# FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 2 OF 5

# MONTEREY COUNTY, CALIFORNIA

## AND INCORPORATED AREAS

| COMMUNITY NAME | COMMUNITY NUMBER |
|---|---|
| CARMEL-BY-THE-SEA, CITY OF | 060196 |
| DEL REY OAKS, CITY OF | 060197 |
| GONZALES, CITY OF | 060198 |
| GREENFIELD, CITY OF | 060446 |
| KING CITY, CITY OF | 060199 |
| MARINA, CITY OF | 060727 |
| MONTEREY, CITY OF | 060200 |
| MONTEREY COUNTY, UNINCORPORATED AREAS | 060195 |
| PACIFIC GROVE, CITY OF | 060201 |
| SALINAS, CITY OF | 060202 |
| SAND CITY, CITY OF | 060435 |
| SEASIDE, CITY OF | 060203 |
| SOLEDAD, CITY OF | 060204 |

FEMA

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Exhibits



**Volume 5**
Exhibits



**Published Separately**

Flood Insurance Rate Map (FIRM)

## 5.2 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. Base flood elevations on the FIRM represent the elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations. These whole-foot elevations may not exactly reflect the elevations derived from the hydraulic analyses. 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. The hydraulic analyses for this FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For streams for which hydraulic analyses were based on cross sections, locations of selected cross sections are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 6.3), selected cross sections are also listed on Table 24, "Floodway Data."

A summary of the methods used in hydraulic analyses performed for this project is provided in Table . Roughness coefficients are provided in Table 14. Roughness coefficients are values representing the frictional resistance water experiences when passing overland or through a channel. They are used in the calculations to determine water surface elevations. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

**Table 13: Summary of Hydrologic and Hydraulic Analyses**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Arroyo Seco | Approximately 17 miles upstream of confluence with Salinas River | Approximately 35 feet upstream of Arroyo Seco Road | Log-Pearson Type III Analysis | Frequency Analysis | * | AE w/ Floodway | Peak discharges were based on a long-Pearson Type III analysis of the stream gage records (U.S. Water Resources Council, 1976).<br>There are two stream gages on Arroyo Seco. The frequency analysis for the gage on Arroyo Seco near Soledad (1906-1978) was used directly. The statistics for the gage on Arroyo Seco near Greenfield (1962-1978) were adjusted based on correlation with the Soledad gage (U.S. Water Resources Council, 1976; USACE, 1962).<br>Equal-conveyance reduction was used in the floodway computations for the detailed-study reach. For nearly the entire reach, the floodway follows the 1-percent annual chance floodplain. For the remainder of the reach, excessive velocity rather than water-surface elevation rise was the limiting factor in floodway encroachment. |
| Arroyo Seco | Confluence with Salinas River | Approximately 17 miles upstream of confluence with Salinas River | Log-Pearson Type III Analysis | Frequency Analysis | * | A | * |
| Big Sur River | At mouth | Approximately 2.5 miles upstream of Cabrillo Highway | * | * | * | A | * |
| Bixby Creek | At mouth | Approximately 447 feet upstream of Highway 1 | * | * | * | A | * |

### Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Calera Creek | Confluence with El Toro Creek | Approximately 1.2 miles upstream of Robley Road | Frequency Analysis | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway, AO | Peak flows were determined from frequency analysis of flows at USGS Gage 11152540, El Toro Creek near Spreckles, located just downstream of the study reach. An appropriate regional skew value was determined from analysis of seven nearby gages. Peak, 10-, 2-, 1-, and 0.2-percent annual chance discharge values were calculated at the gage, then scaled by drainage area to a series of index points along the study reach.<br>Peak discharges were based on the SCS procedure. The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956).<br>Cross sections for the backwater analyses for the revised detailed study were obtained from field surveys and extended with available 2-foot contour topographic mapping.<br>The floodplain boundaries were delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using available 2-foot-contour topographic mapping. Floodplain boundaries for the 1-percent annual chance return interval flood were established from the maximum flood depth raster image of the study area exported from MIKE21. |

### Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Calera Creek, continued | Confluence with El Toro Creek | Approximately 1.2 miles upstream of Robley Road | Frequency Analysis | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway, AO | Polygons defining hazard zones were drawn based on the maximum flood depth raster, ground contours developed from LiDAR, and the influence of significant local structures observed on aerial photographs.<br>Equal-conveyance reduction was used for the entire reach except for a section from 180 feet above Robley Road to 1,105 feet above that road. For this section, a floodway is not applicable because a sidespill during the 1-percent annual chance flood west of the channel cannot be contained in the channel with less than a 1.0-foot rise in water-surface elevation. It must be advised that although the area is designated shallow flooding with depths less than 1.0-foot, high velocities may result upstream on the main channel if development occurs in this west bank near Robley Road.<br>Floodways were computed on the basis of equal area reduction from each side of the floodplain. The results of these computations are tabulated at selected cross sections. Floodways were defined as coincident with the 1-percent annual chance floodplain at cross sections where the 1-percent annual chance peak discharge was conveyed entirely within the channel. Near river mile 3.5 on Calera Creek, a significant portion of the flow overtops the left bank and flows as shallow flow northwest of the channel. The floodway in this area was defined using the discharge capacity of the channel through this reach, 430 cfs, which is about 45 percent of the 1-percent annual chance discharge. The discharge from the channel and into the breakout area must be maintained for the floodway between river mile 3.5 and 3.0 to remain valid. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Canyon Del Rey | Confluence with Monterey Bay | Approximately 65 feet upstream of State Highway 68 | Statistical Analysis and SCS Rainfall-Runoff | USACE HEC-2 step-backwater Computer Program (USACE, 1973) | * | AE w/ Floodway, AO | Flood hydrographs and peak discharges for the 10-, 2-, 1-, and 0.2-percent annual chance floods were based on statistical analyses of stream gage records and rainfall-runoff computations.<br>Flood hydrographs were generated based on the U.S. Soil Conservation Service rainfall-runoff procedure. It uses the basin area, unit hydrograph, soil type, ground cover, antecedent moisture conditions, and a storm rainfall depth and time distribution to develop a runoff hydrograph (U.S. Department of Agriculture, 1972).<br>The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956).<br>Inadequate culvert capacity at several road crossings causes temporary damming effect as water ponds behind the structures. This results in a lower discharge downstream of the affected culvert.<br>Capacities of bridges, culverts, and stream channels were considered in developing the final flow rates. Flows in excess capacity were routed overland and recombined with channel flows where appropriate.<br>Elevations were computed through the use of the USACE HEC-2 step-backwater computer program (USACE, 1973) and were supplemented by hand calculations where required. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Canyon Del Rey, continued | Confluence with Monterey Bay | Approximately 65 feet upstream of State Highway 68 | Statistical Analysis and SCS Rainfall-Runoff | USACE HEC-2 step-backwater Computer Program (USACE, 1973) | * | AE w/ Floodway, AO | Starting water-surface elevations were based on the mean higher high water at Monterey Bay on the Pacific Ocean.<br>Floodplain boundaries were taken from the FIS for the City of Seaside (FEMA, 1981).<br>Equal-conveyance reduction was used in floodway computations. In addition to the 1.0-foot rise and velocity criteria, maintaining storage was also considered. Ponding behind high highway culverts significantly lowered flows. The proposed floodway maintains storage where necessary to avoid increasing flows detrimentally. |
| Canyon Del Rey | At Blue Larkspur Lane | Approximately 1,580 feet upstream of State Highway 68 | Statistical Analysis and SCS Rainfall-Runoff | USACE HEC-2 step-backwater Computer Program (USACE, 1973) | * | AE w/ Floodway | Flood hydrographs and peak discharges for the 10-, 2-, 1-, and 0.2-percent annual chance floods were based on statistical analyses of stream gage records and rainfall-runoff computations. A stream gage is located on Canyon Del Rey in Del Rey Park. However, because of the short record (1967 through 1978) and the large number of small events in the record, it was not considered adequate for the log-Pearson Type III analysis.<br>Flood hydrographs were generated based on the U.S. Soil Conservation Service rainfall-runoff procedure. It uses the basin area, unit hydrograph, soil type, ground cover, antecedent moisture conditions, and a storm rainfall depth and time distribution to develop a runoff hydrograph (U.S. Department of Agriculture, 1972).<br>The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Canyon Del Rey, continued | At Blue Larkspur Lane | Approximately 1,580 feet upstream of State Highway 68 | Statistical Analysis and SCS Rainfall-Runoff | USACE HEC-2 step-backwater Computer Program (USACE, 1973) | * | AE w/ Floodway | Capacities of bridges, culverts, and stream channels were considered in developing the final flow rates. Flows in excess capacity were routed overland and recombined with channel flows where appropriate.<br>Elevations were computed through the use of the USACE HEC-2 step-backwater computer program (USACE, 1973) and were supplemented by hand calculations where required.<br>Starting water-surface elevations were based on the mean higher high water at Monterey Bay on the Pacific Ocean.<br>Equal-conveyance reduction was used in floodway computations. In addition to the 1.0-foot rise and velocity criteria, maintaining storage was also considered. Ponding behind high highway culverts significantly lowered flows. The proposed floodway maintains storage where necessary to avoid increasing flows detrimentally. |
| Canyon Del Rey | Approximately 65 feet upstream of State Highway 68 | At Blue Larkspur Road | Statistical Analysis and SCS Rainfall-Runoff | USACE HEC-2 step-backwater Computer Program (USACE, 1973) | * | A | * |
| Carmel River | Approximately 370 feet upstream of confluence with Pacific Ocean | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Frequency Analysis and log-Pearson Type III Analysis | HEC-RAS | * | AE w/ Floodway | Peak flows were determined from a frequency analysis of flows at USGS Gage 11143200, Carmel River at Robles Del Rio and USGS Gage 11143250, Carmel River near Carmel. |

### Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Carmel River, continued | Approximately 370 feet upstream of confluence with Pacific Ocean | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Frequency Analysis and log-Pearson Type III Analysis | HEC-RAS | * | AE w/ Floodway | A regional skew values was determined from PEAKFQ. Peak 10-, 2-, 1-, and 0.2-percent annual chance discharge values were calculated at the gages, then scaled by drainage area to a series of index points along the study reach.<br>Cross sections used in the backwater analyses of the revised detailed study were obtained from field surveys and a Triangulated Irregular network (TIN) derived from Light Detection and Ranging (LiDAR) data.<br>At the Carmel River mouth, starting water-surface elevations for the backwater analyses were calculated with the normal depth equation using an energy slope of 0.0017 ft/ft. A frequency analysis of peak annual Carmel River Lagoon stages was also conducted. Within the Lagoon, water-surface profiles were based on the higher of the two analyses.<br>Previous studies<br>Peak discharges were based on a log-Pearson Type III analysis of the stream gage records (U.S. Water Resources Council, 1976).<br>The frequency analysis for Carmel River at the San Clemente Dam spillway (1938-1979) was used directly. The statistics for the gage on the Carmel River near Carmel (1963-1978) were adjusted based on the correlation with the record at San Clemente Dam. The gage for the Carmel River at Robles del Rio was not used because of difficulties with the record. Inconsistencies between the three gages are described in a 1974 USACE report (USACE, April 1974). |

### Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Carmel River, continued | Approximately 370 feet upstream of confluence with Pacific Ocean | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Frequency Analysis and log-Pearson Type III Analysis | HEC-RAS | * | AE w/ Floodway | Cross sections for the backwater analyses were obtained from aerial photographs flown in September 1978, at a negative scale of 1:12,000 in rural areas and 1:6,000 in urbanized areas (Harl Pugh and Associates, 1978).<br>Starting water-surface elevations is Mean Higher High Water.<br>Substantial levees or mass fill areas exist on the Carmel River on the north side of the low-flow channel from State Highway 1 upstream approximately 4,000 feet. On the south side of the channel, there are manmade levees from approximately 3,000 feet above the mouth upstream 7,000 feet. Because the 1-percent annual chance floodflow cannot be completely contained within the low-flow channel (the channel capacity is approximately a 20- 25-year flood), 9,000 cfs spill into the north overbank just upstream of the north levee. This water flows parallel to the Carmel River channel on the north side of the levee until it joins with the main channel, downstream of State Highway 1. Whether the south levee will fail during the 1-percent annual chance flood cannot be determined.<br>From its mouth upstream 10,000 feet was analyzed in three ways because of the uncertainty of the south levee's stability and the variable severity of flooding on each overbank.<br>The north overbank was analyzed assuming that the south levee remains intact and forces the entire 9,000 cfs to the north overbank as previously described. The path of this flow is shown as "Carmel River North Overbank" on the maps and profiles. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Carmel River, continued | Approximately 370 feet upstream of confluence with Pacific Ocean | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Frequency Analysis and log-Pearson Type III Analysis | HEC-RAS | * | AE w/ Floodway | The worst set of conditions to be expected in a 1-percent annual chance flood (i.e., highest elevations) is being shown for the north bank.<br>The south overbank was analyzed assuming that the south levee fails during the 1-percent annual chance flood, and the south bank is therefore inundated. This flow path is shown as “Carmel River South Overbank” on the maps and profiles and represents the worse set of conditions (highest elevations) to be expected in the south overbank. The flow breaks out of the main channel just upstream of the south levee and returns to the channel downstream of the levee.<br>The main channel was analyzed assuming that both levees hold, producing higher elevations on the channel between the levees than are shown in the two overbanks. The worst situation to be expected on the main channel is being shown. The main channel elevations are shown on the profiles, with the assumption that both levees remain in tact.<br>The floodplain boundaries were delineated using the flood elevations at each cross section. Between cross sections, the boundaries were interpolated using the topographic data.<br>Equal-conveyance reduction was used in floodway computations for the study reach, except for the lowest 10,000 feet. In this case, the 1-percent annual chance flood flow could not be contained in the north and south overbanks without raising the water-surface elevation by more than 1.0-foot. Often, velocity increase was the controlling restriction rather than a 1.0-foot rise in water-surface elevation. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Carmel River, continued | Approximately 370 feet upstream of confluence with Pacific Ocean | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Frequency Analysis and log-Pearson Type III Analysis | HEC-RAS | * | AE w/ Floodway | A floodway analysis was conducted on Carmel River between RM 15.6 and RM 1.7. For this study, the floodway was computed by applying the equal-conveyance reduction method in HEC-RAS. The maximum allowable surcharge was 1.0-foot. Using the effective floodway as a guide, the resulting floodway delineation was refined to obtain smooth transitions from section to section. In several cases, the floodway width was increased upstream and/or downstream of bridges to avoid exacerbating flow existing pressure flow or roadway overtopping conditions. In confined reaches, the floodway was set at the 1-percent annual chance exceedance flood hazard boundary. |
| Carmel River | Approximately 1,656 feet upstream of Access Road Bridge and Weir | Approximately 1.3 miles upstream of Nanson Road | Frequency Analysis | HEC-RAS | * | A | * |
| Carmel River Garland Ranch Overbank | Convergence with Carmel River main channel | Divergence from Carmel River main channel | Frequency Analysis | HEC-RAS | * | AE | * |
| Carmel River Hacienda Carmel Overbank | Convergence with Carmel River main channel | Approximately 3,250 feet upstream of convergence with Carmel River main channel | Frequency Analysis | HEC-RAS | * | AE w/ Floodway | * |
| Carmel River North Highway 1 Overbank | Confluence with Carmel River main channel | Approximately 1,285 feet upstream of Val Verde Drive | Frequency Analysis | HEC-RAS | * | AE | * |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Carmel River Schulte Overbank | Confluence with Carmel River main channel | Approximately 1,250 feet upstream of Via Sereno Drive | Frequency Analysis | HEC-RAS | * | AE | * |
| Carmel River South Highway 1 Overbank | Confluence with Carmel River main channel | Approximately 1 mile upstream of State Highway 1 | Frequency Analysis | HEC-RAS | * | AE | * |
| Castroville Boulevard Wash | Approximately 890 feet downstream of Dolan Road | Approximately 1,900 feet upstream of Archer Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Peak discharges were based on the SCS procedure (U.S. Department of Agriculture, 1972). The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956). |
| Corncob Canyon Creek | Confluence with Elkhorn Slough | Approximately 290 feet upstream of Jamison Court | U.S. Soil Conservation Service Rainfall-Runoff Procedure (U.S. Department of Agriculture, 1972) | * | * | AE w/ Floodway | Discharges were determined using the SCS rainfall-runoff model upstream of Warner Lake; downstream, the discharge spills from the Pajaro River were used to determine flow rates.<br>Inadequate culvert capacity downstream of Elkhorn Road causes temporary damming effect as water ponds behind the structure. This results in a lower discharge downstream of the affected culvert.<br>Flooding is augmented by spills from the Pajaro River upstream of Salinas Road. Floodwaters enter Corncob Canyon Creek at Warner Lake, just upstream of the Southern Pacific Railroad. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Del Monte Lake | At Garden Drive | At Del Monte Avenue | Hydrographs | Hand Calculations and Drainage-Discharge Information | * | AE | The storm pattern from the storm of December 1955 was used to develop hydrographs for floods of the selected recurrence intervals. Antecedent moisture conditions for each recurrence interval were calibrated based on the results of the analysis of the El Toro Creek stream gage.<br>Flood elevations were determined by hand calculations in conjunction with the drainage-discharge information.<br>Because of extensive urbanization in the vicinity of Del Monte Lake no floodways were computed. |
| East Branch Gonzales Slough | Confluence with Gonzales Slough | Approximately 870 feet upstream of confluence with Gonzales Slough | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, October 1973) | * | AE w/ Floodway | Peak discharges were calculated using the U.S. Soil Conservation Service rainfall runoff procedure (U.S. Department of Agriculture, 1972). This procedure uses the basin area, unit hydrograph, soil type, ground cover, antecedent moisture conditions, and a storm rainfall depth and time distribution to develop a runoff hydrograph.<br>The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals. The storm depths for each subbasin were based on the mean annual precipitation (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956) and a regression equation derived from precipitation stations within the region.<br>Separate regression equations were used for the 10-, 2-, 1-, and 0.2-percent annual chance storms. Basin type and land use factors were selected for El Toro Creek. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| East Branch Gonzales Slough, continued | Confluence with Gonzales Slough | Approximately 870 feet upstream of confluence with Gonzales Slough | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, October 1973) | * | AE w/ Floodway | Antecedent moisture conditions for each recurrence interval were calibrated based on the results of the analysis of the El Toro Creek stream gage.<br>Starting water-surface elevations were set equal to the concurrent water-surface elevations at its mouth in Gonzales Slough. This was done because the peak flows in the two creeks are nearly coincident. |
| East Branch Gonzales Slough | Approximately 870 feet upstream of confluence with Gonzales Slough | Approximately 2,600 feet upstream of el Camino Real | U.S. Soil Conservation Service Rainfall-Runoff Procedure (U.S. Department of Agriculture, 1972) | USACE HEC-2 step-backwater computer program (USACE, October 1973) | * | A | * |
