area of Bandon, Oregon (CH2MHILL, 1998) (continued)

Date	Comments	(Note 1) Observed Tide Level (ft. NGVD)	(Note 2) Estimated Return-Period of Tide Level (yrs)
1/30/92 - 1/31/92	"Huge piles" of driftwood washed up on beach at the S. Jetty.	NHT	---
12/10/92 - 12/11/92	"Heavy surge" cuts through the bank behind Bandon Boatworks Restaurant with new channel cut to Redman Pond. Small driftwood logs (4" dia.) deposited next to 2 houses immediately south of parking lot.	5.28	1.2
12/9/93 - 12/10/93	Ocean waves and river erode backshore shoreline vicinity of Redman Pond	N/A	---

Notes:

1. Tide elevations based on observed tides at Crescent City, which is the primary reference station for tides at Bandon. Elevations shown are for recorded monthly maximums. NHT = not highest monthly tide observed at Crescent City. MD = Missing data for month. N/A = Not available as of late 1994 from NOAA.

Beach morphodynamics along Bastendorff Beach are similar to those observed along the Bandon shore. Prior to construction of the Coos Bay jetties, the entrance to Coos Bay reflected a rocky stretch of coast along its south bank, while an extensive barrier spit was located to the north that protected the Coos Bay estuary from the direct effects of ocean waves. Jetty construction was initiated first on the north spit and by the beginning of the 20th century the shoreline had prograded seaward by about 1 km (~3000 ft), while the shoreline had straightened significantly as sand piled up against the north jetty. With the construction of the south jetty early in the 20th century, a similar response was observed in the south (Figure 5). Sand accreted against the jetty and against the rocky shore and the shoreline began to prograde seaward. As can be seen in Figure 5, the shoreline rapidly prograded seaward up until the 1960s. Since 1967, however, the shoreline has essentially remained much the same as it is today suggesting that the beach has reached a quasi-equilibrium state with the sediment transport processes. With the shoreline progradation having all but ceased by 1967, the back shore portion of the beach rapidly became stabilized due to the introduction of non-native beach grasses, particularly European Beach grass, and from growth of shore pines immediately landward of the primary dune (Figures 6 and 7). This type of response is characteristic of the entire length of Bastendorff Beach. Further south at Lighthouse Beach, the shoreline in the 1920's is essentially unchanged from its position in 1967 and again in 2008. This indicates that the effects of jetty construction did not extend south of Bastendorff Beach and furthermore that the shoreline has been broadly stable over the past 80-90 years.

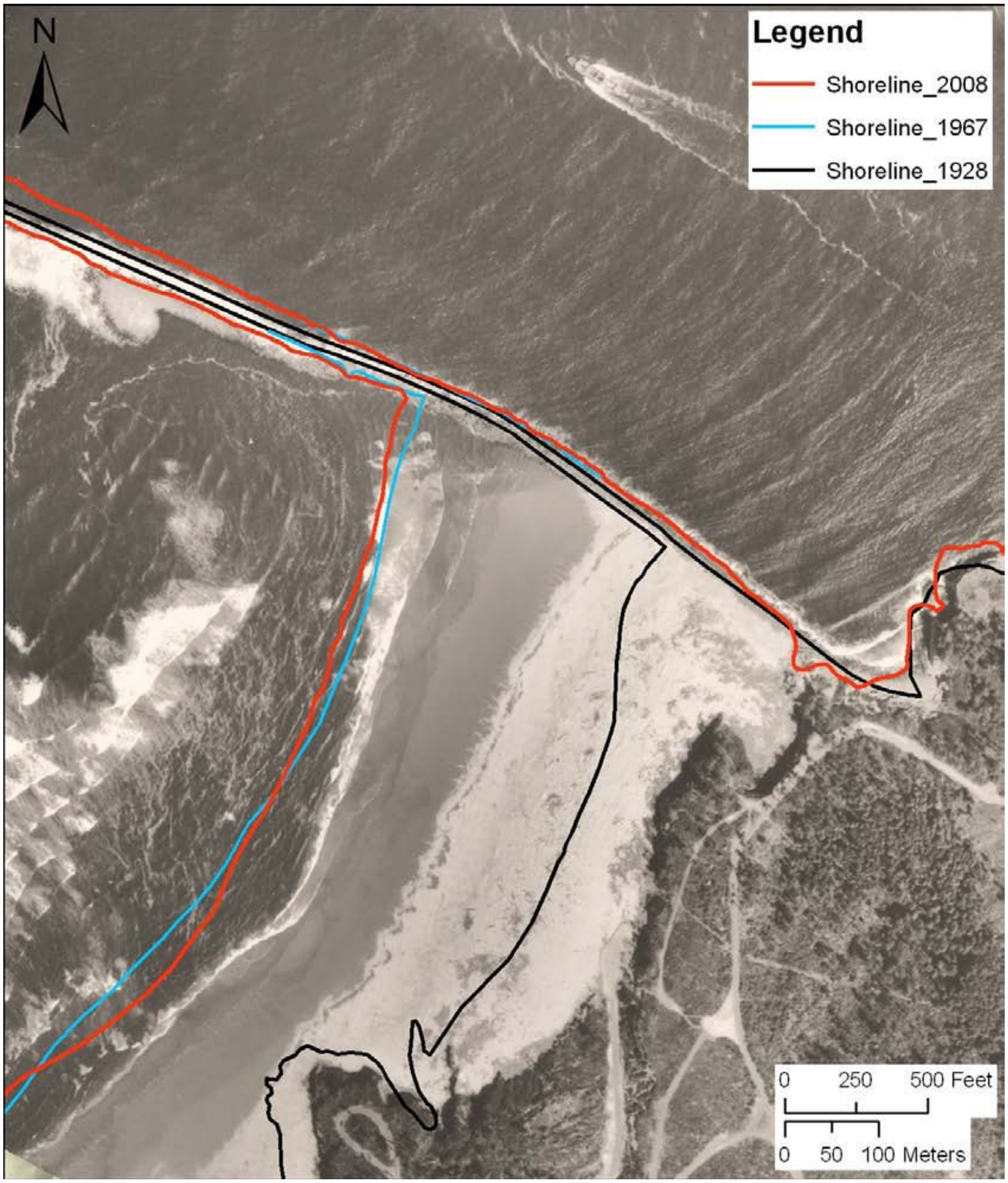


Figure 5 - Historical Shorelines at Bastendorff Beach Overlaid on 1939 Aerial Photo
Historical shoreline changes at Bastendorff Beach adjacent to the Coos Bay jetties. The photo is of the beach in 1939.

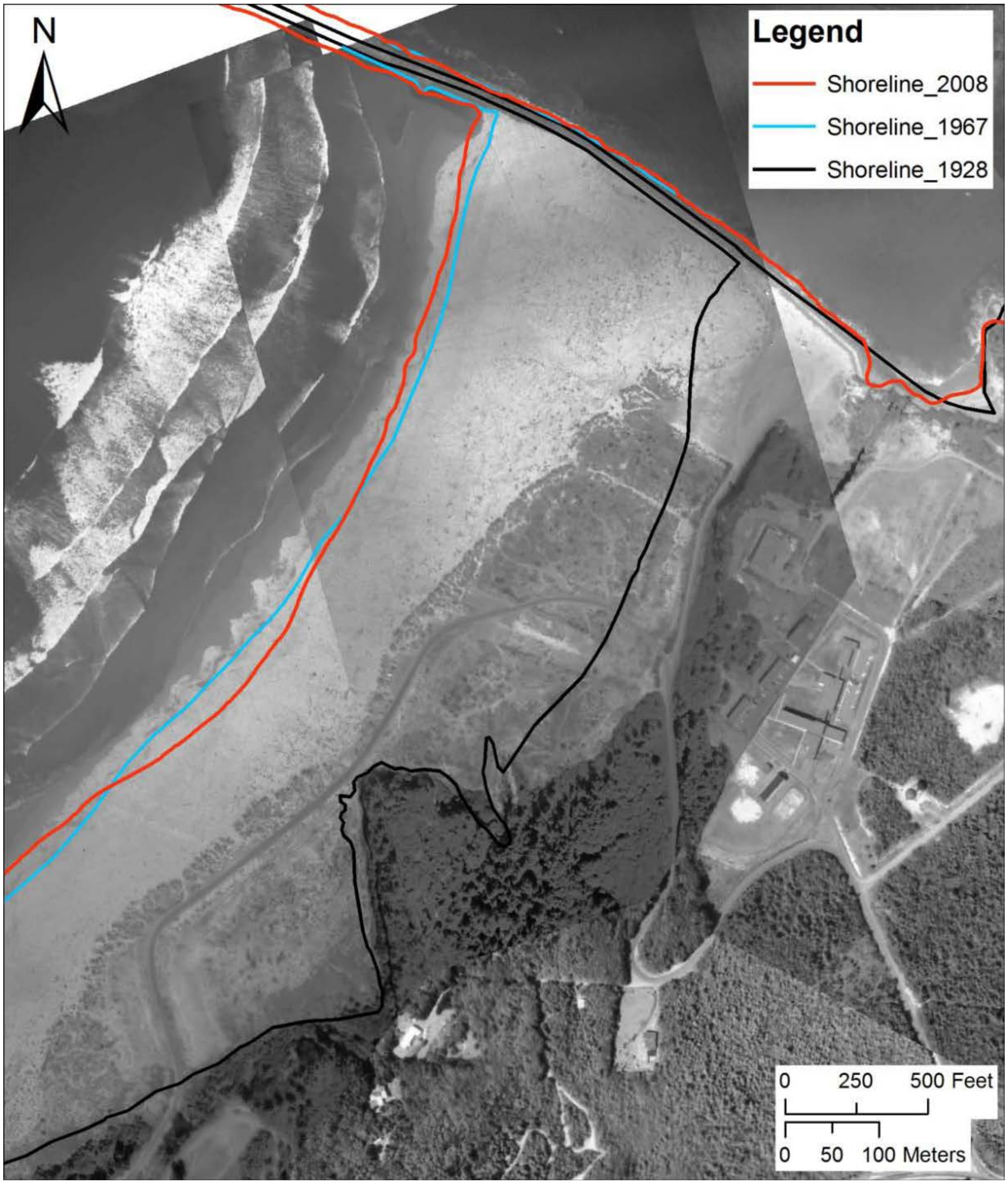


Figure 6 - Historical Shorelines of Bastendorff Beach Overlaid on 1967 Aerial Photo
Historical shoreline changes at Bastendorff Beach adjacent to the Coos Bay jetties. The photo is of the beach in 1967 and shows the degree to which the backshore has become stabilized due to introduction of European beach grass and from growth of shore pines.

Figure 7 - April 9, 2010 Photo of Bastendorff Beach Foredune
Photo of Bastendorff Beach on April 9th 2010 showing the well vegetated foredune and backshore. Photo taken by Jonathan Allan, DOGAMI.

2.4 Flood Protection Measures

Several structural measures providing flood protection have been taken in Coos County. The USACE stabilized the Coos Bay and Coquille River entrances by building jetties on either side of the entrance channels. The Coos Bay jetties were completed in 1929. The Coquille River jetties were completed in 1908. The USACE has also maintained navigation channels in Coos Bay, in the Coquille River estuary, and on the Coos and Millicoma Rivers. The Coos Bay navigation channel is maintained at 45 feet across the outer bar, at 35 feet from Coos Head to the junction of Coalbank and Isthmus Sloughs, and at 22 feet on Isthmus Slough between Coalbank Slough and the community of Millington. The Coquille River navigation channel is maintained at 13 feet between RM 0 and RM 1.3. The Coos River and Millicoma River navigation channels are maintained at 5 feet to RM 8.3 on the Millicoma and 8.8 on the South Fork Coos River. From RM 8.8 to RM 9.2, the South Fork Coos River navigation channel is maintained at 3 feet. All depths in the navigation channels are measured below mean lower low water.

Low-lying areas of Palouse and Larson Creeks, Kentuck Slough, and Willanch Slough have been diked with tide gates at their outlets. The tide gates prevent inundation of the low-lying areas by high tides in the bay. Most of these dikes and tide gates have been built by local drainage districts. Some areas along the South

Slough, Isthmus Slough, Coalbank Slough, Catching Slough, and the Coos River have also been diked. Most of these dikes are not high enough to completely prevent flooding. In the Coos Bay estuary, 2,000 acres of tidelands have been diked for agricultural use (Beaulieu and Hughes, 1975).

Since 1920, 1,500 acres of tidelands have been filled (Beaulieu and Hughes, 1975). Many of these fills are not high enough to completely prevent flooding. Major fills have occurred at the mouth of Pony Slough, at the mouths of Coalbank and Isthmus Sloughs, in the area north of the developed part of eastern Coos Bay (formally known as Eastside), and at Graveyard Point along the Coos River. The first three fill areas will be flooded to some extent during a 1-percent-annual-chance event.

Since the downtown area has flooded so frequently in the past, the City of Coos Bay has taken several structural measures to reduce flood damage. A dike was built along Isthmus Slough from Commercial Avenue to Coalbank Slough to protect the downtown area during high tides. The dike is frequently checked for damage and settling. The dike provides limited protection because the lowest dike elevation is 7.6 feet NGVD (11.2 feet NAVD) and in places the dike would be overtopped during a 10-, 2-, or 1-percent-annual-chance tide in the bay. During a 0.2-percent-annual-chance tide, the entire length of dike would be overtopped.

To minimize ponding behind the dike when high local runoff occurs during a high tide, the City of Coos Bay has built two pumping stations. One pumping station is located near the intersection of Front Street and Johnson Street and protects most of the area bounded by Golden Avenue to the north, 4th Street to the west, Kruse Avenue to the south, and the dike to the east. The other pumping station is located at the intersection of Commercial Avenue and 3rd Street and protects most of the area bounded by Commercial Avenue on the north, 4th Street to the west, Curtis Avenue to the south, and North Broadway to the east. These pumps can only provide complete protection when there is little or no overtopping of the dike.

Several storm sewer systems in the City of Coos Bay, including the Mill Slough Box that drains Blossom Creek, have tide gates at their outlets to prevent high tides from backing up into the systems. During periods of high tide combined with high runoff, ponding will occur behind the tide gates.

Some flood protection is provided on Pony Creek because flow downstream of Ocean Boulevard is regulated by two reservoirs operated by the Coos Bay-North Bend Water Board for municipal water supplies. The reservoirs are not operated for flood control, but some flood control is provided because runoff is stored during the rainy season for use during the dry season. Typically, the upper reservoir reaches its lowest level in late fall and refills during the rainy season. Once the water level reaches an elevation of 82 feet (85.6 feet NAVD88), the pool level will be maintained until mid-March, and no more runoff will be stored. During the winter, the lower reservoir is operated with free flow over the spillway because of dam safety considerations. Unless the reservoir has been drawn down below the spillway lip during the dry season, no storage volume will be available to store runoff.