| El Estero Lake | At Lake Street | At Freemont Street | Hydrographs | Hand Calculations and Drainage-Discharge Information | * | AE | The storm pattern from the storm of December 1955 was used to develop hydrographs for floods of the selected recurrence intervals. Antecedent moisture conditions for each recurrence interval were calibrated based on the results of the analysis of the El Toro Creek stream gage.<br>The outflows were based on the maximum pumping capacity of the pump station that drains the lake. The pump station was assumed to be in operation during the entire storm for each recurrence interval.<br>Flood elevations were determined by hand calculations in conjunction with the drainage-discharge information.<br>Because of extensive urbanization in the vicinity of El Estero Lake no floodways were computed. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| El Toro Creek | Confluence with Salinas River | Approximately 300 feet upstream of Monterey Highway 68 | Frequency Analysis and log-Pearson Type III Analysis | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Peak flows were determined from frequency analysis of flows at USGS Gage 11152540, El Toro Creek near Spreckles, located just downstream of the study reach. An appropriate regional skew value was determined from analysis of seven nearby gages. Peak, 10-, 2-, 1-, and 0.2-percent annual chance discharge values were calculated at the gage, then scaled by drainage area to a series of index points along the study reach.<br>Peak discharges were based on a log-Pearson Type III analysis of the stream gage records (U.S. Water Resources Council, 1976).<br>Cross sections for the backwater analyses for the revised detailed study were obtained from field surveys and extended with available 2-foot contour topographic mapping.<br>The starting water-surface elevations were taken from the existing FIS profile. |
| Elkhorn Slough | At Pacific Ocean | Approximately 2,360 feet upstream of U.S. Highway 101 | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Peak discharges were based on the SCS procedure (U.S. Department of Agriculture, 1972). The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956).<br>Cross sections for the backwater analyses were obtained from aerial photographs flown in September 1978, at a negative scale of 1:12,000 in rural areas and 1:6,000 in urbanized areas (Harl Pugh and Associates, 1978). |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Elkhorn Slough, continued | At Pacific Ocean | Approximately 2,360 feet upstream of U.S. Highway 101 | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Starting water-surface elevations is Mean Higher High Water.<br>Levees along lower Elkhorn Slough were ignored because they have no effect on the 1-percent annual chance flood.<br>Floodways were delineated without consideration of tidal influence from the Pacific Ocean. |
| Gabilan Creek | Confluence with Reclamation Ditch | Approximately 50 feet upstream of Hebert Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | The SCS model was used on a weighted-average basis along with statistical analysis of the stream gage and regional regression equations (U.S. Department of Agriculture, 1972).<br>Starting water-surface elevations were based on coincident water-surface elevations from Carr Lake determined from the Monterey County Master Drainage Plan report for Carr Lake and Reclamation Ditch (Monterey County, California, 1979).<br>Equal-conveyance reduction was used in floodway computations for the study reach. Occasionally, velocity increase was the controlling restriction rather than a 1.0-foot rise in water-surface elevation. |
| Gonzales Slough | Approximately 1,520 feet downstream of 7th Street | Approximately 1,380 feet upstream of Hebert Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, October 1973) | * | AE w/ Floodway | Peak discharges were calculated using the U.S. Soil Conservation Service rainfall runoff procedure (U.S. Department of Agriculture, 1972). This procedure uses the basin area, unit hydrograph, soil type, ground cover, antecedent moisture conditions, and a storm rainfall depth and time distribution to develop a runoff hydrograph.<br>The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Gonzales Slough, continued | Approximately 1,520 feet downstream of 7th Street | Approximately 1,380 feet upstream of Hebert Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, October 1973) | * | AE w/ Floodway | The storm depths for each subbasin were based on the mean annual precipitation (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956) and a regression equation derived from precipitation stations within the region. Separate regression equations were used for the 10-, 2-, 1-, and 0.2-percent annual chance storms. Basin type and land use factors were selected for El Toro Creek.<br>Antecedent moisture conditions for each recurrence interval were calibrated based on the results of the analysis of the El Toro Creek stream gage.<br>The effects of channel and valley (overbank) storage on flood flow rates were determined by developing storage-discharge relationships for reaches on Gonzales Slough. The storage-discharge relationships were developed by computing a series of water-surface profiles for various flow rates and determining the storage in the reach for each outflow rate.<br>Cross sections were taken sufficiently downstream of the corporate limits to ensure that the starting water-surface elevation assumptions would not influence the water-surface profiles within the study reach.<br>Gonzales slough has enough storage capacity downstream of the Monterey Vineyard culvert to significantly attenuate flow. Encroachment of the 1-percent annual chance floodplain with fill material would decrease the storage, and, thus, cause higher flows downstream. After the floodway boundaries were computed a first time, the flows ere recomputed with decreased storage capacity in the slough. The floodway boundaries were then recomputed with the higher flows. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Harper Creek | At Paseo Verde Road | Approximately 260 feet upstream of Private Road | Regional Regression Equations | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Peak flows were estimated by applying the scaling function to these estimated flows. The estimated peak flows were computed using regional regression equations. Correction factors were developed by comparing the peak flows of the watershed and subwatersheds at the El Toro Creek gage and San Benancio at El Toro Creek.<br>The 1- and 0.2-percent-annual-chance floodplain boundaries were delineated using the flood elevations determined at each cross section.<br>The floodway was mapped by marking the calculated distance from the centerline on each of the cross-sections, and using the shape of the channel centerline as a guide, generating one line along either side of the channel that intersected the cross-sections in the appropriate location. For a large portion of the mapped channel, the floodway boundary as noted at each cross section was outside of the 1-percent annual chance floodplain boundary, which indicates that 1-percent annual chance flood is contained within the channel banks. When this situation occurred, the floodway boundary was assumed to coincide with the 1-percent annual chance floodplain. |
| Josselyn Canyon Creek | Confluence with Monterey Bay | Approximately 15 feet upstream of Mark Thomas Drive | Hydrographs | Hand Calculations and Drainage-Discharge Information | * | AE, AH | The storm pattern from the storm of December 1955 was used to develop hydrographs for floods of the selected recurrence intervals. Antecedent moisture conditions for each recurrence interval were calibrated based on the results of the analysis of the El Toro Creek stream gage. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Josselyn Canyon Creek, continued | Confluence with Monterey Bay | Approximately 15 feet upstream of Mark Thomas Drive | Hydrographs | Hand Calculations and Drainage-Discharge Information | * | AE, AH | Flood elevations were determined by hand calculations in conjunction with the drainage-discharge information.<br>Starting water surface elevations were obtained using the mean higher high water at Monterey Bay.<br>Because of extensive urbanization in the vicinity of Josselyn Canyon Creek no floodways were computed. |
| Little Sur River | Confluence with Monterey Bay | Approximately 15 feet upstream of Mark Thomas Drive | * | * | * | A | * |
| Natividad Creek | Confluence with Reclamation Ditch | Approximately 4,870 feet upstream of Gee Street | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Flows were derived from the SCS rainfall-runoff model (U.S. Department of Agriculture, 1972). Discharges and storage capacities for Carr Lake were determined in a report prepared by the Monterey County Flood Control and Water conservation District (MCFCWCD) for the Monterey County Master Drainage Plan (MCFCWCD, 1979).<br>Starting water-surface elevations were based on coincident water-surface elevations from Carr Lake determined from the Monterey County Master Drainage Plan report for Carr Lake and Reclamation Ditch (Monterey County, California, 1979).<br>Equal-conveyance reduction was used in floodway computations for the study reach, except immediately upstream from East Laurel Drive, where overbank storage must be retained to prevent increases in design flows. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Pajaro River | Approximately 200 feet above mouth at Pacific Ocean | County boundary | USACE HEC-1 | * | * | AE w/ Floodway, AO | Peak flows in the Pajaro River basin for the 10-, 2-, 1-, and o.2-percent annual chance events were based on rainfall-runoff computations using the USACE HEC-1 computer model (USACE, 1973). Calibration of rainfall-runoff parameters employed in the model was performed using the techniques described in the HEC-1 user documentation (USACE, 1973, HEC-1 Flood Hydrograph Package, User's Manual).<br>Flood hydrographs are influenced by storage and routing conditions in the overbanks. A flood hydrograph for the Pajaro River was obtained from Interim Report for Flood Control- Pajaro River Basin, California (USACE, June 1973). This hydrograph was scaled to give peak flows corresponding to the most recent USACE estimates. These flood flow estimates account for upstream basin characteristics including regulated storage and are, therefore, more acceptable that USGS estimates based solely on gaged flow records.<br>Cross sections for backwater analyses were obtained from topographic maps prepared by the USACE, at a scale of 1:1,200 (USACE, 1971) and from topographic maps, developed from aerial surveys, at a scale of 1:4,800 (Spink Corporation, 1978).<br>Starting water-surface elevations is Mean Higher High Water.<br>Because the Pajaro River levees do not provide 3 feet of freeboard with respect to the 1-percent annual chance flood, water-surface elevations were computed for two cases. In the first case, flood elevations were computed before levee overtopping begins, assuming that the levees remain in tact. |

### Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Pajaro River, continued | Approximately 200 feet above mouth at Pacific Ocean | County boundary | USACE HEC-1 | * | * | AE w/ Floodway, AO | In the second, case, floods were computed after overtopping occurs, assuming that the levees had failed. The worst case is sued to establish flood elevations in the channel and in the floodplain area. In this study, water-surface elevations before levee overtopping were always highest for the channel, while the highest elevations for the floodplain area were computed when the levees were assumed overtopped. The location of levee failure cannot be predicted during major floods; therefore, it was assumed that all levees fail.<br>Profiles labeled “Pajaro River” represent channel elevations from the mouth at the Pacific Ocean upstream to the county limits. The extent of this coverage includes flood elevations both downstream and upstream of the levees, as well as channel elevations inside the levees, under the assumption that they are not overtopped.<br>Floodways were computed based on the lower elevations obtained assuming that the levees fail. No floodway was computed between cross sections G and H because of the independent shallow flooding that occurs south of the levees. A floodway is not appropriate in areas of shallow flooding. |
| Pajaro River – Without Consideration of Levee | Approximately 1.6 miles downstream of McGowan Road | Approximately 1.6 miles upstream of the confluence of Thomasello Creek | USACE HEC-1 | * | * | AE w/ Floodway, AO | Cross sections for backwater analyses were obtained from topographic maps prepared by the USACE, at a scale of 1:1,200 (USACE, 1971) and from topographic maps, developed from aerial surveys, at a scale of 1:4,800 (Spink Corporation, 1978).<br>Starting water-surface elevations is Mean Higher High Water. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Pajaro River – Without Consideration of Levee, continued | Approximately 1.6 miles downstream of McGowan Road | Approximately 1.6 miles upstream of the confluence of Thomasello Creek | USACE HEC-1 | * | * | AE w/ Floodway, AO | Because the Pajaro River levees do not provide 3 feet of freeboard with respect to the 1-percent annual chance flood, water-surface elevations were computed for two cases. In the first case, flood elevations were computed before levee overtopping begins, assuming that the levees remain in tact. In the second, case, floods were computed after overtopping occurs, assuming that the levees had failed. The worst case is sued to establish flood elevations in the channel and in the floodplain area.<br>In this study, water-surface elevations before levee overtopping were always highest for the channel, while the highest elevations for the floodplain area were computed when the levees were assumed overtopped. The location of levee failure cannot be predicted during major floods; therefore, it was assumed that all levees fail.<br>Floodways were computed based on the lower elevations obtained assuming that the levees fail. No floodway was computed between cross sections G and H because of the independent shallow flooding that occurs south of the levees. A floodway is not appropriate in areas of shallow flooding. |
| Pine Canyon Creek | Confluence with Salinas River | Approximately 616 feet upstream of Pine Canyon Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Peak discharges were based on the SCS procedure (U.S. Department of Agriculture, 1972). The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956). |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Pine Canyon Creek, continued | Confluence with Salinas River | Approximately 616 feet upstream of Pine Canyon Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Equal-conveyance reduction was used for the study reach. For many sections, excessive velocities were the limiting factor rather than a 1.0-foot rise in water-surface elevation. |
| Reclamation Ditch | Confluence with Tembladero Slough | Approximately 3,050 feet upstream of Airport Boulevard | U.S. Soil Conservation Service Rainfall-Runoff Procedure | Slope/Area Method | * | AE w/ Floodway, AO | Reclamation Ditch flows were derived from the SCS rainfall-runoff model and further modified by storage-discharge curves for Heinz and Carr Lakes. Heinz Lake is a dry lake located southeast of Salinas along Reclamation Ditch. As these derived flows were within 10 percent of the flows of the Carr Lake study (Monterey county Flood Control and Water Conservation District, 1979), the flows derived from the SCS model were used (U.S. Department of Agriculture, 1972).<br>Cross sections for the backwater analyses of the Reclamation Ditch for the revised detailed study between Tembladero Slough and Boronda Road were obtained from field surveys.<br>Starting water-surface elevations were determined using the slope/area method.<br>Downstream of East Alisal Street, Reclamation Ditch overflows the left overbank and becomes ponded along the U.S. Highway 101 embankment and along an area of high ground between Bridge Street and Sherwood Drive.<br>These areas of shallow flooding and ponding were determined using surveyed and photogrammetric elevations, field investigations by experienced engineers, and hand calculations based on normal depths. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Reclamation Ditch, continued | Confluence with Tembladero Slough | Approximately 3,050 feet upstream of Airport Boulevard | U.S. Soil Conservation Service Rainfall-Runoff Procedure | Slope/Area Method | * | AE w/ Floodway, AO | Equal-conveyance reduction was used in floodway computations for the study reach. Just downstream from Carr Lake, maintenance of the water-surface elevation in Carr Lake was the controlling restriction. The entire surface area of Carr Lake is retained as floodway to preserve storage. |
| Salinas River | Approximately 1.6 miles downstream of State Highway 1 | Approximately 5.3 miles upstream of State Highway 68 | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | Peak discharges were based on hydrologic modeling of the basin. A HEC-1 model (USACE, January 1973) was calibrated to fit the frequency-discharge curve for the river prior to the construction of the Nacimiento and San Antonio Dams. This frequency curve was based on Salinas River near Spreckles stream gage (1930-1956) using the log-Pearson Type III analysis including historic adjustment. The flood-control storage-discharge relationships for the dams were added to the model to estimate the regulated discharge for each recurrence interval.<br>On the Salinas River, floodwaters downstream of Salinas River Overbank cross Nashua Road as weir flow. The flow (4,000 cfs) is trapped between Nashua Road and State Highway 183 and flows into Tembladero Slough.<br>Starting water-surface elevations were based on normal depth approximately 2 miles downstream.<br>Stationing was based on the Pacific Southwest Inter-Agency Committee River Mile Index. Correlations were made at certain river mile locations, resulting in some minor distortion between such locations because of scale change and uncertainties in the location of the channel centerline (FEMA, 1986). |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Salinas River, continued | Approximately 1.6 miles downstream of State Highway 1 | Approximately 5.3 miles upstream of State Highway 68 | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | The starting water-surface elevation, which drains into the Pacific Ocean, is near higher high-water.<br>Channel roughness factors (Manning's "n") for hydraulic computations were assigned on the basis of field inspection of floodplain areas. Roughness factors for the Salinas River were determined by calibration through successive iterations using high-water marks for the January 18-21 and February 23-28, 1969, flooding events and stage-discharge data for the February 8-12, 1978, flood event. The 1969 high-water marks were obtained from a USACE report on the January and February floods (USACE, 1970). The 1978 stage-discharge data were obtained from the USGS (U.S. Department of the Interior, 1978) for the Salinas River stream gages at Bradley and Spreckles.<br>Salinas River stationing was based on the Pacific Southwest Inter-Agency Committee River Mile Index. Correlations were made at certain river mile locations, resulting in some minor distortion between such locations because of scale change and uncertainties in the location of the channel centerline.<br>A bridge constriction at Blanco Road west of the City of Salinas causes 1-percent annual chance floodwaters from the Salinas River to flow over a low ridge east of the main channel. The ridge is inundated by the 1-percent annual chance flood and acts as a weir to convey the flow northward across Blanco Road and parallel to the main channel. Lowlands adjacent to the ridge allow this breakout flow to pond southeast of Blanco Road. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Salinas River, continued | Approximately 1.6 miles downstream of State Highway 1 | Approximately 5.3 miles upstream of State Highway 68 | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | The flow, called Salinas River Overbank, rejoins the main channel approximately 4 miles downstream of Blanco Road. A separate flood profile for the Salinas River Overbank has been presented.<br>Upstream of the City of Salinas, shallow flooding with depths of less than 1 foot occurs on the northern bank of the Salinas River, inundating the overbank up to the Southern Pacific Railroad embankment. This situation prevails downstream as far as the Pacific coast. Areas of this extensive shallow flooding that occur adjacent to Tembladero Slough and Elkhorn Slough originate from the Salinas River.<br>The floodways were computed on the basis of equal-conveyance reduction. Because of its sandy bed, floodway velocities were of primary concern in the determination of the floodway boundaries. Care was taken to minimize excessive velocities in the channel under encroached conditions. Where velocities in the channel were in excess of 6 feet per second, floodway velocities were held to a maximum increase of 0.5 foot per second. For 1-percent annual chance flood velocities less than 6 feet per second, a maximum of 1 foot per second increase in floodway velocities was observed. In no event was more than a 1.0-foot rise in water-surface elevation allowed. A floodway is not appropriate for Salinas River Overbank and there was not shown. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Salinas River | Approximately 1.1 miles downstream of Pine Canyon Creek | Approximately 4,874 feet upstream of confluence of San Lorenzo Creek | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | On the Salinas River near King City, a profile baseline is used to show the path taken by the 1-percent annual chance flood flows. The natural channel is also shown on the maps to represent the low-flow location of Salinas River drainage. |
| Salinas River | Approximately 1 mile downstream of Cattlemen Road | Approximately 3,000 feet upstream of Cattlemen Road | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | * |
| Salinas River | Approximately 5.3 miles upstream of State Highway 68 | Approximately 1.1 miles downstream of Pine Canyon Creek | HEC-1 and log-Pearson Type III | * | * | A | * |
| Salinas River | Approximately 4,874 feet upstream of confluence of San Lorenzo Creek | Approximately 1 mile downstream of Cattlemen Road | HEC-1 and log-Pearson Type III | * | * | A | * |
| Salinas River | Approximately 3,000 feet upstream of Cattlemen Road | County boundary | HEC-1 and log-Pearson Type III | * | * | A | * |
| Salinas River Overbank | Convergence with Salinas River | Approximately 2,760 feet upstream of Blanco Road | HEC-1 and log-Pearson Type III | * | * | AE w/ Floodway | * |
| San Benancio Gulch | Confluence with El Toro Creek | Approximately 745 feet upstream of San Benancio Road | Regional Regression Equations | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Peak flows were estimated by applying the scaling function to these estimated flows. The estimated peak flows were computed using regional regression equations. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| San Benancio Gulch, continued | Confluence with El Toro Creek | Approximately 745 feet upstream of San Benancio Road | Regional Regression Equations | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Correction factors were developed by comparing the peak flows of the watershed and subwatersheds at the El Toro Creek gage and San Benancio at El Toro Creek. The subwatershed peak flows are correct by applying these correction factors.<br>Starting water surface elevations at the confluence with El Toro Creek were determined from the results of the FIS study of Calera Creek performed by North West Hydraulic Consultants in 2005.<br>The 1- and 0.2-percent-annual-chance floodplain boundaries were delineated using the flood elevations determined at each cross section.<br>The floodway was mapped by marking the calculated distance from the centerline on each of the cross-sections, and using the shape of the channel centerline as a guide, generating one line along either side of the channel that intersected the cross-sections in the appropriate location. For a large portion of the mapped channel, the floodway boundary as noted at each cross section was outside of the 1-percent annual chance floodplain boundary, which indicates that 1-percent annual chance flood is contained within the channel banks. When this situation occurred, the floodway boundary was assumed to coincide with the 1-percent annual chance floodplain. |
| San Jose Creek | At Highway 1 | Approximately 2,462 feet upstream of Highway 1 | * | * | * | A | * |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| San Lorenzo Creek | Confluence with Salinas River | Approximately 4,740 feet upstream of Southern Pacific Railroad | Log-Pearson Type III | * | * | AE w/ Floodway | Peak discharges were based on log-Pearson Type III analysis (U.S. Water Resources Council, 1977) of the stream-gage records for San Lorenzo Creek below Bitterwater Creek gage (1959-1978).<br>Peak discharges were based on a long-Pearson Type III analysis of the stream gage records (U.S. Water Resources Council, 1976).<br>The record for the existing gage (1959-1978) located below Bitterwater Creek gage was supplemented with additional data from years during which a gage was present on the creek at a different location (1940-1942 and 1943-1945). The peak discharges for those years were adjusted to account for the differences in drainage area between the various gage locations.<br>Starting water-surface elevations were based on critical depth in the constricted section where the creek discharges into the Salinas River floodplain.<br>The floodways were computed on the basis of equal-conveyance reduction from each side of the floodplain. Due to the sandy bed material floodway velocities were of primary concern in the determination of the floodway boundaries. |
| San Miguel Canyon Creek | At U.S. Highway 101 | Approximately 270 feet upstream of confluence of North San Miguel Canyon Creek | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | Peak discharges were based on the SCS procedure (U.S. Department of Agriculture, 1972). The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906- |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| San Miguel Canyon Creek, continued | At U.S. Highway 101 | Approximately 270 feet upstream of confluence of North San Miguel Canyon Creek | U.S. Soil Conservation Service Rainfall-Runoff Procedure | * | * | AE w/ Floodway | 1956).<br>Equal-conveyance reduction was used for the study reach. Velocity was often the limiting factor in the floodway computation. |
| Santa Rita Creek | Approximately 1 mile downstream of U.S. Highway 101 (El Camino Real) | Approximately 1.5 miles upstream of Rogue Road | U.S. Soil Conservation Service Rainfall-Runoff Procedure | Slope/Area Method | * | AE w/ Floodway | Flows were derived from the SCS rainfall-runoff model (U.S. Department of Agriculture, 1972). Discharges and storage capacities for Carr Lake were determined in a report prepared by the Monterey County Flood Control and Water conservation District (MCFCWCD) for the Monterey County Master Drainage Plan (MCFCWCD, 1979).<br>Starting water-surface elevations were determined using the slope/area method.<br>Floodways were computed on the basis of equal-conveyance reduction. |
| Seal Rock Creek | Approximately 344 feet downstream of Highway 1 | Approximately 163 feet upstream of Stevenson Drive | * | * | * | A | * |
| Tembladero Slough | Approximately 1,265 feet downstream of State Highway 1 | Approximately 20 feet upstream of Southern Pacific Railroad | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, 1984) | * | AE w/ Floodway | Peak discharges were based on the SCS procedure (U.S. Department of Agriculture, 1972). The storm pattern from the storm of December 1955 was used to develop hydrographs for all four recurrence intervals.<br>Mean annual precipitation values were based on an isohyetal map (USACE, Isohyetal Map, 50-year Normal Annual Precipitation, 1906-1956).<br>The starting water-surface elevation was determined from the 1-percent annual chance water-surface profile. |