The South Fork Coquille River stream gage at Powers, the staff gage at Coquille, and the staff gage at Myrtle Point are three of 15 key stations in Subregion 10 of the Flood Forecasting System operated by the National Weather Service (Pacific Northwest River Basins Commission, 1971). Subregion 10 covers coastal systems in Oregon and part of Washington. Flood warnings are issued when forecasts indicate that near bankfull stages are expected. When flood stage is reached, bulletins are issued at 12-hour intervals until the streams recede and the danger has passed.

In the City of Bandon, several property owners along the Pacific Ocean have placed berms and riprap around their homes to protect them from wave action.

The Portland Weather Forecast Office issues storm tide warnings indicating expected tidal flooding along low-lying coastal areas. Warnings include expected tidal stages above mean lower low water or departure from normal high tide, degree of flooding, possible wave or surf battering, and significant beach erosion.

The U.S. Coast and Geodetic Survey prepared warnings and advisories of tsunamis. Local officials have the responsibility for advising the local population.

The Cities of Bandon, Coos Bay, Coquille, Lakeside, Myrtle Point, North Bend, Powers, and Coos County participate in the National Flood Insurance Program and each have a floodplain ordinance approved by FEMA for controlling development in flood hazard areas.

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

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-, 50-, 100-, 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-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 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 peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Hydrology for Detailed Riverine Studies

Regionalized flood prediction equations were developed for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods based on statistical analysis of the data recorded at USGS stream gages listed in Table 6. The statistical analyses of these gages followed the standard log-Pearson Type III method as outlined by the U.S. Water Resources Council (1977).

Table 6. USGS Stream Gages Used for Statistical Analysis

Gage Number	Location	Years of Record[2]
14299000[1]	South Fork Necanicum River near Seaside	16
14301500	Wilson River near Tillamook	46
14302500[1]	Trask River near Tillamook	37
14303600	Nestucca River near Beaver	11
14305500	Siletz River at Siletz	60
14306100	North Fork Alsea River at Alsea	18
14306400	Five Rivers near Fisher	14
14306500	Alsea River near Tidewater	37
14324500	West Fork Millicoma River near Allegany	25

Table 6. USGS Stream Gages Used for Statistical Analysis (continued)

Gage Number	Location	Years of Record[2]
143246001	South Fork Coquille River above Panther Creek, near Illahe	14
14324700[1]	South Fork Coquille River near Illahe	18
14324900[1]	South Fork Coquille River near Powers	14
14325000	South Fork Coquille River at Powers	60
14326500[1]	Middle Fork Coquille River near Myrtle Point	17
14326800[1]	North Fork Coquille River near Fairview	16
14327000[1]	North Fork Coquille River near Myrtle Point	22

[1] Discontinued gages

[2] As of 1982

Flow records for 23 other gages were initially considered but were not used in this study for several reasons. These reasons included significant regulation by lakes, stream flow records from abnormally dry periods, and gauging of watersheds less than 10 square miles where local hydrologic conditions are not representative of regional conditions.

Flood flows for the Coquille River, South Fork Coquille River, Millicoma River, East Fork Millicoma River, and West Fork Millicoma River were calculated using the regional flow equation:

$$Q=KA^n$$

“Q” and “A” are the discharge in cubic feet per second (cfs) and drainage area in square miles at the study site, respectively. The constant “K” and the exponent “n” were determined for each flood using logarithmic plots of drainage area versus frequency-discharge relationship of the stream gages given in Table 4. The values determined for “K” and “n” are 550 and 0.71 for the 10-percent-annual-chance flood, 661 and 0.73 for the 2-percent-annual-chance flood, 708 and 0.74 for the 1-percent-annual-chance flood, and 830 and 0.74 for the 0.2-percent-annual-chance flood. These equations are only valid when the drainage area at the site is greater than 10 square miles.

Drainage areas at points in the study area were measured on USGS topographic maps or taken from the River Mile Index for Coastal Tributaries (Pacific Northwest River Basins Commission, 1975).

Flood flows on Calloway, Cunningham and Ferry Creeks were determined using the USGS regional method presented in Magnitude and Frequency of Floods in Western Oregon (Harris et al., 1979). Ferry Creek has been gaged near the fish hatchery by the Oregon Department of Water Resources since 1977 (No. 14327120) (Oregon Department of Water Resources, 1978). This gage has a drainage area of 4.2 square miles. At the time of the original study (1983), the gage record was too short to produce accurate estimates of low-frequency flood flows. Flows from a log-Pearson Type III frequency analysis done by the USGS (1980) on Gieger Creek flows, when transferred to the mouth of Ferry Creek were only slightly lower than those determined using regional equations.

The USGS operated the Tenmile Creek gage, Number 14323200 from August 1957 to September 1976. Because of a shifting rating curve and regulation by the two lakes, the USGS discontinued operation of the gage.

Storage volume analyses were carried out to determine the 10-, 2-, 1-, and 0.2-percent-annual-chance outflows from Tenmile Lake and the resulting elevation of Tenmile and North Tenmile Lakes.

The 10-, 2-, 1-, and 0.2-percent-annual-chance, 24-hour precipitation values (Miller et al., 1973) were used to generate inflow hydrographs to the lakes. Most major storms in this area have durations longer than 24 hours. The 24-hour precipitation amounts were used because the analyses showed peak outflow from Tenmile Lake was not very sensitive to duration and because precipitation records for longer durations were not available. Hourly precipitation amounts during a 24-hour storm were calculated using the U.S. Soil Conservation Service Type 1A precipitation distribution (U.S. Department of Agriculture, 1970). Precipitation excess was calculated assuming near-saturation conditions with a constant infiltration rate of 0.02 of an inch per hour. Snyder’s unit hydrograph method was used to generate inflow hydrographs from precipitation excess.

Base flow at the Tenmile Lake outlet was set equal to 680 cfs. The respective base flows for North Tenmile and Tenmile Lake inflow hydrographs were estimated using ratios of the tributary drainage areas to the total drainage area.

The infiltration rate, base flow, and lag times were assumed to be equal for the 10-, 2-, 1-, and 0.2-percent-annual-chance events. The infiltration rate, base flow, and lag times were determined by calibrating a hydrograph, generated from precipitation at Reedsport and Allegany recorded during the December 1964 flood (USACE, 1966; U.S. Department of Commerce, 1965), to the recorded flood hydrograph at the Tenmile Creek gage (City of Myrtle Point, 1964). The 24-hour precipitation was taken as the only variable for the 10-, 2-, 1-, and 0.2-percent-annual-chance events.

The USACE HEC-1 flood hydrograph computer program (USACE, 1973) was used to generate the inflow hydrographs from precipitation and to route the hydrographs through the lakes. Routing through the lakes required storage-capacity curves that were developed from USGS topographic maps (Harris et al., 1979). The outflow rating curve for Tenmile Lake was developed from a backwater analysis on Tenmile Creek. The outflow rating curve for North Tenmile Lake was approximated by a normal depth calculation for a canal cross section at the North Lake Avenue Bridge.

The peak lake elevation for Tenmile Lake was determined from its outflow rating curve using the peak 10-, 2-, 1-, and 0.2-percent-annual-chance outflows. A backwater analysis on the short canal between the two lakes showed that North Tenmile Lake would peak at the same elevation as Tenmile Lake regardless of the flow through the canal connecting the lakes. These analyses reflect stillwater levels (SWLs) only. A summary of the elevation-frequency relationship for the two lakes is shown in Table 8, “Summary of Elevations”.

Flows in Pony Creek downstream of Ocean Boulevard are regulated by two Coos Bay – North Bend Water Board water-supply reservoirs. For this reason, the USACE HEC-1 computer program was used to generate inflow hydrographs through the reservoirs downstream to the former location of the tide gates at Crowell Lane.

Inflow hydrographs were generated from the 10-, 2-, 1-, and 0.2-percent-annual-chance, 24-hour precipitation (Miller et al., 1973) for each drainage subarea along Pony Creek. The precipitation was distributed over a 24-hour period using the U.S. Soil Conservation Service’s Type 1A precipitation distribution (U.S. Department of Agriculture, 1970). Excess precipitation was calculated using an infiltration rate of 0.43 inches per hour estimated from local soil data (U.S. Department of Agriculture, 1975).

Peak flows from the upper reservoir inflow hydrographs were compared to peak flows transferred from the USGS Geiger Creek Gage No. 14327100 near Bandon using the relationship

$$Q=Q_g(A/A_g)^{0.92}$$

Where:

Q is the flow in cubic feet per second at the study site.
A is the drainage area in square miles at the study site.
Q_g is the flow in cubic feet per second at the gage.
A_g is the drainage area in square miles at the gage.

The USGS performed a log-Pearson Type III frequency analysis on the Geiger Creek flows following the U.S. Water Resources Council Guidelines (1977). The hydrograph lag time was adjusted until the two frequency-discharge relationships were in close agreement.

The upper reservoir inflow hydrographs were then routed through the upper reservoir assuming the water level was initially at 82 feet (85.6 feet NAVD88). The upper reservoir outflow rating curve was developed from spillway geometry with stop logs placed to elevation 82 feet (85.6 feet NAVD88). The storage-capacity curve was taken from a CH2M HILL Pony Creek Water Supply report (1978). The outflow hydrographs were combined with local inflow between the two reservoirs and routed through the lower reservoir assuming the water level was initially at the spillway lip elevation of 28.4 feet (32 feet NAVD88). The lower reservoir outflow rating curve was developed from the spillway geometry with no stop logs in place. The storage capacity curve was taken from the Pony Creek Water Supply report (CH2M HILL, 1978).

Downstream of the lower reservoir, local inflow hydrographs were generated from precipitation. Urbanization was accounted for in each drainage subarea. The percent of impervious area and the extent of storm sewers in each subarea were used to determine hydrograph coefficients for the Denver Urban Storm Drainage Criteria Manual (Wright-McLaughlin Engineers, 1969). The extent of storm sewered areas was determined using a storm sewer study for the City of North Bend (Pacific Northwest River Basins Commission, 1968) and a storm sewer master plan for the City of Coos Bay (Erichsen et al., 1975). The percent of impervious area was estimated using aerial photographs at a scale of 1:12,000 (CH2M HILL, 1980). Local inflow hydrographs were combined with the lower reservoir outflow hydrographs and routed to Crowell Lane using storage-outflow relationships developed from preliminary step-backwater calculations. Drainage areas for Pony Creek were measured on USGS 7.5-Minute topographic maps (USGS, various years).

Hydrology for Approximate Riverine Studies (Revised)

Stream flow data for revised approximate studies of riverine flooding in Coos County were provided by the USGS web tool StreamStats for Oregon (Cooper, 2005). Discharges were acquired for the 1-percent-annual-chance peak flow at each stream confluence and downstream terminus (i.e. the Coquille River's confluence with the Pacific Ocean).

There were several exceptions where StreamStats for Oregon was not used to acquire stream flow data. Due to the unsuitability of using StreamStats for reaches downstream of large water bodies, stream flow data for the approximate study sections of Tenmile Creek was acquired from the hydrologic model prepared by CH2M HILL for the detailed study of Tenmile Creek. Coastal lakes in the Oregon Dunes National Recreation Area (Lyons Reservoir, Snag Lake, Sandpoint Lake, Spirit Lake, Horsfall Lake) are not hydrologically connected to any riverine flooding source and were therefore re-delineated to a representative 1-percent-annual-chance flooding elevation based on the previous mapping. The Empire Lake reservoirs and Tarheel Lake reservoir were mapped to a 1-percent-annual-chance flooding elevation equal to the elevation of dam-overtopping.

Hydrology for Detailed Estuarine Studies

The methodology developed by CH2M HILL for study of Pacific Northwest storms was used to study the coastal flooding influence on estuaries in Coos County. This method involves statistical analysis of the various components of ocean flooding caused by storms and a combined probability analysis to determine the effect of these components on flood levels. It is applicable to detailed study areas in the cities of Bandon, Coos Bay, North Bend, and Lakeside where static base flood elevations have been determined for Coquille River, Ferry Creek, Coos Bay, South Slough, Pony Slough, North Slough, Haynes Inlet, Coalbank Slough, Blossom Creek, Isthmus Slough, Catching Slough, Coos River, North Tenmile Lake, and Tenmile Lake.

High astronomical tides are a major component of ocean flooding. Predicted astronomical tides were calculated on an hourly basis for the study areas based on the National Oceanic and Atmospheric Administration (NOAA) Tide Tables (1980). The hourly predicted tides were used to compute the astronomical tide height histogram (Brocherdt and Borgman, 1970).

Storm surge, or the rise in water from wind stress and low atmospheric pressure, is also a common component of flooding. Significant storm surge-producing events were selected from 3-hour surface weather maps for the period 1942 to 1980. The storm surge heights were computed for these events and grouped into three winds direction classes. Storm-surge frequency distributions were computed from a population of the highest storm surges for each class.

Waves are another component of ocean flooding. A wave forecasting computer program was used to compute wind-generated wave height (Oregon State University, 1976). The program uses wind speed, direction, and fetch data from the surface weather maps to compute significant wave height and period at 6-hour intervals. Frequency curves were plotted for the three wind direction classes of both sea waves and swell wave heights.

The peak SWL at the entrance to Coos Bay and inflow to the bay from major streams are the main causes of flooding in the Coos Bay estuary. A series of normal winter tide cycles with the 10-, 2-, 1-, and 0.2-percent-annual-chance peak SWLs superimposed on one cycle were used in the detailed estuary analysis. Subsequently, these tide cycles will be referred to as the 10-, 2-, 1-, and 0.2-percent-annual-chance tide cycles.

SWL is a function of two components. The first component, astronomical tide, is caused by the gravitational forces exerted on the earth by the sun and the moon. The second component, storm surge, is the rise in water level due to wind stress and low atmospheric pressure.

A peak SWL-frequency curve was developed for the Coos Bay entrance using 47 years of observed tide data from an open-coast tide gage at Crescent City, California, and 12 years of observed tide data from a tide gage located in Coos Bay at Charleston. The Crescent City gage is located 100 statute miles south of the Charleston gage but both gages were found to respond similarly to major storms monitored at both gages. A frequency curve developed for the Crescent City gage was transferred to the Coos Bay entrance by adjusting for datum and location differences and compared with an elevation-frequency curve developed for the Charleston gage. The Charleston curve was then adjusted slightly to show the effects of a longer period of record the Crescent City frequency curve. SWLs at the Coos Bay entrance were then taken from the revised Charleston frequency curve.

The peak SWLs were superimposed on one cycle of a series of normal winter tide cycles predicted using the West Coast of North and South America Tide Tables (1980). It was assumed that the surge component would cause an increase in water level above the normal predicated tide level for a period of 12 hours, and that the largest increase in water level would occur half-way through that period.

Peak inflows to the Coos Bay estuary from the South Slough, North Slough, Palouse and Larson Creeks, Isthmus Slough, Catching Slough, and the Coos River were determined using the regional flow equation given previously. Triangular hydrographs were then developed using the peak inflows and assumed times to peak. A time of 20 hours was used for the Coos River basin. A time of 4 hours was used for the South Slough, Isthmus Slough, Catching Slough, Larson and Palouse Creeks, and the North Slough. The peak inflows are summarized in Table 6.

Estuary elevation-frequency curves were developed assuming a combination of riverine and tidal influences. Inflow hydrographs for the major streams entering Coos Bay were developed for the detailed estuary analysis. The peak hydrograph flows were calculated using regional flood prediction equations. These equations were developed for the 10-, 2-, 1-, and 0.2-percent-annual-chance flows based on statistical analysis of the data recorded at the USGS stream gages listed in Table 6. The statistical analyses at these gages followed the standard log-Pearson Type III method outlined by the U.S. Water Resources Council (1977).

Drainage areas for each stream used in the estuary analysis were measured on a South Coast Drainage Basin Map (Oregon State Water Resources Board, 1971) or taken from the River Mile Index for Coastal Tributaries (Pacific Northwest River Basins Commission, 1968).

Hydrology for Detailed Coastal Studies (Revised)

Measurements of tides on the Oregon coast are available from various tide gages operated by the National Ocean Service (NOS). Hourly tidal records are available from the following long-term (30+ years) coastal sites: the Columbia River (Astoria, #9439040), South Beach (Newport, #9435380), Port Orford (#9431647), and at Charleston (#9432780) located midway along the Coos County shoreline. Long-term tidal records are also available from the Crescent City tide gage (#9419750), located in northern California, and have been used in previous FIS carried out in Coos County (e.g. CH2MHILL, 1995). For the purposes of this study, we have based our SWL and wave runup calculations on the Charleston tide gage due to its central proximity along the Coos County coast and importantly because of its relatively long record (38 years). All hourly tide data were purchased from the NOS and were processed using various scripts developed in Matlab. In addition to the measured tides, hourly tide predictions were calculated for all years using the NOS tide prediction program, NTP4.

Tides along the Oregon coast are classified as moderate, with a maximum range of up to 14 ft and an average range of about 6 ft (Komar, 1997). There are two highs and two lows each day, with successive highs (or lows) usually having markedly different levels (Figure 8). Tidal elevations are given in reference to the mean of the lower low water levels (MLLW), and can be easily adjusted to the NAVD88 vertical datum. As a result, most tidal elevations are positive numbers with only the most extreme lower lows having negative values. Figure 8 shows the tidal elevation statistics derived from the Charleston tide gage (#9432780), with a mean range of 5.69 ft and a diurnal range of 7.62 ft. The highest tide measured at Charleston reached 11.18 ft, recorded in January 1983 during the peak of the strong 1982-83 El Niño.

The actual level of the measured tide can be considerably higher than the predicted level provided in standard Tide Tables, and is a function of a variety of atmospheric and oceanographic forces, which ultimately combine to raise the mean elevation of the sea. These latter processes also vary over a wide range of timescales, and may have quite different effects on the coastal environment. For example, strong onshore winds coupled with the extreme low atmospheric pressures associated with a major storm can cause the water surface to be locally raised along the shore as a storm surge, and have been found in tide-gage measurements to be as much as 4.9 ft along the Pacific Northwest coast (Allan and Komar, 2002). However, during the summer months these processes can be essentially ignored due to the absence of major storms systems.

On the Oregon coast, tides tend to be enhanced during the winter months due to warmer water temperatures and the presence of northward flowing ocean currents that raise water levels along the shore, persisting throughout the winter rather than lasting for only a couple of days as is the case for a storm surge. This effect can be seen in the monthly averaged water levels derived from the Charleston tide gage, but where the averaging process has removed the water-level variations of the tides, yielding a mean water level for the entire month. Based on 38 years of data, the results show that on average monthly-mean water levels during the winter are nearly 0.7 ft higher than in the summer. Water levels are most extreme during El Niño events, due to an intensification of the processes, largely enhanced ocean sea surface temperatures offshore from the Oregon coast. This occurred particularly during the unusually strong 1982-83 and 1997-98 El Niños. Water levels during those climate events were approximately 0.8 ft higher than the seasonal peak, and as much as 1.6 ft higher than during the preceding summer, enabling wave swash processes to reach much higher elevations on the beach during the winter months, with storm surges potentially raising the water levels still further.

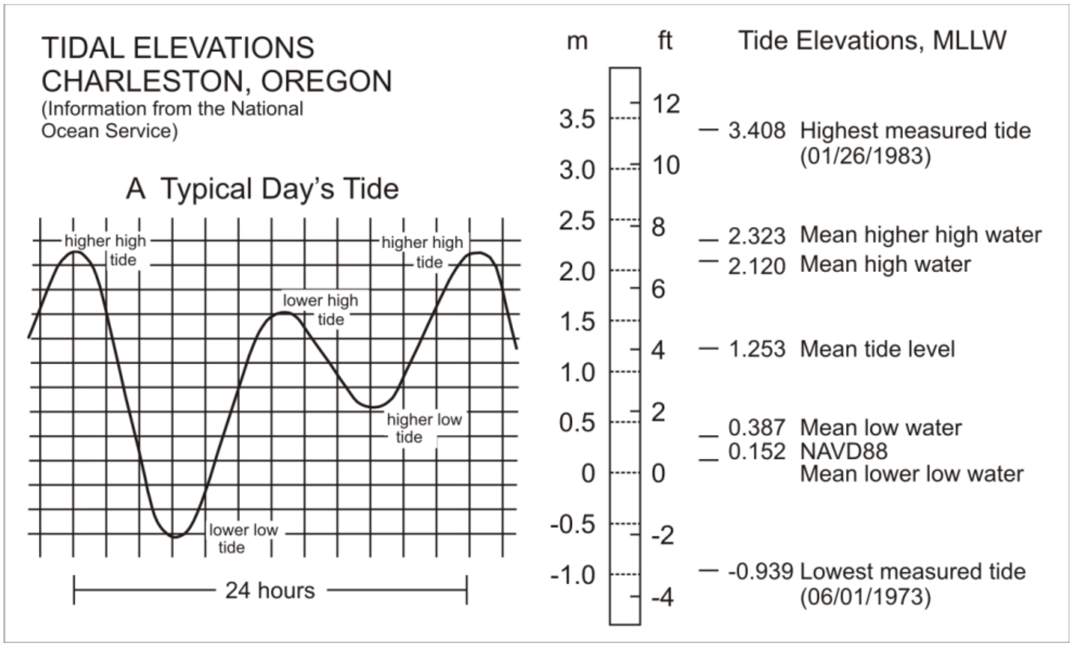


Figure 8 - Daily Tidal Elevations Measured at Charleston
Daily tidal elevations measured at Charleston on the southern Oregon coast. Data from the National Ocean Service.

Figure 9 presents results of the generalized extreme value analyses for the Charleston tide gage. In constructing this plot, a threshold of 9.2 ft was used. The calculated SWLs in Figure 9 project to the 1-percent-annual-chance event. As can be seen in Figure 9, the 1-percent-annual-chance SWL calculated for the Charleston gage is 11.2 ft, relative to MLLW. When adjusted to the NAVD88 vertical datum, this value becomes 10.7 ft; note the adjustment from NAVD88 to MLLW is 0.5 ft. The 0.2-percent-annual-chance SWL is estimated to be 10.9 ft NAVD88. As observed previously, the highest tide measured at the Charleston gage reached 10.7 ft NAVD88. Of interest, the SWL identified in the original flood mapping calculations at Bandon, based on the Crescent City tide gage (and compared with the Charleston tide gage) indicated a SWL of 10.6 ft, close to the current estimate.

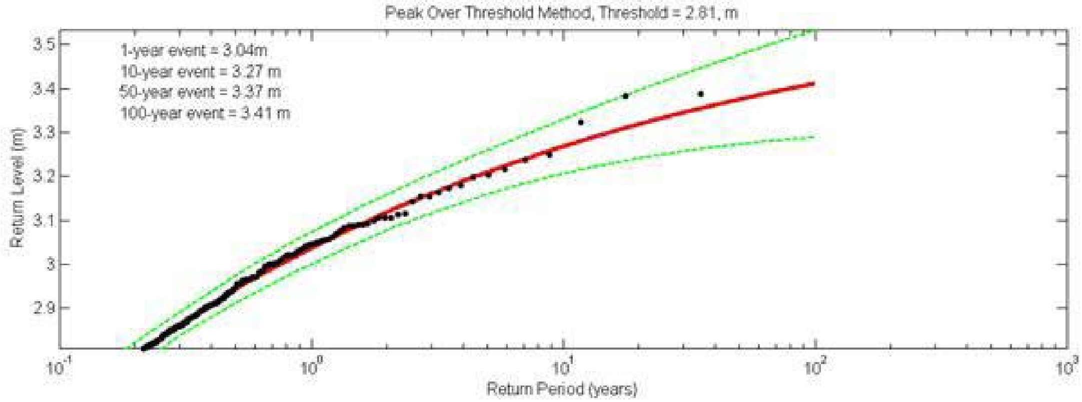


Figure 9 - Extreme-Value Analyses of SWL at Charleston Tide Gauge
Extreme-value analyses of the stillwater level (SWL) determined for the Charleston tide gage.

Flood elevations are summarized in Table 8, "Summary of Elevations". Peak discharge-drainage area relationships for each stream studied in detail are shown in Table 7, "Summary of Discharges".

Table 7. Summary of Discharges

		Peak Discharges (cubic feet per second)			
Flooding Source and Location	Drainage Area (square miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Blossom Creek					
At inlet to Mill Creek Slough Box	1.0	130	170	190	240
Calloway Creek					
Above Central Boulevard	2.7	280	400	440	530
Catching Slough					
At east side of Coos Bay corporate limits	25.2	5,440	6,970	7,710	9,040
Coos River					
At mouth	415	39,700	53,900	61,300	71,800
Coquille River					
Confluence with Pacific Ocean	1,058	77,200	107,000	122,000	143,000
At Riverton	980	73,100	101,000	116,000	136,000
At Coquille	930	70,500	97,100	111,000	130,000
At Arago	902	69,000	95,000	109,000	128,000
Confluence of North and South Forks	879	67,700	93,200	107,000	125,000
Cunningham Creek					
At mouth	14.2	1,360	1,860	2,020	2,410
Above Central Boulevard	2.7	280	400	440	530
East Fork Millicoma River					
At confluence with West Fork	79	12,200	16,000	18,000	21,000
Ferry Creek					
Confluence with Coquille River	5.2	640	890	980	1,220
Above Highway 241 bridge	25	5,410	6,930	7,660	8,980

Table 7. Summary of Discharges (continued)

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Millicoma River					
Below Woodruff Creek	137	18,100	24,000	27,000	31,600
North Slough					
Above Highway 101 bridge	11.3	3,080	3,880	4,260	4,990
Pony Creek					
At Ocean Boulevard	3.9	84	140	180	290
At Woodland Drive	4.9	260	350	400	480
At Crowell Lane	6.2	320	420	480	590
South Fork Coquille River					
Confluence with North Fork at Myrtle Point	598	51,100	69,700	79,600	93,300
Tenmile Creek					
At Wildwood Drive	71.2	2,640	3,480	3,900	4,870
West Fork Millicoma River					
At confluence with East Fork	55	9,460	12,300	13,700	16,100

Table 8. Summary of Elevations

Flooding Source	Peak Water Surface Elevations (Feet NAVD88) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Blossom Creek				
City of Coos Bay	8.6[1]	11.6[2]	12.6[3]	13.3[3]
Coos Bay				
South Slough	10.4	11.0	11.2	11.7
Ponding in the City of Coos Bay	11.2[4]	12.3[3]	12.6[3]	13.3[3]
West corporate limit of North Bend	11.2	11.8	12.1	12.6
Pony Slough	11.3	12.0	12.2	12.8
North Slough	11.5	12.1	12.4	13.0
Haynes Inlet	11.5	12.1	12.4	13.0
Southeast corporate limit of North Bend	11.6	12.3	12.6	13.3
Isthmus Slough at downtown Coos Bay	11.7	12.3	12.6	13.3
Isthmus Slough at Millington	11.8	12.4	12.7	13.4
Coalbank Slough	11.9	12.5	12.8	13.4
Coos River	12.3	13.1	13.5	14.5
Coquille River				
City of Bandon	12.6	14.5	15.2	17.0
Ferry Creek				
City of Bandon	12.6	14.5	15.2	17.0

[1] Peak elevation is controlled by volume of Blossom Creek hydrograph that must be stored.

[2] Peak elevation is controlled by the total volume of flow over the dike stored in downtown Coos Bay and Blossom Creek areas.

[3] Peak elevation is controlled by elevation in slough.

[4] Limited flow over city dike will fill low areas of downtown Coos Bay.

Table 8. Summary of Elevations (continued)

Flooding Source	Peak Water Surface Elevations (Feet NAVD88)			
	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
North Tenmile Lake				
At City of Lakeside	21.8	23.2	23.8	25.0
Pacific Ocean				
Bastendorff/Lighthouse Beach Profile 1	--	--	23.8	25.1
Bastendorff/Lighthouse Beach Profile 2	--	--	24.0	25.5
Bastendorff/Lighthouse Beach Profile 3	--	--	22.6	24.6
Bastendorff/Lighthouse Beach Profile 4	--	--	21.6	23.3
Bastendorff/Lighthouse Beach Profile 5	--	--	23.7	25.5
Bastendorff/Lighthouse Beach Profile 6	--	--	23.4	25.2
Bastendorff/Lighthouse Beach Profile 7	--	--	36.2	39.0
Bastendorff/Lighthouse Beach Profile 8	--	--	31.6	34.0
Bastendorff/Lighthouse Beach Profile 9	--	--	33.2	35.7
Bastendorff/Lighthouse Beach Profile 10	--	--	31.3	33.3
Bastendorff/Lighthouse Beach Profile 11	--	--	26.5	27.9
Bastendorff/Lighthouse Beach Profile 12	--	--	29.0	30.9
Bandon Profile 1	--	--	30.1	31.6
Bandon Profile 2	--	--	32.6	34.2
Bandon Profile 3	--	--	29.9	31.2
Bandon Profile 4	--	--	29.4	30.7
Bandon Profile 5	--	--	25.3	26.4
Bandon Profile 6	--	--	23.7	24.5
Bandon Profile 7	--	--	22.5	23.5
Bandon Profile 8	--	--	21.5	22.6
Bandon Profile 9	--	--	22.9	24.6
Bandon Profile 10	--	--	23.0	24.6
Bandon Profile 11	--	--	23.1	25.1
Bandon Profile 12	--	--	32.8	34.1
Bandon Profile 13	--	--	36.2	40.4
Bandon Profile 14	--	--	31.5	32.9
Bandon Profile 15	--	--	22.2	23.7
Bandon Profile 16	--	--	20.8	22.1
Bandon Profile 17	--	--	20.8	22.0
Bandon Profile 18	--	--	20.6	21.9
Bandon Profile 19	--	--	30.6	31.3
Bandon Profile 20	--	--	26.7	29.3
Bandon Profile 21	--	--	31.6	32.1
Tenmile Lake				
At City of Lakeside	21.8	23.2	23.8	25.0

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 Table in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS report in conjunction with the data shown on the FIRM.