## Table 13: Summary of Hydrologic and Hydraulic Analyses, continued

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Tembladero Slough, continued | Approximately 1,265 feet downstream of State Highway 1 | Approximately 20 feet upstream of Southern Pacific Railroad | U.S. Soil Conservation Service Rainfall-Runoff Procedure | USACE HEC-2 step-backwater computer program (USACE, 1984) | * | AE w/ Floodway | The backwater area of Tembladero Slough was delineated using the elevation at the confluence of Tembladero Slough and Reclamation Ditch. |
| Thomasello Creek | Confluence with Pajaro River | Approximately 900 feet upstream of confluence with Pajaro River | HEC-1 | * | * | AE | Flows used in the hydraulic analysis were developed from HEC-1 computer modeling (USACE, 1973). These flows were adjusted to agree with flows developed by the USACE in an unpublished local drainage study for the area within the Pajaro River basin.<br>Cross sections for backwater analyses were obtained from topographic maps prepared by the USACE, at a scale of 1:1,200 (USACE, 1971) and from topographic maps, developed from aerial surveys, at a scale of 1:4,800 (Spink Corporation, 1978).<br>An elevated right bank causes 100 cfs to be retained in the channel; however, during a 1-percent annual chance flood, the creek flows westerly over its elevated bank and ponds at a lover elevation behind the Pajaro River levee.<br>A floodway was not computed because the flow that escapes the channel cannot be contained within a floodway without incurring a rise in water-surface elevation of more than 1.0-foot. |
| Watson Creek | Approximately 20 feet downstream of Calera Canyon | Approximately 4,120 feet upstream of Corral de Tierra | Frequency Analysis | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Peak flows were determined from frequency analysis of flows at USGS Gage 11152540, El Toro Creek near Sprecklers, located just downstream of the study reach. An appropriate regional skew value was determined from analysis of seven nearby gages. |

**Table 13: Summary of Hydrologic and Hydraulic Analyses, continued**

| Flooding Source | Study Limits Downstream Limit | Study Limits Upstream Limit | Hydrologic Model or Method Used | Hydraulic Model or Method Used | Date Analyses Completed | Flood Zone on FIRM | Special Considerations |
|---|---|---|---|---|---|---|---|
| Watson Creek, continued | Approximately 20 feet downstream of Calera Canyon | Approximately 4,120 feet upstream of Corral de Tierra | Frequency Analysis | USACE HEC-RAS step-backwater computer program (USACE, 2003) | * | AE w/ Floodway | Peak, 10-, 2-, 1-, and 0.2-percent annual chance discharge values were calculated at the gage, then scaled by drainage area to a series of index points along the study reach.<br>Cross sections for the backwater analyses for the revised detailed study were obtained from field surveys and extended with available 2-foot contour topographic mapping.<br>The starting water-surface elevations were based on the Calera Creek flow profile.<br>The floodplain boundaries were delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using available 2-foot-contour topographic mapping. Floodplain boundaries for the 1-percent annual chance return interval flood were established from the maximum flood depth raster image of the study area exported from MIKE21. Polygons defining hazard zones were drawn based on the maximum flood depth raster, ground contours developed from LiDAR, and the influence of significant local structures observed on aerial photographs.<br>Floodways were computed on the basis of equal area reduction from each side of the floodplain. The results of these computations are tabulated at selected cross sections. Floodways were defined as coincident with the 1-percent annual chance floodplain at cross sections where the 1-percent annual chance peak discharge was conveyed entirely within the channel. |

**Table 14: Roughness Coefficients**

| Flooding Source | Channel "n" | Overbank "n" |
|---|---|---|
| East Branch Gonzales Slough | 0.015-0.040 | 0.025-0.030 |
| Gabilan Creek | 0.030-0.050 | 0.030-0.100 |
| Gonzales Slough | 0.015-0.045 | 0.015-0.040 |
| Natividad Creek | 0.030-0.040 | 0.010-0.200 |
| Reclamation Creek | 0.030-0.040 | 0.030-0.040 |
| Salinas Creek | 0.030 | 0.045 |
| San Lorenzo Creek | 0.030 | 0.045 |
| Santa Rita Creek | 0.030-0.050 | 0.020-0.060 |

## 5.3 Coastal Analyses

For the areas of Monterey County that are impacted by coastal flooding processes, coastal flood hazard analyses were performed to provide estimates of coastal BFEs. Coastal BFEs reflect the increase in water levels during a flood event due to extreme tides and storm surge as well as overland wave effects.