Cross sections for backwater analyses of the Coquille River at Coquille and Arago and the South Fork of Coquille River at Myrtle Point were obtained by digitizing aerial photographs at a scale of 1:12,000. The underwater sections were obtained by field measurement. Cross sections for Tenmile Creek, the Millicoma River, the West Fork Millicoma River, the East Fork Millicoma River, and the Coquille River at Riverton were obtained by field measurement. Bridges were field checked to obtain elevation data and structure geometry.

Cross sections for backwater analyses of Calloway Creek and Cunningham Creek were measured on City of Coquille topographic maps at a scale of 1:1,200 with a 5-foot contour interval. The channel geometry was based on field observation. Culvert geometry was determined using state and county bridge plans.

Cross sections for the backwater analysis of Pony Creek were scaled from City of North Bend and City of Coos Bay topographic maps at a scale of 1:1,200 with 2-foot contour intervals (Chickering-Green Empire Inc., 1976). Channel sections, obtained by field measurements, were used with the scaled cross sections. All bridges were field checked to obtain elevation data and structural geometry.

Cross sections for the backwater analysis of the Coquille River estuary were scaled from City of Bandon topographic maps at a scale of 1:2,400 (Chickering, 1973), a USACE pre-dredge survey map at a scale of 1:2,000 (1979), and a NOAA nautical chart at a scale of 1:10,000 (1981). Cross sections for Ferry Creek were scaled from the Bandon topographic maps (Chickering, 1973) with the channel section obtained by field measurement. All bridges and culverts were field checked to obtain elevation data and structural geometry. Starting water surface elevations for the Coquille River and Ferry Creek were initially calculated using the slope-area method. When the 10-, 2-, 1-, and 0.2-percent-annual-chance elevations for the Coquille River were compared with the 10-, 2-, 1-, and 0.2-percent-annual-chance ocean elevations, it was found that backwater from the ocean would control the flood elevation in the estuary. It was also found that backwater from the Coquille River estuary would control the flood elevation in Ferry Creek; therefore, no flood profiles for the Coquille River and Ferry Creek are presented.

Channel roughness factors (Manning’s “n”) used in the hydraulic computations were chosen by engineering judgment and based on field observation of the river channel and flood plain. The range of roughness values for all floods is shown in Table 9. The acceptability of all assumed hydraulic factors, cross sections, non-effective flow areas, and hydraulic structure data was checked by hydraulic computations that were calibrated against historic floodwater profiles.

Table 9. Range of Manning's Roughness Values

Flooding Source	Channel "n"	Overbanks "n"
Calloway Creek	0.040-0.060	0.040-0.080
Cunningham Creek	0.040-0.060	0.040-0.080
Coquille River	0.080-0.100	0.040-0.080
Coquille River Estuary	0.030	0.030-0.035
East Fork Millicoma River	0.045	0.050-0.080
Ferry Creek	0.035-0.040	0.040-0.070
Millicoma River	0.040	0.040-0.080
Pony Creek	0.030-0.060	0.035-0.080
South Fork Coquille River	0.050-0.060	0.040-0.080
Tenmile Creek	0.030-0.085	0.060-0.120
West Fork Millicoma River	0.045	0.040-0.080

Water surface elevations of floods of the selected recurrence intervals were computed through use of the USACE HEC-2 step-backwater computer program (USACE,1976).

Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. Starting water-surface elevations for Tenmile Creek were estimated using the relationship between peak recorded flow and elevation at the Tenmile Creek gage. Starting water-surface elevations for the Millicoma River, the Coquille River at Riverton, Cunningham Creek and Calloway Creek were determined using the slope-area method. Starting water-surface elevations for the West Fork Millicoma River and the East Fork Millicoma River were taken from the Millicoma River profiles. It was assumed that the West Fork and East Fork Millicoma Rivers would peak at about the same time. To determine starting water-surface elevations for the Coquille River at Coquille, Arago, and at the confluence of the North and South Forks Coquille River, the backwater analysis was continued between detailed study areas using cross sections scaled from 1:24,000 USGS topographic maps (USGS, various dates).

Downstream of Crowell Lane the estuary elevations control the flood elevations. Between Crowell Lane and Newmark Street, the flood elevations are controlled by the volume of water that must be stored behind the tide gates when the gates are closed.

A series of outflow rating curves were developed for the Crowell Lane culverts and tide gates assuming a range of tidal elevations downstream. A storage-capacity curve for the area above the tide gates was developed using the City of North Bend topographic maps (Chickering-Green Empire Inc., 1976).

Using the outflow rating and storage-capacity curves, several frequency hydrographs were routed through the area above the tide gates balancing inflows and outflows with changes in the volume of stored water. The storage routing was conducted over tide cycles predicted for the mean annual event and the 10-percent-annual-chance event.

On log-probability paper, the maximum elevations resulting from the storage routing for a mean annual tide cycle were plotted against the probability of the mean annual tide cycle occurring during each runoff event. A curve was drawn through the plotted points. The maximum elevations resulting from the routing for a 10-year tide cycle were plotted against the probability of the 10-year tide cycle occurring during each runoff event. A second curve was then drawn through these points. An enveloping curve was then drawn tangent to the two curves. This resulted in a peak elevation-frequency curve valid for other combinations of inflows and tide cycles. During this analysis, it was reasoned and demonstrated that the highest elevations behind the tide gates would occur when the inflow hydrograph and tide cycle peaks coincided. This condition was assumed in the original analysis.

During the community coordination meeting held on March 14, 2006, it was learned that the above tide gates on Pony Creek located at Crowell Lane had been removed and that the portion of Pony Creek upstream is now subject to flooding due to tidal and storm surge conditions. The flood profile and FIRM have been updated to reflect this condition.

Calloway Creek and Cunningham Creek run along the edge of a very flat area. At flood stage, the two creeks form one floodplain in the study area. Approximately 30 percent of the flood flow in Cunningham Creek will pass through the culvert under Fairview Road. The remaining flow is forced across the floodplain toward the Calloway Creek bridge at West Central Boulevard. On the downstream side of West Central Boulevard, approximately half of the combined flow of Calloway Creek and Cunningham Creek overflows in the area near the Cunningham Creek Bridge. The remaining flow continues down the normal channel alignment. Although a separate floodway was developed for the Cunningham Creek Overflow channel, a flood profile was not developed as the entire reach is backwatered by the Coquille River.

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.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

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 was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

Hydraulics for Detailed Estuarine Studies

Tsunami and storm flood events were considered to be independent events because tsunami waves can occur at any time during the year and storm waves are seasonal. Because of the uncertainties involved in combining these events, no probabilistic mapping of tsunami hazard was undertaken in this study.

Peak elevation frequency curves were developed for the Coos Bay estuary using a computer model that simulated the hydraulic response of the estuary to the 10-, 2-, 1-, and 0.2-percent-annual-chance tidal conditions at the entrance to the bay and to the 10-, 2-, 1-, and 0.2-percent-annual-chance inflows from major streams entering the bay. The hydrodynamic algorithm of the Dynamic Estuary Computer Model (Water Resources Engineers Inc. and CH2M HILL, 1977; Federal Water Quality Administration, 1975) was used for the hydraulic simulation.

A junction and channel grid network was constructed using the NOAA Nautical Chart for Coos Bay at a scale of 1:20,000 (1980), to represent the geometric flow pattern in the estuary. A total of 50 junctions and 78 interconnecting channels were used to model the estuary and adjoining sloughs within the detailed study limits.

Inputs to the hydraulic model included surface area and depth for the area represented by each junction, channel length, width, and roughness factors (Manning's "n"), and tidal and riverine inflow boundary conditions. For the Coos Bay network, channel widths ranged from 150 to 2,000 feet and lengths ranged from 3,200 to 8,300 feet. Channel roughness values varied from 0.023 to 0.035.

The Dynamic Estuary Model computed stage and channel velocities at each junction for each time step throughout several complete tide cycles by simultaneously solving one-dimensional equations of motion and continuity. Output from the hydraulic simulation summarizes the hourly stage and channel velocity at each junction.

The estuary computer model was calibrated to historical tide cycles recorded from November 8-12, 1976. Coincident records for those days were available for tide gages located throughout the bay (Water Resources Engineers Inc. and CH2M HILL, 1977; Federal Water Quality Administration, 1975). No significant storm activity occurred during this period. The simulated tide cycles at the junctions agreed with recorded tide cycles. The range of computed velocities correlated with velocity surveys conducted by the USACE in a similar study of Coos Bay during the period October 14-22, 1976 (USACE, 1978).

Combined tidal and riverine inflows effects were used to establish the 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations within the estuary. Hydraulic simulations were made using the 10-, 2-, 1-, and 0.2-percent-annual-chance tide cycles combine with the 10-percent-annual-chance inflow hydrographs for major stream inflows. It was assumed that the inflow hydrograph peak would coincide with the peak tidal stillwater levels (SWLs), because high estuary elevations will occur when they coincide.

Hydraulic simulations were also run with the 10-year tide cycle combined with the 10-, 2-, 1-, and 0.2-percent-annual-chance stream inflows. The resulting estuary elevations were compared to those determined using the 2-, 1-, and 0.2-percent-annual-chance tide cycles. The higher computed elevation at each junction for each frequency was used. Flood profiles are not applicable for areas of tidal flooding; therefore, no flood profiles are shown for Coos Bay or the Coos River.

The estuary elevations are SWLs resulting from tidal conditions at the Coos Bay entrance. They do not include any contributions from wind setup in the estuary or from wave action. Calculations for wind setup suggested the contribution was insignificant, while the increase in flood hazard from wave action will be less than 1 foot.

Peak flood elevation in downtown Coos Bay results from high water in Isthmus Slough overtopping the city dike. Peak flood elevations in Blossom Creek are controlled by the volume of water entering the creek when the tide is high enough to prevent any outflow past the tide gates.

During the 1- and 0.2-percent-annual-chance events, the volume of water overtopping the dike along Isthmus Slough will be great enough to fill Blossom Creek and the downtown area to be same elevation as the Slough. During the 2-percent-annual-chance event, the volume of water overtopping the dike will be great enough to fill the downtown area to the same elevation as the slough, but a constriction at 6th Street between Central and Bennett Avenues will limit the volume of water reaching Blossom Creek. While the dike is being overtopped, the water level will reach an elevation of approximately 7 feet (10.6 ft NAVD) in Blossom Creek. After the bay elevation recedes to below the top of the dike, there will continue to be a hydraulic gradient causing water to flow from the downtown area into Blossom Creek. This will continue until the total volume of water that overtopped the dike reaches a constant elevation of 8 feet (11.6 ft NAVD) throughout both areas.

Whenever the tide gates are closed and the water level in the downtown area is greater than the water level in Blossom Creek area, the backflow will tend to equalize the water levels in the two areas.

During the 10-percent-annual-chance event, only a small volume of water will flow over the dike and pond in the lowest areas of downtown Coos Bay. No dike overflows will reach Blossom Creek. The 10-percent-annual-chance peak flood elevation is Blossom Creek was determined assuming that the greatest 4-hour volume under the 10-percent-annual-chance inflow hydrograph would occur during a high tide in the bay and have to be stored. This results in a 10-percent-annual-chance peak elevation of approximately 5 feet (8.6 ft NAVD).

Storage capacity curves for Blossom Creek and the downtown area of Coos Bay were developed using the City of Coos Bay topographic maps (Chickering-Green Empire Inc., 1976). Peak flood elevations in downtown Coos Bay and Blossom Creek are summarized in Table 5.

Hydraulics for Approximate Riverine Studies (Revised)

Cross sections were developed from aerial LiDAR surveys performed in the summer of 2008 (Oregon LiDAR Consortium, 2009). LiDAR was collected at a nominal density of 8 points per square meter. On flat surfaces the average vertical accuracy of the LiDAR point cloud is within 5 centimeters of true elevation. A 1-meter resolution digital elevation model (DEM) representing ground points was derived from the LiDAR point cloud. No hydro-enforcement was applied to the LiDAR DEM (e.g. the stream water surface during the time of survey was included in the DEM).

Cross sections were developed directly from the LiDAR DEM at regularly spaced intervals along straight channels. Where channels change direction significantly or engineered structures (e.g. bridges) are present, cross sections were spaced more closely.

Cross sections, overbank flow lines, banks, and stream centerlines were developed using the HEC-GeoRAS extension (USACE, 2010) for ArcGIS Desktop 9.3.1. A representative “Manning’s N” value of 0.04 was applied to all studied reaches.

Normal depth was calculated to produce output flood zone polygons. Output polygons were then checked to assure flood zones had hydraulic connection to the main channel. Output polygons were removed where no reasonable connection could be established.

Hydraulics for Detailed Coastal Studies (Revised)

Field surveys were undertaken during the 2008-09 winter along the two beach study sites (Bandon, and Bastendorff and Lighthouse Beach) in Coos County. The purpose of these surveys was to provide measurements of the beach in its most eroded state (e.g. most eroded winter profile) in order to define the morphology, elevation, and slope of the beach face for use in subsequent wave runup and overtoping computations. Surveying at Bandon was carried out over a period of three days on February 8-10, 2009, and on March 8-10, 2009 at Bastendorff and Lighthouse Beach. In both cases, the surveys were completed late in the winter season when Oregon beaches are typically in their most eroded state (Aguilar-Tunon and Komar, 1978; Komar, 1997; Allan and Komar, 2002b; Allan and Hart, 2008). A total of 21 transects were established along the Bandon shoreline, while 11 transects were established between Sunset Beach State Park and Bastendorff Beach, adjacent to the mouth of Coos Bay (Figure 10).

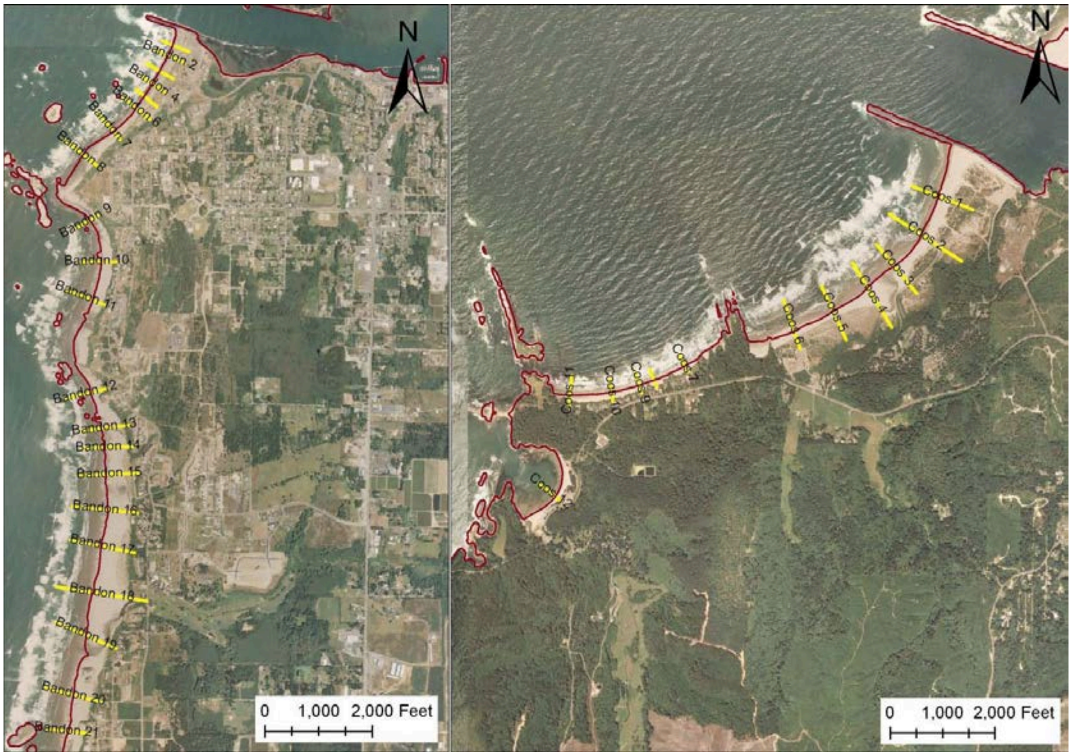


Figure 10 - Location Map of Beach Transects for Detailed Coastal Studiess
Location map of beach profiles measured at Bandon (left) and at Bastendorff/ Lighthouse Beach (right) in Coos County.

Wave runup is the culmination of the wave breaking process whereby the swash of the wave above the SWL is able to run up the beach face, where it may encounter a dune, structure or bluff, potentially resulting in the erosion (Figure 11), or overtopping and flooding of adjacent land. Runup, "R", or wave swash is generally defined as the time-varying location of the intersection between the ocean and the beach, and summarized as a function of several key parameters. These include the deepwater wave height, peak spectral wave period and the wave length (specifically the wave steepness), and through the breaker parameter (or Iribarren number), which accounts for the slope of a beach or an engineering structure and the steepness of the wave.

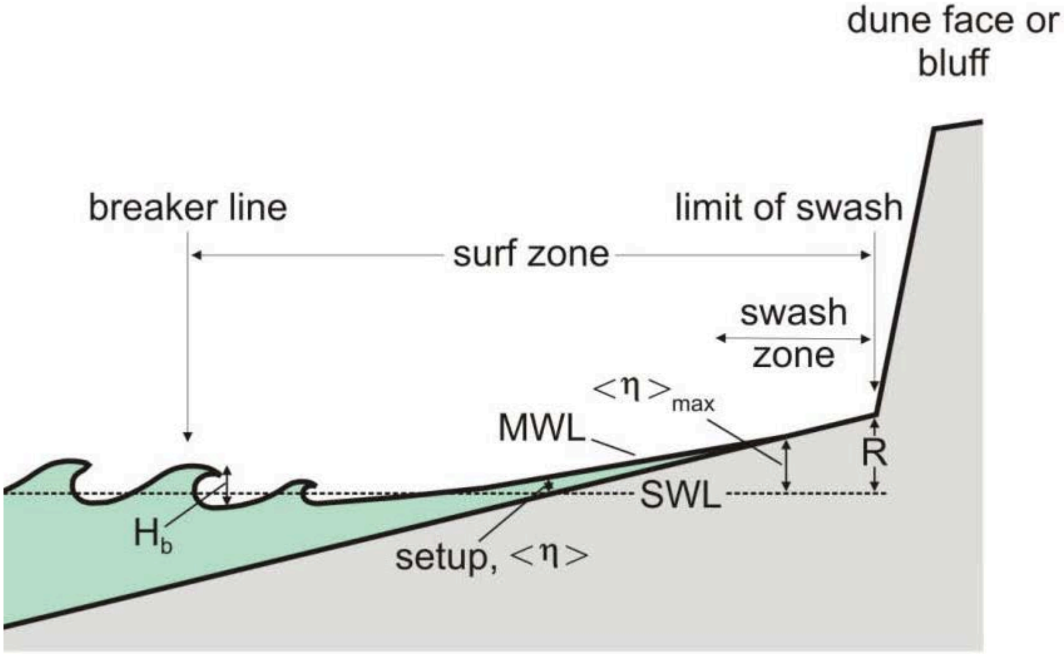


Figure 11 - Conceptual Model of Wave Runup
Conceptual model showing the components of wave runup associated with incident waves (modified from Hedges and Mase, 2004).

The total runup, “R”, produced by waves includes three main components:

- wave setup, $<\eta>$;
- a dynamic component, η^; and,
- incident wave runup, R_{inc}

$$R = <\eta> + \eta\,\hat{} + R_{inc}$$

Along the Pacific Northwest Coast of Oregon and Washington, the dynamic component of runup, η^, has been demonstrated to be a major component of the total wave runup due to infragravity energy becoming trapped in the surf zone, allowing the swash to reach to much higher elevations at the shore.

A variety of models have been proposed for calculating wave runup on beaches (Ruggiero et al., 2001; Hedges and Mase, 2004; NHC, 2005; Stockdon et al., 2006). DOGAMI employed the runup model developed by Stockdon et al. (2006) due to its demonstrated ability to best represent beach environments in Coos County when compared to other models.

For calculating wave runup on barriers (e.g. bluffs) the method developed by the Technical Advisory Committee for Water Retaining Structures (TAW) was employed. Tables 10 and 11 provide the barrier runup reduction factors used for those selected profile sites along the Bandon and Bastendorff/Lighthouse beach shorelines. In the case of bluff roughness along the Bandon shore, we used a value of 0.6 due to the highly vegetated nature of the Bandon bluffs. These bluffs are located at their stable angle of repose and are covered with salal plants, where it forms a deep, nearly impenetrable thicket. Wave direction reduction factors presented in Table 10 and Table 11 are the mean values determined for all storms for each transect site.

Table 10. Barrier Runup Reduction Factors Used for Calculating Runup (Bandon)

Bandon Profile	Roughness	Berm	Wave Direction	Description
1	N/A	N/A	N/A	Dune-backed
2	N/A	N/A	N/A	Dune-backed
3	N/A	N/A	N/A	Dune-backed
4	N/A	N/A	N/A	Dune-backed
5	N/A	N/A	N/A	Dune-backed
6	N/A	N/A	N/A	Dune - Bluff-backed
7	0.6	1.0	0.81	Dune - Bluff-backed
8	0.6	1.0	0.89	Bluff-backed
9	0.6	1.0	0.90	Bluff-backed
10	0.6	1.0	0.99	Bluff-backed
11	0.6	1.0	0.98	Bluff-backed
12	0.6	1.0	0.99	Bluff-backed
13	0.6	1.0	1.0	Bluff-backed
14	0.6	1.0	1.0	Bluff-backed
15	N/A	N/A	N/A	Dune - Bluff-backed
16	N/A	N/A	N/A	Dune - Bluff-backed
17	N/A	N/A	N/A	Dune - Bluff-backed
18	N/A	N/A	N/A	Dune - Bluff-backed
19	0.6	1.0	0.96	Dune - Bluff-backed
20	0.6	1.0	1.0	Dune - Bluff-backed
21	0.6	1.0	1.0	Dune - Bluff-backed

Table 11. Barrier Runup Reduction Factors Used for Calculating Runup (Bastendorff/Lighthouse Beach)

Coos Profile	Roughness	Berm	Wave Direction	Description
1	N/A	N/A	N/A	Dune-backed
2	N/A	N/A	N/A	Dune-backed
3	N/A	N/A	N/A	Dune-backed
4	N/A	N/A	N/A	Dune-backed
5	N/A	N/A	N/A	Dune-backed
6	N/A	N/A	N/A	Dune-backed
7	1.0	1.0	0.73	Bluff-backed
8	1.0	1.0	0.74	Bluff-backed
9	1.0	1.0	0.72	Bluff-backed
10	1.0	1.0	0.68	Bluff-backed
11	1.0	1.0	0.64	Bluff-backed
11	N/A	N/A	N/A	Dune - Bluff-backed

For both beach and barrier models, the calculated runup is combined with the appropriate measured tides to develop the total water level (TWL) conditions used to generate the 1- and 0.2-percent-annual-chance events. These extreme flood hazard statistics were calculated using the Stockdon et al. (2006) runup model at all 21 profiles at the Bandon focus site and 12 profiles along Bastendorff/Lighthouse Beach. Where applicable (Bandon 7-14 and 19-21 profile sites and for the Bastendorff/Lightbouse 7-11 profiles) these same statistics were calculated using the TAW method. TWLs produced from both the Stockdon et al. method and the TAW method are shown as the 1- and 0.2-percent-annual-chance in Table 8, “Summary of Elevations”. Most TWLs come from the Stockdon et al. method. However, where the TAW method produced higher TWLs than the Stockdon et al. method (for bluff-backed beaches only), the TAW method TWLs are shown.

Overtopping of natural features such as foredunes, spits and coastal engineering structures and barriers occurs when the wave runup superimposed on the tide exceeds the crest of the foredune or structure (Figure 12). Based on TWL calculations, only Bandon profiles 1-6 and Bastendorff/Lighthouse profiles 1-5 and 12 experience overtopping during the 1-percent-annual-chance event.

Mapping flood inundation zones requires an estimate of the velocity, “*V*”, or discharge, “*q*”, of the water that is carried over the crest, the envelope of the water surface that is defined by the water depth, “*h*”, landward of the barrier crest, and the inland extent of green water and splash overtopping. According to NHC (2005) these hazard zones are ultimately defined based on the following two derivations:

- Base Flood Elevations (BFEs) are determined based on the water surface envelope landward of the barrier crest; and

- Hazard zones are determined based on the landward extent of green water and splash overtopping, and on the depth and flow velocity in any sheet flow areas beyond that, defined as $hV^2 = 200\ ft^3/s^2$.

A distinction can be made between whether green water (or bore) or splash overtopping predominates at a particular location, dependent on the ratio of the calculated wave runup height, "*R*", relative to the barrier crest elevation, "Z_c" (Figure 11). When $1 < R/Z_c < 2$, splash overtopping dominates and for $R/Z_c > 2$, bore propagation occurs. In both cases, *R* and Z_c are relative to the 2% Dynamic Water Level ($DWL_{2\%}$) at the barrier (NHC, 2005).

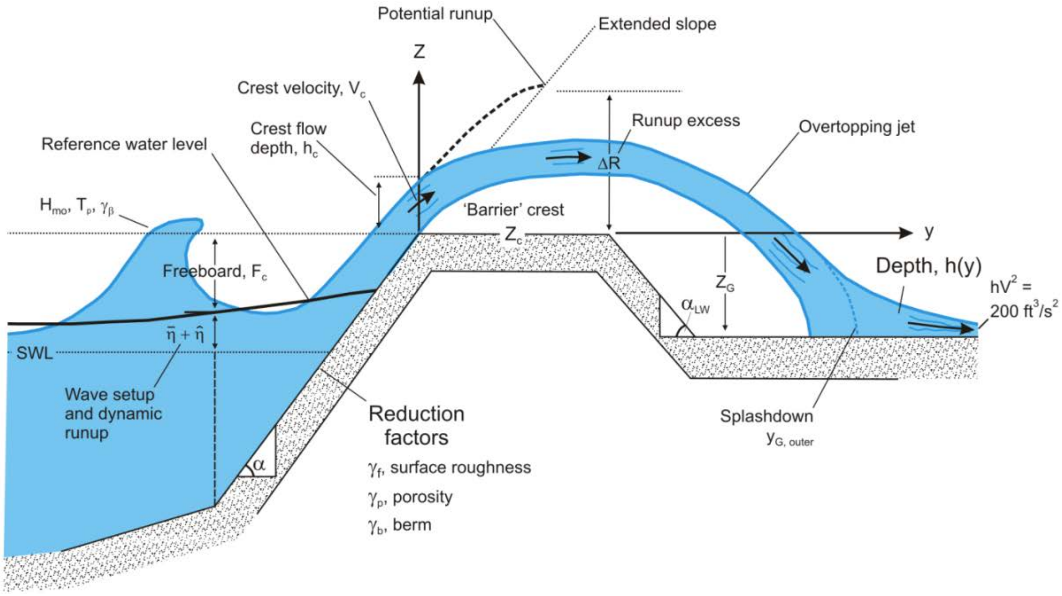


Figure 12 - Nomenclature of Wave Runup Parameters
Nomenclature of overtopping parameters available for mapping base flood elevations (BFEs) and flood hazard zones (after NHC, 2005).

Prior to calculating the mean overtopping rate at the barrier crest, it is necessary to first distinguish between four contrasting types of wave breaking situations that may impact a particular barrier or dune overtopping situation. The four conditions include (1) non-breaking or (2) breaking on normally sloped barriers, and (3) reflecting or (4) impacting on steeper barriers. Of these, the only one that applies to the Coos County detailed coastal study sites is the breaking wave situation (2), where the waves have already broken across the surf zone and are reforming as bores prior to swashing up the beach face or barrier.

At the beach or barrier crest, the relative freeboard, "F_c", (Figure 11), is a particularly important parameter since changing these two parameters controls the volume of water that flows over the barrier crest. For example, increasing the wave height or period increases the overtopping discharge, as does reducing the ‘beach or barrier crest height or raising the water level.