The following subsections provide summaries of how each coastal process was considered for this FIS Report. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation. Table 15 summarizes the methods and/or models used for the coastal analyses. Refer to Section 2.5.1 for descriptions of the terms used in this section.

**Table 15: Summary of Coastal Analyses**

| Flooding Source | Study Limits From | Study Limits To | Hazard Evaluated | Model or Method Used | Date Analysis was Completed |
|---|---|---|---|---|---|
| Pacific Ocean | Southern Santa Cruz County Border | Northern San Luis Obispo County Border | Wave Runup | FEMA Pacific Guidelines (2005). Stockdon, DIM, and TAW used to evaluate Runup | 11/11/2014 |

### 5.3.1 Total Stillwater Elevations

The total stillwater elevations (stillwater including storm surge plus wave setup) for the 1% annual chance flood were determined for areas subject to coastal flooding. The models and methods that were used to determine storm surge and wave setup are listed in Table 15. The stillwater elevation that was used for each transect in coastal analyses is shown in Table 17, "Coastal Transect Parameters." Figure  shows the total stillwater elevations for the 1% annual chance flood that was determined for this coastal analysis.

**Figure 8: 1% Annual Chance Total Stillwater Elevations for Coastal Areas**


### Astronomical Tide

Astronomical tidal statistics were generated directly from local tidal constituents by sampling the predicted tide at random times throughout the tidal epoch.

### Storm Surge Statistics

Storm surge is modeled based on characteristics of actual storms responsible for significant coastal flooding. The characteristics of these storms are typically determined by statistical study of the regional historical record of storms or by statistical study of tidal gages.

When historic records are used to calculate storm surge, characteristics such as the strength, size, track, etc., of storms are identified by site. Storm data was used in conjunction with numerical hydrodynamic models to determine the corresponding storm surge levels. An extreme value analysis was performed on the storm surge modeling results to determine a stillwater elevation for the 1% annual chance event.

Tidal gages can be used instead of historic records of storms when the available tidal gage record for the area represents both the astronomical tide component and the storm surge component. Table  provides the gage name, managing agency, gage type, gage identifier, start date, end date, and statistical methodology applied to each gage used to determine the stillwater elevations.

**Table 16: Tide Gage Analysis Specifics**

| Gage Name | Managing Agency of Tide Gage Record | Gage Type | Start Date | End Date | Statistical Methodology |
|---|---|---|---|---|---|
| Monterey (9413450) | NOAA | Tide (1240) | 11/4/1973 | 12/31/2009 | GEV |

Wave Setup Analysis

Wave setup was computed during the storm surge modeling through the methods and models listed in Table 15 and included in the frequency analysis for the determination of the total stillwater elevations.

### 5.3.2 Waves

An integral component of the transect-based TWL analysis is an accurate determination of the offshore and nearshore wave climate. A continuous 50-year hourly deep-water wave hindcast was developed by Oceanweather Inc. using reanalysis of historical wind fields. Three nested model grid components of sequentially higher resolution were used to resolve wave conditions of varying spatial scales, including basin (global), regional (Northeast Pacific Ocean), and coastal (California) grids.

The deep-water dataset was further transformed to reflect nearshore conditions at the edge of the surf zone in approximately 33-49 feet water depth. The nearshore wave transformation component was carried out by Scripps Institute of Oceanography (SIO) Coastal Data Information Program (CDIP) research group in collaboration with BakerAECOM using the SIO SHELF model. The output from this wave transformation model provides the input conditions for the 1-D transect coastal hazard analysis used to calculate BFEs.

### 5.3.3 Coastal Erosion

A single storm episode can cause extensive erosion in coastal areas. Storm-induced erosion was evaluated to determine the modification to existing topography that is expected to be associated with flooding events. Erosion was evaluated using the methods listed in Table 15.

### 5.3.4 Wave Hazard Analyses

Overland wave hazards were evaluated to determine the combined effects of ground elevation, vegetation, and physical features on overland wave propagation and wave runup. These analyses were performed at representative transects along all shorelines for which waves were expected to be present during the floods of the selected recurrence intervals. The results of these analyses were used to determine elevations for the 1% annual chance flood.

Transect locations were chosen with consideration given to the physical land characteristics as well as development type and density so that they would closely represent conditions in their locality. Additional consideration was given to changes in the total stillwater elevation. Transects were spaced close together in areas of complex topography and dense development or where total stillwater elevations varied. In areas having more uniform characteristics, transects were spaced at larger intervals. Transects shown in Figure 9, “Transect Location Map,” are also depicted on the FIRM. Table  provides the location, stillwater elevations, and starting wave conditions for each transect evaluated for overland wave hazards. In this table, “starting” indicates the parameter value at the beginning of the transect.

### Wave Height Analysis

Wave height analyses were performed to determine wave heights and corresponding wave crest elevations for the areas inundated by coastal flooding and subject to overland wave propagation hazards. Refer to Figure 6 for a schematic of a coastal transect evaluated for overland wave propagation hazards.

Wave heights and wave crest elevations were modeled using the methods and models listed in Table 15, “Summary of Coastal Analyses”.

### Wave Runup Analysis

Wave runup analyses were performed to determine the height and extent of runup beyond the limit of stillwater inundation for the 1% annual chance flood. Wave runup elevations were modeled using the methods and models listed in Table 15.