A variety of prediction methods are available for calculating the overtopping discharge and are almost entirely based on laboratory experiments based on a range of structure slopes (slopes between 1:1 and 1:8, with occasional tests at slopes around 1:15 or lower). Factors that reduce the potential overtopping discharge include the barrier surface roughness, “γ_f”, the presence of a berm, “γ_b”, wave approach directions, “γ_β”, and the porosity of the barrier, “γ_p” (Figure 11). Of the four reduction parameters, only the angle of wave attack was used to reduce the overtopping discharge along the Coos County detailed study sites. The presence of a berm can be ignored since berms are non-existent in a most eroded winter profile. The surface roughness was ignored since the beach face and backshore is composed of sand and hence has only a nominal effect on reducing overtopping. Porosity was also ignored as the beach is characterized by medium to coarse sand and during major storms the beach is typically in a saturated state due to the combination of high runup and the storm duration, such that the beach is less capable of taking up additional water.

Initial computations of the landward extent of wave overtopping using the prescribed method (NHC, 2005) yielded narrow hazard zones for Coos County. To calibrate the method for realistic application on the Coos County coast, wave overtopping calculations were performed for a site on the northern Oregon coast where field observations of wave overtopping had been observed. The site is Cape Lookout State Park located on the northern Oregon coast in Tillamook County (Allan and Komar, 2002a; Komar et al., 2003; Allan et al., 2006). The southern portion of Cape Lookout State Park is characterized by a wide, gently sloping, dissipative sand beach, backed by a moderately steep gravel berm and ultimately by a low foredune that has undergone significant erosion since the early 1980’s (Komar et al., 2000).

In March 1999, the crest of the cobble berm/dune at Cape Lookout State Park was overtopped during a major storm; the significant wave heights reached 14.1 m (46.3 ft), while the peak periods were 14.3 seconds (Allan and Komar, 2002b). Wave overtopping of the dune and flooding extended 230 ft into the park (Dr. P. Komar, Emeritus Professor, College of Oceanic and Atmospheric Sciences, pers. comm., 2010), evidence for which included photos and field evidence including pock-marks at the base of the tree trunks located in the park. These pock-marks were caused by cobbles having been carried into the park from the beach by the overtopping waves, where they eventually slammed into the base of the trees as ballistics. Since the average beach slopes at Cape Lookout State park are analogous to those observed along the shore near the Bandon south jetty and that large wave events associated with extra-tropical storms affect significant stretches (hundreds to thousands of miles) of the coast at any single point in time, these data are believed to provide a reasonable means in which to investigate a range of alpha values, “α”, (Figure 11) that may be used to determine the landward extent of wave inundation at Cape Lookout State Park.

Using beach morphology data from Cape Lookout State Park and deepwater wave statistics from a nearby National Data Buoy Center (NDBC) wave buoy (#46050), a range of alpha values were experimented with in order to replicate the landward extent of the inundation. In order to emulate the landward extent of flooding observed at Cape Lookout State Park the analyses yielded an alpha of 0.58. Using this alpha value, the extent of the hazard zone was calculated where $hV^2(y) = 200\ ft^3/s^2$, which was found to be approximately 34 meters from the crest of the cobble berm/dune, consistent with damage to facilities in the park.

Table 12 presents the results of the calibrated splashdown distances, “$y_{G\ outer}$”, (Figure 11) and the landward extent of the flow, “hV^2”, (Figure 11) where the flows approach $200\ ft^3/s^2$. The calculated splashdown distances, “$y_{G\ outer}$”, (Table 12) were based on an enhanced wind velocity of 64.3 ft/s. This enhanced wind velocity was determined from an analysis of wind speeds measured by the Cape Arago C-MAN station located adjacent to the mouth of Coos Bay. The range of wind speeds identified at Cape Arago was examined for each storm event defined for this study and revealed a wide range of values, with the maximum being 64.3 ft/s. Since the measured wind speeds reflect a 2-minute average such that higher wind speeds have been measured throughout the entire record (e.g. the maximum 2-minute average wind speed is 96 ft/s, while the maximum 5-second wind gust reached 125.0 ft/s), it is considered justified to use the more conservative enhanced wind velocity of 64.3 ft/s rather than the default of 44 ft/s prescribed by NHC (2005).

The Bastendorff/Lighthouse Beach profile 2 site presents a situation where the calculated 1-percent-annual-chance TWL of 24 ft approximately equals the beach/dune crest elevation of 23.9 ft, suggesting that overtopping would probably not occur; in this situation the landward location of the primary frontal dune (PFD) would determine the width of the hazard zone.

Table 12. Splashdown and Flood Zone Limits for Detailed Coastal Profiles

Profile	# of Wave Overtopping Events, and Events where $hV^2 > 200\ ft^3/s^2$	Maximum Splashdown $y_{G\ outer}$ (ft)	Maximum $hV^2(y) = 200\ ft^3/s^2$ (ft)	Maximum Width of Hazard Zone (ft)	Distance from Profile Benchmark (ft)
Bandon Profile Sites					
1	127 / 11	4.3	149.3	153.2	529.2
2	115 / 15	11.2	193.6	204.7	432.4
3	103 / 12	11.2	165.0	176.2	524.9
4	83 / 15	13.5	183.7	197.2	367.5
5	55 / 1	4.9	29.2	33.5	274.9
6	101 / 3	6.2	69.2	75.1	152.2
Bastendorff/Lighthouse Beach Profile Sites					
1	6 / 0	2.0	-	2.0	998.7
2	0 / 0	-	-	-	-
3	3 / 0	10.2	-	10.2	631.2
4	105 / 25	14.8	149.9	164.7	602.0
5	14 / 0	8.5	-	8.5	829.9
12	132 / 132	5.6	373.7	379.3	-50.9

Mapping of the SFHA for bluff-backed beaches used TWLs shown in Table 8, “Summary of Elevations”, and extended them into the bluff. The contour of interest was extracted from a 1-meter resolution DEM derived from LiDAR ground points surveyed in the summer of 2008 (Oregon LiDAR Consortium, 2009). In all cases, the calculated TWLs were rounded to the nearest whole foot. The landward extent of the SFHA (Zone VE) is defined by the contour representing the TWL calculated for each of the surveyed profiles. To define the landward extent of the SFHA (Zone VE) between profile locations professional judgment was used to establish appropriate zone breaks by identifying along-shore geomorphic barriers within which a particular TWL is valid. Slope and hillshade derivatives of the LiDAR DEM, as well as 1-meter orthophotos (Oregon Geospatial Data Clearinghouse, 2009), provided base reference. An effort was made to orient zone breaks perpendicular to the beach at the location of the geomorphic barrier. In all cases, the seaward extent of the SFHA (Zone VE) was inherited from the previous FIS.

Mapping of the SFHA for dune-backed beaches was performed by calculating the degree of wave overtopping at each profile location (Figure 11; Table 12). The furthest point landward of the dune crest that experiences coastal flooding due to overtopping and is ultimately controlled by the extent of the landward flow where it approaches 200 ft^3/s^2; values greater than 200 ft^3/s^2 are located within the Zone VE SFHA, while values that dissipate below that threshold are designated within the Zone AE SFHA. For SFHAs (Zone VE) seaward of the dune crest, TWLs shown in Table 8, "Summary of Elevations", were used. As with bluff-backed beaches, professional judgment was used to establish appropriate zone breaks between profile locations. This was achieved using the LiDAR DEM (Oregon LiDAR Consortium, 2009), supplemented by knowledge of the local geomorphology. Again, an effort was made to orient zone breaks perpendicular to the beach and the seaward extent of the SFHA (Zone VE) was inherited from the previous FIS. Elevations were identified from the LiDAR DEM to aid in establishing zone breaks due to changes in flood depth landward of the dune crest. Slope and hillshade derivatives of the LiDAR DEM, as well as 1-meter orthophotos (Oregon Geospatial Data Clearinghouse, 2009), provided base reference. Some interpretation was required to appropriately map the SFHA for the printed FIRM panel scale.

Figure 13 - Overtopping of Barrier Beach at Garrison Lake Near Port Orford
Overtopping of the barrier beach adjacent to Garrison Lake during a major storm on February 16, 1999 (Photo courtesy of a resident at Port Orford, Oregon).

Hydraulics for Approximate Coastal Studies (Revised)

FEMA guidelines direct that for mapping the SFHA in coastal areas where no detailed studies have occurred (Zone V), the location of the primary frontal dune

(PFD) be defined as the most landward extent of flooding. The PFD is defined as “a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The landward limit of the primary frontal dune, also known as the toe or heel of the dune, occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope. The primary frontal dune toe represents the landward extension of the Zone VE coastal high hazard velocity zone” (Part 44 of the US Code of Federal Regulations, Section 59.1; FEMA Coastal Hazard Bulletin, No. 15).

The mapping approach developed by DOGAMI addresses three distinct geomorphic environments where the PFD variably discernible: (1) dune-backed beaches, (2) bluff-backed beaches, and (3) areas where streams drain into the Pacific Ocean.

The approach developed by DOGAMI to define the morphology of dune-backed beaches, including the location of the PFD, was based on detailed analyses of LiDAR elevation data measured by the USGS/NASA/NOAA in 1998 and 2002, and by the Oregon LiDAR Consortium (OLC) in the summer of 2008. However, because the LiDAR flown by the USGS/NASA/NOAA is of relatively poor resolution (nominal point spacing of 1 point per square meter) and reflects only a single return (i.e. includes vegetation where present) it was not used for mapping, only geomorphic time series analysis. OLC LiDAR is of much higher precision (nominal point spacing of 8 points per square meter) and was characterized by multiple returns enabling the development of a ground LiDAR DEM. Determination of the PFD was based entirely on analysis of the OLC LiDAR.

Profiles spaced 50 meters apart were cast perpendicular to the full length of the county coastline using the Digital Shoreline Analysis System (DSAS) developed by the USGS (Thieler et al., 2009). For each profile, 3D coordinates for the 1998, 2002 and 2008 LiDAR were extracted at 1-meter intervals along each profile.

Processing of the LiDAR was performed in Matlab using a custom beach profile analysis script developed by DOGAMI that interactively defines various morphological features, including the dune/bluff crest/top, bluff slope (where applicable), landward edge of the PFD, beach/dune juncture elevations for each year, and the slope of the beach foreshore.

Time series analysis of morphological features identified in the serial LiDAR indicate that erosion predominates along both the north Coos Spit and along much of the New River Spit, while much of the shore along Bullards Beach, located north of Bandon, appears to be accreting.

Due to uncertainties in identifying the PFD (as defined by FEMA), mapping of the SFHA for dune-backed beaches required that some professional judgment be employed. For example, where there was determined to be a high probability of erosion within ten years, the SFHA was mapped slightly landward of the PFD.

For bluff-backed beaches the landward extent of the SFHA was mapped at the top of the bluff, a readily identifiable feature in the 2008 OLC LiDAR.

Mapping of the SFHA in areas influenced by fluvial processes (e.g. near the mouth of Tenmile Creek) required professional judgment. Historical aerial photos and serial LiDAR were referred to for past evidence of flotsam and debris, wetlands, and channel migration.

3.3 Wave Height Analysis

Figure 14 - February 9, 2009 Photo of Coquille Jetties During a Winter Storm Event
Looking north toward the Coquille River jetties in Bandon, Oregon during a typical winter storm on February 9, 2009 (Photo by Jon Allan, DOGAMI).

The wave climate offshore from the Oregon coast is one of the most extreme in the world, with winter storm waves regularly reaching heights in excess of several meters. This is because the storm systems emanating from the North Pacific travel over fetches that are typically a few thousand miles in length and are also characterized by strong winds, the two factors that account for the development of large wave heights and long wave periods (Tillotson and Komar, 1997). These storm systems originate near Japan or off the Kamchatka Peninsula in Russia, and typically travel in a southeasterly direction across the North Pacific towards the

Gulf of Alaska, eventually crossing the coasts of Oregon and Washington or along the shores of British Columbia in Canada.

Wave statistics (heights and periods) have been measured in the North Pacific using wave buoys and sensor arrays since the mid 1970's. These data have been collected by NOAA, which operates the National Data Buoy Center (NDBC) and by Scripps Institution of Oceanography, which operates the Coastal Data Information Program (CDIP). The buoys cover the region between the Gulf of Alaska and Southern California, and are located in both deep and in intermediate to shallow water over the continental shelf. The NDBC operates some 30 stations along the West Coast of North America, while CDIP has at various times carried out wave measurements at 80 stations. Presently there is one CDIP buoy operating offshore from Coos Bay (#46229), and two NDBC buoys (Oregon [#46002] and Port Orford [#46015]) located offshore from the southern Oregon coast. Wave measurements by NDBC are obtained hourly. CDIP provides measurements every 30 minutes. Measurements are transmitted via satellite to the laboratory for analysis of the wave energy spectra, significant wave heights and peak spectral wave periods (NOAA, 2009).

Analyses of the wave climate offshore from Coos County were performed at Oregon State University (OSU), and included numerical analyses of the 1-percent-annual-chance extreme storm wave event and the associated wave setup to determine the degree of coastal flood risk along the coast of Coos County.

OSU performed a series of analyses including wave transformations, empirical wave runup modeling, and TWL modeling. For the purposes of this study, OSU used the SWAN (Simulating Waves Nearshore) wave model to transform deepwater waves (for a range of 1-percent-annual-chance events) to the nearshore (typically the 65.6 ft [20 m] contour). The deep-water equivalent of these refracted nearshore waves was determined using the linear shoaling relation in order to calculate wave runup levels, which were then combined with the tidal component in order to estimate the flood risk along the Bandon shore and at Bastendorff/Lighthouse Beach.

All available NDBC and CDIP hourly wave buoy data were acquired for several wave buoys in the region. In addition, wave hindcast information on the deepwater wave climate determined through the Wave Information Studies (WIS) (Baird, 2005) was acquired for station 074, located adjacent to NDBC buoy #46002, the primary wave buoy used in this study due to its high quality long record of data (1975-present). However, since this buoy is located in 11,500 ft of water and is over 250 miles from the location of the shelf edge buoys (Port Orford #46015 and Umpqua Offshore #46229), it was necessary to develop a methodology to transform these 'off-shelf' waves to the 'shelf-edge' offshore boundary condition of the SWAN model. The wave climate observed at NDBC buoy #46002 has significant differences compared to the climate observed at the Port Orford #46015 and Umpqua Offshore #46229 buoys.

To transform the NDBC buoy #46002 waves to the shelf edge, wave period bins were created to evaluate if there has been a wave period dependent difference in wave heights observed at NDBC buoy #46002 compared with the Port Orford #46015. For comparison, the time stamps associated with waves measured at NDBC buoy #46002 were adjusted based upon the group celerity (for the appropriate wave period bin) and travel time it takes the wave energy to propagate to Port Orford #46015.

After correcting for the time of wave energy propagation the differences in wave heights between the two buoys, for each wave period bin, were calculated in two ways. First, a best-fit linear regression through the wave height differences was computed for each wave period bin. Second, a constant offset was computed for the wave height differences for each period bin.

Upon examination of the empirical probability density functions (PDF) of both buoys' raw time series (using only approximately last 5 years of NDBC buoy #46002, the time of overlap with the shelf buoys) and after applying both transformation methods, it was determined that the constant offset method did a superior job of matching the PDF, particularly at high wave heights. Therefore, a constant offset adjustment dependent on the wave period was applied to the wave heights of NDBC buoy #46002.

Because the WIS hindcast data used in this study was also located well beyond the boundary of the SWAN model (effectively at the location of NDBC buoy #46002), the same series of steps comparing WIS wave heights to those from Port Orford #46015 were carried out, with a new set of constant offsets having been calculated and applied. Data from the Port Orford #46015 and Umpqua Offshore #46229 were also compared in this same manner and it was determined that their wave height differences in the alongshore extent (e.g. offshore from Coos County) are negligible. Therefore it is assumed that a constant offshore wave height boundary condition is appropriate for the SWAN model.

After applying the wave height offsets to the NDBC buoy #46002, gaps in this time series were filled in respectively with Port Orford #46015 and subsequently the Umpqua Offshore #46229. Where there were still gaps following this procedure the time series was then filled in with the corrected WIS data. Because wave transformations (particularly refraction) computed by SWAN are significantly dependent on wave direction, when this information was missing in the buoy records it was replaced with WIS data for the same date in the time series; the wave height and period data was carried over from buoy observations where applicable. For conditions in the time series that had no estimate of wave direction from either the buoys or the WIS data a value of 270 degrees (e.g. westerly waves) was assumed.

The final synthesized wave time series developed for Coos County extends from late 1979 through to the end of 2008 and consists of approximately 27.5 years of good data (measurements including at least wave height and periods) out of a possible 29.2 years.

The wave climate offshore from the Oregon coast is episodically characterized by large wave events (> 26 ft), with some storms having generated deepwater extreme waves on the order of 49 ft. The average wave height offshore from Coos County is 8.5 ft, while the average peak spectral wave period is 11.1 seconds, although periods of 20-25 seconds are not uncommon.

The Pacific Northwest wave climate is characterized by a distinct seasonal cycle evident in the variability in the wave heights and peak periods between summer and winter. Monthly mean significant wave heights are typically highest in December and January, although large wave events (> 39.4 ft) have occurred in all of the winter months except March. The highest significant wave height observed in the wave climate record is 50.9 ft, substantially exceeding the 1-percent-annual-chance wave height used in the previous Bandon FIS (1996), which was 24.6 ft and was derived from WIS data for the period of 1956 to 1975. In general, the smallest waves occur during late spring and in the summer, with wave heights typically averaging approximately 5 ft during the peak of the summer (July/August). These findings are consistent with other studies that have examined the Pacific Northwest wave climate (Tillotson and Komar, 1997; Allan and Komar, 2006; P. Ruggiero et al., 2010).

A probability density function determined for the complete time series indicates that for 50% of the time waves are typically less than 7.2 ft, and less than 14.8 ft for 90% of the time. Wave heights exceed 24.3 ft for 1% of the time. However, it is these latter events that typically produce the most significant erosion and flooding events along the Oregon coast.

With regard to wave direction along the south Oregon coast, in general, the summer is characterized by waves arriving from the northwest, while winter waves typically arrive from the west or southwest (Komar, 1997). Separate analyses of the summer and winter directional data developed from the synthesized time series, comprised of both WIS data from the shelf edge buoys, agree with this pattern. To better highlight the predominant wave directions for the winter months, wave heights less than 33 ft have been eliminated from the analyses. Summer months are characterized by waves arriving from mainly the west-northwest (~25%) to northwesterly quadrant (~21%), with few waves out of the southwest. The bulk of these reflect waves with amplitudes that are predominantly less than 9.8 ft. In contrast, the winter months are dominated by much larger wave heights out of the west (~25-35%), and to a lesser extent the northwest (~18%).

Figure 15 is a profile for a hypothetical transect 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 15.

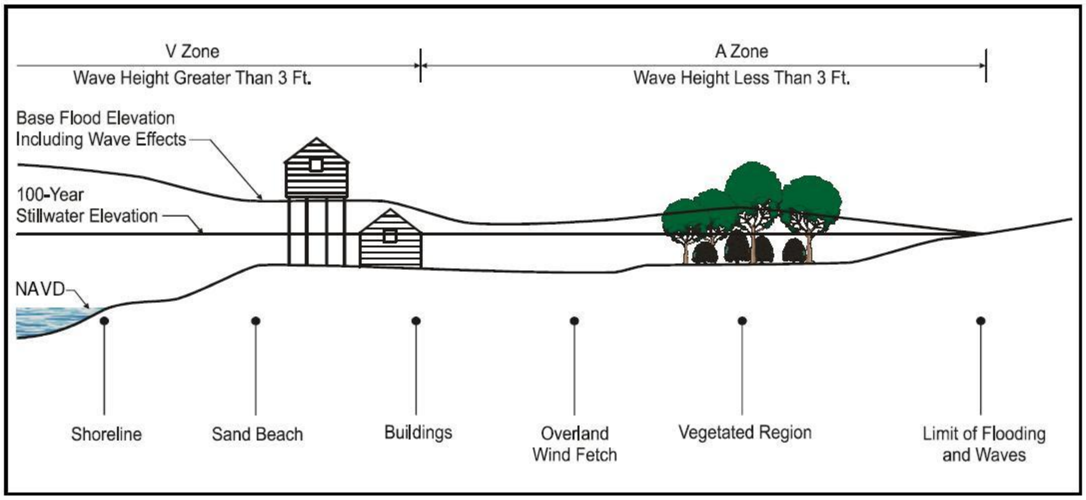


Figure 15 - Schematic of Coastal Profile

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

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in Base Flood Elevations (BFEs) across the corporate limits between the communities.

For additional information regarding conversion between NGVD29 and NAVD88, visit the NGS website at www.ngs.noaa.gov, or contact the NGS 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

The conversion factor from NGVD to NAVD for all streams in this report was +3.62 feet. The conversion was performed during the initial countywide update.

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 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, Floodway Data Table, and Summary of Elevations 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 flooding source 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 1 meter resolution bare earth LiDAR DEMs (effective map scale of approximately 1:2,300), with a contour interval of 0.5 feet (Oregon LiDAR Consortium, 2009).

For streams studied by approximate methods, the 1-percent-annual-chance floodplain boundaries have been delineated using flood elevations at every grid cell of 1 meter resolution bare earth LiDAR DEMs (effective map scale of approximately 1:2,300). No interpolation was performed. Note that exceptions exist where LiDAR was not available in the far eastern portion of Coos County. In these areas 1-percent-annual-chance flood boundaries were delineated using Flood Hazard Boundary Maps for Coos County (U.S. Department of Housing and Urban Development, 1977), Geologic Hazard Maps (Beaulieu and Hughes, 1975), and engineering judgment. These exceptions include areas along the upper East Fork Millicoma River, Glenn Creek, upper East Fork Coquille River, West Fork Brummit Creek, and East Fork Brummit Creek.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, V, 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.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

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 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this FIS report and on the FIRM were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations have been tabulated for selected cross sections in Table 13, “Floodway Data”. In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

Floodways for the Coquille River and the South Fork Coquille River were computed on the basis of equal-conveyance reduction from each side of the floodplain. Because of the complexity and hydraulic controls on the Calloway

Creek/Cunningham Creek floodplain, a standard floodway based on equal-conveyance reduction is not possible. Instead, the floodways for these two creeks were calculated by trial-and-error based on the flow divisions of the normal depth 1-percent-annual-chance flood.

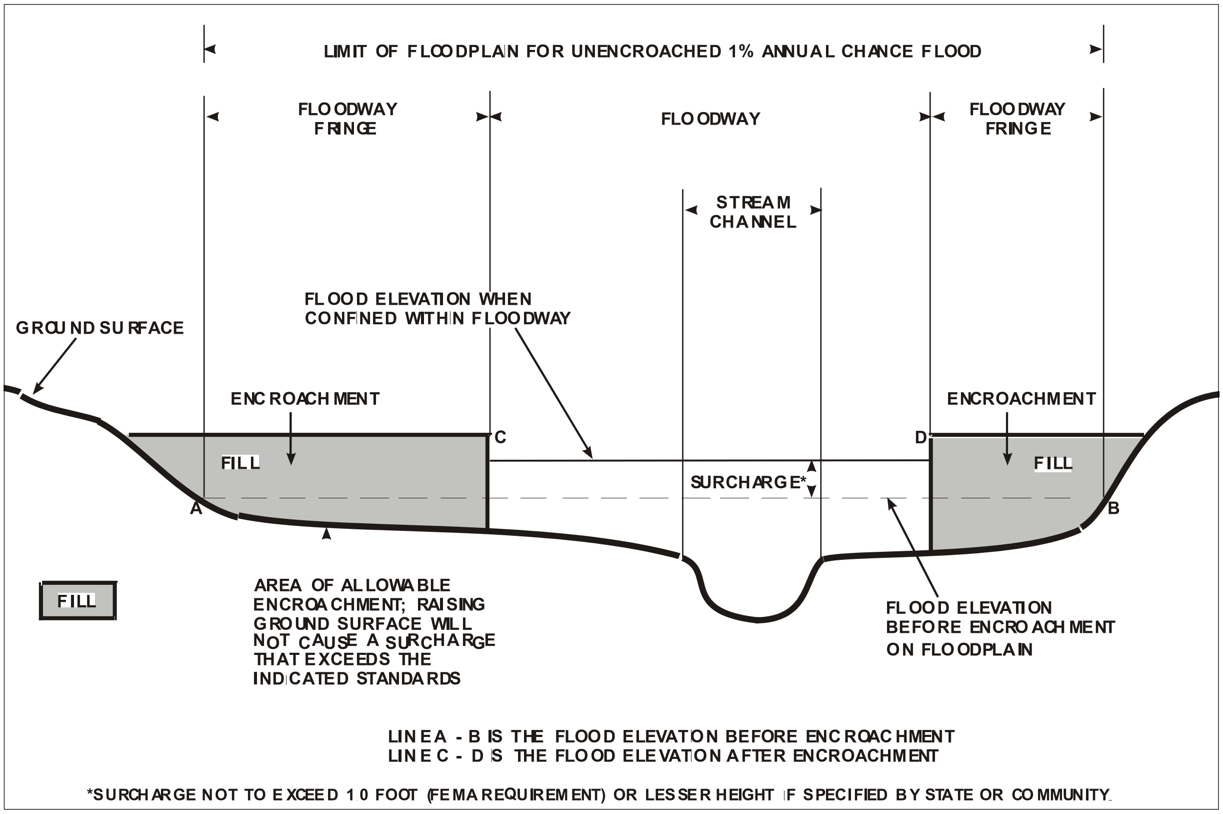
As shown on the Flood Information Rate Maps (FIRM), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 1-percent-annual-chance flood are either close together or collinear, only the floodway boundary has been shown.

The floodway for Pony Creek above Newmark Street was computed on the basis of equal conveyance reduction from each side of the floodplain. No floodway was delineated on Pony Creek between Crowell Lane and Newmark Street or downstream of Crowell Lane because the floodway concept is not applicable in areas where flooding is controlled by tidal influences.

No floodway was determined for the Coquille River within the City of Bandon corporate limits and for Ferry Creek because both streams are subject to tidal influence.

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 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 16.

Figure 16. Floodway Schematic



LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT

*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER HEIGHT IF SPECIFIED BY STATE OR COMMUNITY.

FLOODING SOURCE		FLOODWAY				1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	PRIOR STUDY WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
Calloway Creek									
A	60[1]	37		262	5.8	24.0	20.1	20.2	0.1
B	160[1]	61		353	4.3	24.8	21.5	22.5	1.0
C	680[1]	173		1,253	1.2	24.8	22.0	22.9	0.9
Cunningham Creek									
A	920[2]	56		219	4.4	24.0	14.2[3]	15.2[3]	1.0
B	2,560[2]	47		188	4.6	24.0	18.0[3]	18.1[3]	0.1
C	3,560[2]	47		187	4.7	24.0	20.0[3]	20.1[3]	0.1
D	4,280[2]	51		169	2.5	24.0	20.1[3]	20.2[3]	0.1
E	4,390[2]	N/A[4]	38	169	2.5	24.5	20.1[3]	20.2[3]	0.1
F	4,830[2]	36		102	4.2	24.6	20.6[3]	20.7[3]	0.1
G	5,270[2]	38		109	3.9	24.6	21.5[3]	21.7[3]	0.2
H	5,360[2]	40		109	3.9	24.6	21.5[3]	21.7[3]	0.2
I	5,530[2]	45		167	2.6	24.8	22.0[3]	23.0[3]	1.0
Cunningham Creek Overflow Channel									
A	1,130[2]	121		452	2.4	24.0	10.9[3]	11.9[3]	1.0
B	2,710[2]	120		660	1.6	24.0	12.4[3]	13.4[3]	1.0
C	4,030[2]	195		194	5.5	24.0	19.5[3]	19.5[3]	0.0

[1] Feet above Cunningham Creek [2] Feet above mouth [3] Elevations computed without effects from Coquille River [4] Due to re-delineation floodway is now outside of SFHA at this location

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON

AND INCORPORATED AREAS

FLOODWAY DATA

CALLOWAY CREEK, CUNNINGHAM CREEK, CUNNINGHAM CREEK OVERFLOW CHANNEL

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)
Coquille River at Riverton								
A	82,440	1,377	23,879	4.9	22.2	22.2	23.2	1.0
B	84,650	2,194	42,275	2.7	22.8	22.8	23.8	1.0
C	86,800	2,511	45,371	2.6	23.1	23.1	24.1	1.0
D	89,600	3,945	72,926	1.6	23.3	23.3	24.3	1.0
Coquille River at Coquille								
E	121,600	5,535	88,146	1.3	24.0	24.0	25.0	1.0
F	123,550	6,949	129,249	0.9	24.0	24.0	25.0	1.0
G	126,250	7,603	138,886	0.8	24.0	24.0	25.0	1.0
H	128,400	6,443	125,613	0.9	24.1	24.1	25.1	1.0
I	130,300	7,178	133,927	0.8	24.1	24.1	25.1	1.0
J	132,250	6,716	128,508	0.9	24.1	24.1	25.1	1.0
K	133,050	7,211	131,137	0.8	24.1	24.1	25.1	1.0
L	135,700	6,110	113,706	1.0	24.1	24.1	25.1	1.0
M	137,800	5,930	103,284	1.1	24.1	24.1	25.1	1.0
N	139,600	6,293	115,736	1.0	24.2	24.2	25.2	1.0
O	141,500	6,376	111,041	1.0	24.2	24.2	25.2	1.0
P	143,150	6,546	101,204	1.1	24.2	24.2	25.2	1.0
Q	145,200	5,996	88,563	1.2	24.3	24.3	25.3	1.0

[1] Feet above mouth

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON
AND INCORPORATED AREAS

FLOODWAY DATA

COQUILLE 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)
Coquille River at Arago								
R	168,350	5,605	49,712	2.2	30.4	30.4	31.4	1.0
S	171,350	5,669	47,885	2.3	31.2	31.2	32.2	1.0
T	174,250	7,465	62,370	1.7	31.9	31.9	32.8	0.9
Coquille River at Myrtle Point								
U	191,520	1,106	16,630	6.4	38.0	38.0	39.0	1.0
South Fork Coquille River at Myrtle Point								
V	192,920	1,574	25,610	3.1	39.9	39.9	40.9	1.0
W	194,650	1,506	17,474	4.5	40.5	40.5	41.5	1.0
X	196,300	924	12,254	6.5	41.8	41.8	42.6	0.8
Y	196,950	1,013	15,959	5.0	42.7	42.7	43.6	0.9
Z	197,590	947[2]	16,806	4.7	43.0	43.0	44.0	1.0
AA	197,640	1,486[2]	17,025	4.7	43.1	43.1	44.1	1.0
AB	197,840	1,778	25,829	3.1	43.5	43.5	44.5	1.0
AC	200,260	2,493	32,327	2.5	43.9	43.9	44.8	0.9
AD	202,260	3,048	35,928	2.2	44.2	44.2	45.1	0.9

[1] Feet above mouth [2] Floodway bifurcated due to re-delineation

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON

AND UNINCORPORATED AREAS

FLOODWAY DATA

COQUILLE RIVER, SOUTH FORK COQUILLE 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)
Millicoma River								
A	39,950	622	16,224	1.7	36.7	36.7	37.7	1.0
B	43,630	300	7,306	3.7	36.7	36.7	37.7	1.0
C	45,630	291	7,335	3.7	37.0	37.0	38.0	1.0
East Fork Millicoma River								
D	46,590	446	7,137	2.5	37.2	37.2	38.2	1.0
E	48,910	317	6,198	2.9	37.5	37.5	38.5	1.0
F	50,070	451	6,885	2.6	37.7	37.7	38.7	1.0
G	50,670	316	5,233	3.2	37.8	37.8	38.8	1.0
H	50,760	286	5,330	3.2	38.1	38.1	39.1	1.0
I	50,860	289	5,335	3.1	38.2	38.2	39.2	1.0
J	52,260	205	4,812	3.5	38.4	38.4	39.3	0.9
K	53,700	109	4,275	3.9	38.7	38.7	39.6	0.9
L	54,080	121	3,835	4.4	38.8	38.8	39.7	0.9
M	54,130	142	3,835	4.4	38.8	38.8	39.7	0.9
N	54,350	179	3,784	4.4	39.0	39.0	39.8	0.8
O	55,190	191	3,605	4.7	39.2	39.2	40.1	0.9
P	57,150	132	3,352	5.0	39.9	39.9	40.9	1.0

[1] Feet above mouth

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON
AND UNINCORPORATED AREAS

FLOODWAY DATA

MILLICOMA RIVER, EAST FORK MILLICOMA RIVER

FLOODING SOURCE		FLOODWAY				1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	PRIOR STUDY WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
West Fork Millicoma River									
A	500[1]	319		7,466	1.8	37.2	37.2	38.2	1.0
B	620[1]	259		7,221	1.8	37.2	37.2	38.2	1.0
C	1,020[1]	284		7,632	1.8	37.3	37.3	38.3	1.0
D	2,620[1]	286		9,307	1.5	37.4	37.4	38.4	1.0
E	4,580[1]	298		6,278	2.2	37.4	37.4	38.4	1.0
F	7,020[1]	327		6,501	2.1	37.6	37.6	38.6	1.0
G	7,940[1]	234		3,395	4.0	37.6	37.6	38.6	1.0
H	8,140[1]	231		3,346	4.1	37.7	37.7	38.7	1.0
I	8,190[1]	236		3,337	4.1	37.7	37.7	38.7	1.0
J	8,420[1]	219		3,175	4.3	37.8	37.8	38.8	1.0
K	10,700[1]	180		3,745	3.7	38.6	38.6	39.6	1.0
Pony Creek									
A – L[3]									
M	13,165[2]	N/A[4]	25	98	4.5	12.2	12.2	13.2	1.0
N	13,315[2]	66		210	2.1	12.2	12.2	12.9	0.7
O	13,835[2]	81		279	1.6	12.2	12.2	13.0	0.8
P	14,345[2]	42		85	4.7	12.2	12.2	12.5	0.3
Q	14,425[2]	36		95	4.2	12.2	12.2	12.5	0.3
R	14,695[2]	29		91	4.4	12.2	12.2	12.3	0.1

[1] Feet above mouth [2] Feet above Coos Bay [3] Floodway not shown for these cross sections due to tidal influence [4] Due to re-delineation floodway is now outside of SFHA at this location

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON

AND INCORPORATED AREAS

FLOODWAY DATA

WEST FORK MILLICOMA RIVER, PONY CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD88)	WITHOUT FLOODWAY (FEET NAVD88)	WITH FLOODWAY (FEET NAVD88)	INCREASE (FEET)
Pony Creek								
S	14,985[1]	93	144	2.8	12.6	12.6	12.7	0.1
T	15,785[1]	31	98	2.2	13.6	13.6	13.8	0.2
U	16,465[1]	40	80	2.7	14.8	14.8	15.7	0.9
V	17,965[1]	27	69	3.2	19.8	19.8	20.3	0.5
Tenmile Creek								
A	17,700[2]	93	1,273	3.1	21.5	21.5	22.5	1.0
B	19,180[2]	350	3,260	1.2	22.3	22.3	23.3	1.0
C	21,380[2]	215	2,389	1.6	22.9	22.9	23.9	1.0
D	22,900[2]	812	7,235	0.5	23.1	23.1	24.1	1.0
E	24,680[2]	964	6,866	0.6	23.2	23.2	24.2	1.0
F	26,200[2]	127	1,577	2.5	23.4	23.4	24.4	1.0
G	26,570[2]	109	1,602	2.4	23.6	23.6	24.6	1.0
H	26,597[2]	112	1,602	2.4	23.7	23.7	24.7	1.0
I	26,807[2]	116	1,680	2.3	23.8	23.8	24.8	1.0

[1] Feet above Coos Bay [2] Feet above mouth

TABLE 13

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON

AND UNINCORPORATED AREAS

FLOODWAY DATA

PONY CREEK, TENMILE CREEK

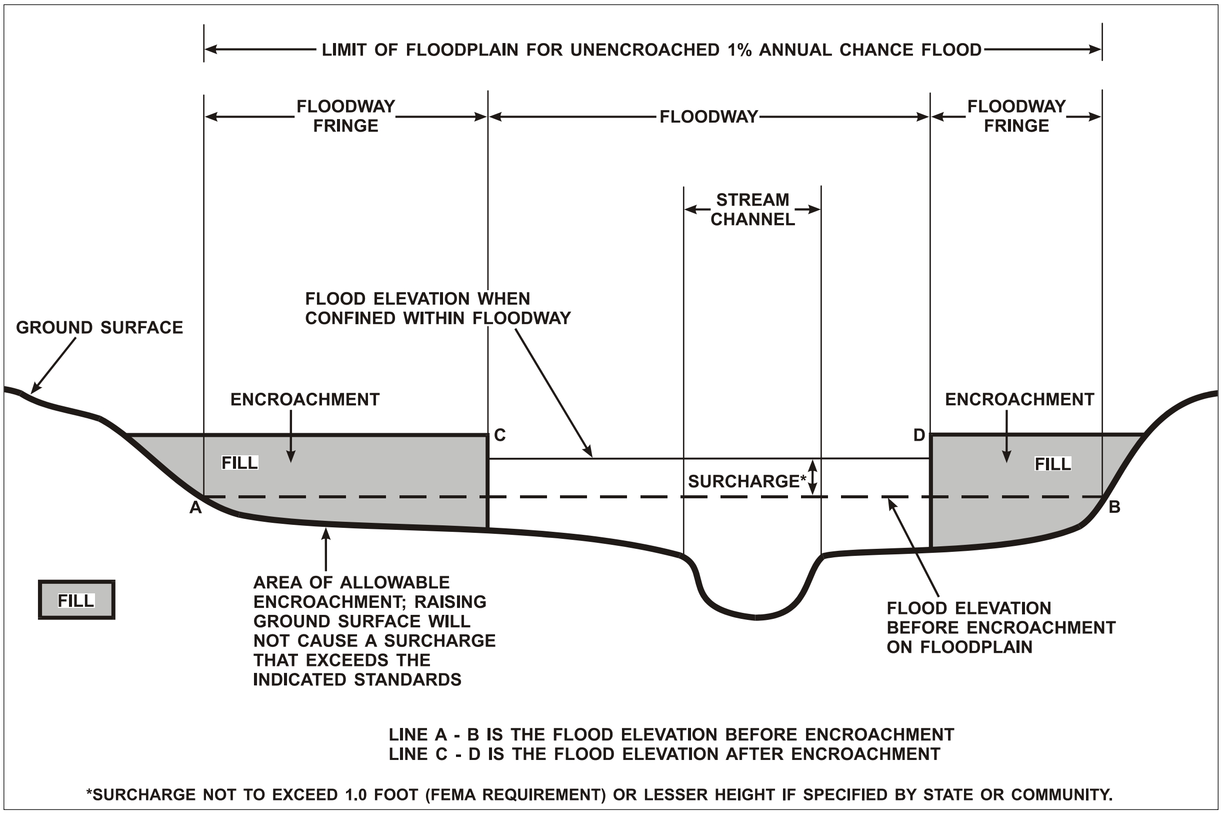


Figure 16 - Floodway Schematic

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 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 (USACE, 1975). This was based on a study of wave action effects on structures. This criterion has been adopted by FEMA for the determination of VE zones. Because of the additional hazards associated with high-energy waves, the NFIP regulations require much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in VE zones are higher than those in AE zones.

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

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

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

Zone AE

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

Zone V

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

Zone VE

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

Zone X

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

Table 14 lists the flood insurance zones that each community is responsible for regulating.

Table 14. Flood Insurance Zones within Each Community

Community	Flood Zone(s)
Bandon, City of	A, AE, V, VE, X
Coos Bay, City of	A, AE, X
Coos County, Unincorporated Areas	A, AE, V, VE, X
Coquille, City of	A, AE, X
Lakeside, City of	A, AE, X
Myrtle Point, City of	A, AE, X
North Bend, City of	AE, X
Powers, City of	A, X

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 entire geographic area of Coos County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas 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, where applicable. Historical data relating to the maps prepared for each community are presented in Table 15, "Community Map History".

7.0 OTHER STUDIES

The Federal Insurance Administration previously published Flood Hazard Boundary Maps for Coos County (U.S. Department of Housing and Urban Development, 1975), City of Bandon (U.S. Department of Housing and Urban Development, 1976), City of Coos Bay (U.S. Department of Housing and Urban Development, 1977), City of Coquille (U.S. Department of Housing and Urban Development, 1975), the City of Myrtle Point (U.S. Department of Housing and Urban Development, 1975), the City of North Bend (U.S. Department of Housing and Urban Development, 1974). The present Flood Insurance Study is more detailed and thus supersedes the earlier maps.

The USACE Tsunami Prediction Study (Garcia and Houston, 1978) was used in the coastal flood analysis.

This 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.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, Federal Regional Center, 130 228th Street Southwest, Bothell, WA 98021-8627.

For previous versions of the FIRM Index, the Map Repository information was included on the FIRM Index itself. The map repositories are listed in Table 16 in the FIS.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE	FIRM EFFECTIVE DATE	FIRM REVISION DATE
Bandon, City of	December 21, 1973	April 16, 1976	August 15, 1984	February 18, 1998
Coos Bay, City of	August 23, 1974	March 25, 1977	August 1, 1984	
Coos County (Unincorporated Areas)	November 1, 1974	September 6, 1977	November 15, 1984	
Confederated Tribes of the Coos, Lower Umpqua and Siuslaw[1]	November 1, 1974	September 6, 1977	November 15, 1984	
Coquille, City of	November 3, 1973	October 10, 1975	September 28, 1984	
Coquille Indian Tribe[1]	November 1, 1974	September 6, 1977	November 15, 1984	
Lakeside, City of	November 22, 1977	N/A	August 1, 1984	
Myrtle Point, City of	November 23, 1973	December 5, 1975	July 16, 1984	
North Bend, City of	June 28, 1974	July 11, 1975	August 1, 1984	
Powers, City of	November 23, 1973	October 17, 1975	June 30, 1976	

[1] This community does not have map history prior to the first countywide mapping

TABLE 15

FEDERAL EMERGENCY MANAGEMENT AGENCY

COOS COUNTY, OREGON
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

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Map	Date	Scale	Contour Interval in Feet
Reedsport	1956	1:62,500	80
Scottsburg	1955	1:62,500	80
Ivers Peak	1955	1:62,500	80
Tyee	1955	1:62,500	80
Bandon	1942	1:62,500	50
Coquille	1942	1:62,500	50
Sitkum	1955	1:62,500	80
Camas Valley	1955	1:62,500	80
Langlois	1954	1:62,500	80
Powers	1954	1:62,500	80
Bone Mountain	1954	1:62,500	80
Dutchmen Butte	1946	1:62,500	50
Agness	1954	1:62,500	80
Marial	1954	1:62,500	80
Empire	1970	1:24,000	20
North Bend	1971	1:24,000	40
Coquille	1971	1:24,000	40
McKinley	1971	1:24,000	40
Bandon	1970	1:24,000	40
Bill Peak	1971	1:24,000	40
Myrtle Point	1971	1:24,000	40
Bridge	1971	1:24,000	40
Allegany	1971	1:24,000	40
Cape Arago	1970	1:24,000	40
Charleston	1970	1:24,000	40
Coos Bay	1971	1:24,000	40
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