**Table 17: Coastal Transect Parameters**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 1 | 606214.59 | 4077757.40 | 14.3 | 15.4 | 15.9 | 16.9 | VE | 16 |
| 2 | 606589.49 | 4076769.74 | 15.3 | 16.6 | 17.2 | 18.5 | VE | 17 |
| 3 | 606987.21 | 4075812.36 | 18.8 | 19.8 | 20.2 | 20.8 | VE | 20 |
| 4 | 607324.71 | 4075106.55 | 13.4 | 14.4 | 14.8 | 15.7 | VE | 15 |
| 5 | 607468.07 | 4074780.33 | 21.2 | 23.4 | 24.3 | 26.3 | VE | 24 |
| 6 | 607609.79 | 4074286.79 | 14.6 | 15.4 | 15.7 | 16.5 | VE | 16 |
| 7 | 607637.49 | 4073806.71 | 13.6 | 14.5 | 14.8 | 15.6 | VE | 15 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 8 | 607637.05 | 4073685.06 | 12.6 | 13.3 | 13.6 | 14.4 | VE | 14 |
| 9 | 607609.66 | 4073510.70 | 11.7 | 12.4 | 12.7 | 13.3 | VE | 13 |
| 10 | 607412.32 | 4072679.23 | 14.3 | 15.6 | 16.1 | 17.5 | VE | 16 |
| 11 | 607158.04 | 4071714.60 | 14.9 | 15.9 | 16.2 | 16.8 | VE | 16 |
| 12 | 606802.66 | 4070345.40 | 18.5 | 19.7 | 20.1 | 21.1 | VE | 20 |
| 13 | 606479.17 | 4069071.52 | 20.4 | 22.2 | 22.9 | 24.5 | VE | 23 |
| 14 | 605915.13 | 4064960.97 | 16.6 | 17.8 | 18.3 | 19.2 | VE | 18 |
| 15 | 605698.16 | 4062206.20 | 18.7 | 20.4 | 21.1 | 22.6 | VE | 21 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 16 | 605269.48 | 4060575.15 | 19.9 | 21.8 | 22.6 | 24.5 | VE | 23 |
| 17 | 603871.68 | 4057127.94 | 20.1 | 21.8 | 22.5 | 24.1 | VE | 23 |
| 18 | 603227.29 | 4055972.22 | 14.8 | 15.9 | 16.5* | 17.6 | VE | 16 |
| 19 | 602726.15 | 4055168.06 | 14.1 | 14.9 | 15.2 | 15.8 | VE | 15 |
| 20 | 602051.31 | 4054160.88 | 13.7 | 14.4 | 14.6 | 15.0 | VE | 15 |
| 21 | 601844.31 | 4053869.90 | 13.6 | 14.1 | 14.3 | 14.6 | VE | 14 |
| 22 | 601231.93 | 4053181.80 | 18.9 | 20.4 | 21.0 | 22.5 | VE | 21 |
| 23 | 600958.86 | 4052912.54 | 15.4 | 16.7 | 17.2 | 18.5 | VE | 17 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 24 | 600708.50 | 4052696.69 | 15.8 | 16.9 | 17.3 | 18.2 | VE | 17 |
| 25 | 599959.09 | 4051870.74 | 12.3 | 12.8 | 13.0 | 13.4 | VE | 13 |
| 26 | 599724.44 | 4051892.58 | 12.3 | 13.1 | 13.4 | 14.1 | VE | 13 |
| 27 | 599512.24 | 4052076.21 | 8.6 | 8.9 | 9.0 | 9.3 | VE | 9 |
| 28 | 599703.56 | 4051906.55 | 9.8 | 10.2 | 10.4 | 10.7 | VE | 10 |
| 29 | 599216.30 | 4052496.02 | 10.3 | 11.4 | 11.9 | 13.1 | VE | 12 |
| 30 | 599088.59 | 4052628.45 | 17.6 | 18.1 | 18.2 | 18.5 | VE | 18 |
| 31 | 599020.00 | 4052699.77 | 10.3 | 10.8 | 11.0 | 11.4 | VE | 11 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 32 | 598836.47 | 4052907.21 | 12.5 | 13.1 | 13.4 | 13.9 | VE | 13 |
| 33 | 598715.27 | 4053030.23 | 14.7 | 15.5 | 15.8 | 16.4 | VE | 16 |
| 34 | 598466.50 | 4053261.96 | 30.1 | 31.4 | 31.8 | 32.5 | VE | 32 |
| 35 | 598357.96 | 4053361.38 | 14.3 | 15.3 | 15.7 | 16.5 | VE | 16 |
| 36 | 597768.83 | 4053634.28 | 25.1 | 26.6 | 27.1 | 28.2 | VE | 27 |
| 37 | 597319.96 | 4053937.07 | 14.5 | 15.4 | 15.8 | 16.6 | VE | 16 |
| 38 | 597311.82 | 4053949.72 | 14.2 | 15.6 | 16.3 | 18.0 | VE | 16 |
| 39 | 596868.39 | 4054457.33 | 14.1 | 15.2 | 15.7 | 16.8 | VE | 16 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 40 | 596664.54 | 4054673.32 | 14.1 | 16.0 | 16.8 | 18.6 | VE | 17 |
| 41 | 596343.94 | 4055140.62 | 14.6 | 15.9 | 16.5* | 18.0 | VE | 16 |
| 42 | 595289.21 | 4055619.41 | 20.6 | 23.3 | 24.6 | 28.1 | VE | 25 |
| 43 | 594428.69 | 4055238.69 | 16.3 | 18.0 | 18.9 | 21.0 | VE | 19 |
| 44 | 594011.41 | 4054431.99 | 16.5 | 17.7 | 18.2 | 19.2 | VE | 18 |
| 45 | 593544.49 | 4053434.57 | 16.5 | 18.0 | 18.7 | 20.4 | VE | 19 |
| 46 | 593262.79 | 4053086.01 | 23.9 | 26.3 | 27.3 | 29.8 | VE | 27 |
| 47 | 592138.95 | 4050745.46 | 20.7 | 21.9 | 23.6 | 25.7 | VE | 26 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 48 | 591810.56 | 4049876.18 | 19.2 | 21.0 | 21.8 | 23.8 | VE | 22 |
| 49 | 591641.41 | 4049592.34 | 21.5 | 23.8 | 24.8 | 26.9 | VE | 25 |
| 50 | 591575.36 | 4047687.68 | 34.1 | 38.0 | 39.5* | 42.5 | VE | 39 |
| 51 | 592819.58 | 4046697.00 | 21.9 | 25.3 | 26.9 | 31.2 | VE | 27 |
| 52 | 594071.45 | 4046541.14 | 26.4 | 30.8 | 32.8 | 37.6 | VE | 33 |
| 53 | 594404.16 | 4046545.86 | 22.1 | 26.8 | 28.9 | 34.2 | VE | 29 |
| 54 | 595028.82 | 4046472.00 | 12.7 | 14.5 | 15.4 | 17.9 | VE | 15 |
| 55 | 595274.15 | 4046289.09 | 17.3 | 21.7 | 24.1 | 31.4 | VE | 24 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 56 | 595390.11 | 4045984.27 | 14.3 | 15.4 | 15.8 | 16.9 | VE | 16 |
| 57 | 595490.76 | 4045477.42 | 21.2 | 28.5 | 32.2 | 42.9 | VE | 31 |
| 58 | 595422.07 | 4045187.34 | 16.7 | 21.2 | 23.8 | 32.0 | VE | 24 |
| 59 | 595044.82 | 4044515.75 | 15.4 | 17.4 | 18.5 | 21.8 | VE | 18 |
| 60 | 595316.56 | 4043955.08 | 24.2 | 26.1 | 26.8 | 28.2 | VE | 27 |
| 61 | 595379.29 | 4043854.80 | 24.8 | 26.0 | 27.6 | 29.1 | VE | 28 |
| 62 | 595773.60 | 4043142.12 | 15.8 | 16.8 | 17.2 | 18.2 | VE | 17 |
| 63 | 595678.95 | 4042940.59 | 17.8 | 18.6 | 19.7 | 21.1 | VE | 20 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 64 | 595249.81 | 4042915.05 | 17.6 | 18.7 | 19.1 | 20.0 | VE | 19 |
| 65 | 593745.23 | 4040545.48 | 18.3 | 19.3 | 19.7 | 20.5 | VE | 20 |
| 66 | 593890.65 | 4040069.47 | 23.6 | 31.6 | 36.1 | 49.5 | VE | 36 |
| 67 | 594059.77 | 4037726.98 | 32.8 | 40.4 | 44.1 | 53.7 | VE | 44 |
| 68 | 595684.88 | 4033298.03 | 39.6 | 40.4 | 40.6 | 40.7 | VE | 41 |
| 69 | 596000.30 | 4031569.20 | 20.8 | 22.9 | 23.8 | 25.9 | VE | 24 |
| 70 | 596372.00 | 4029592.18 | 23.9 | 28.5 | 30.7 | 36.5 | VE | 31 |
| 71 | 597264.16 | 4025363.22 | 18.3 | 21.5 | 23.2 | 27.8 | VE | 23 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 72 | 598328.89 | 4022161.64 | 23.8 | 26.7 | 28.0 | 31.4 | VE | 28 |
| 73 | 597978.42 | 4019498.04 | 24.9 | 28.4 | 30.2 | 35.2 | VE | 30 |
| 74 | 599286.27 | 4016936.16 | 21.8 | 25.2 | 26.7 | 30.2 | VE | 27 |
| 75 | 601063.03 | 4015532.71 | 18.1 | 19.7 | 20.4 | 22.0 | VE | 20 |
| 76 | 605467.23 | 4010445.50 | 22.0 | 27.6 | 30.6 | 38.9 | VE | 31 |
| 77 | 609220.22 | 4008670.08 | 18.1 | 22.2 | 24.4 | 31.0 | VE | 24 |
| 78 | 613558.23 | 4006625.92 | 23.9 | 28.5 | 30.7 | 36.5 | VE | 31 |
| 79 | 615660.77 | 4005259.86 | 18.2 | 19.5 | 20.0 | 21.0 | VE | 20 |

**Table 17: Coastal Transect Parameters, continued**

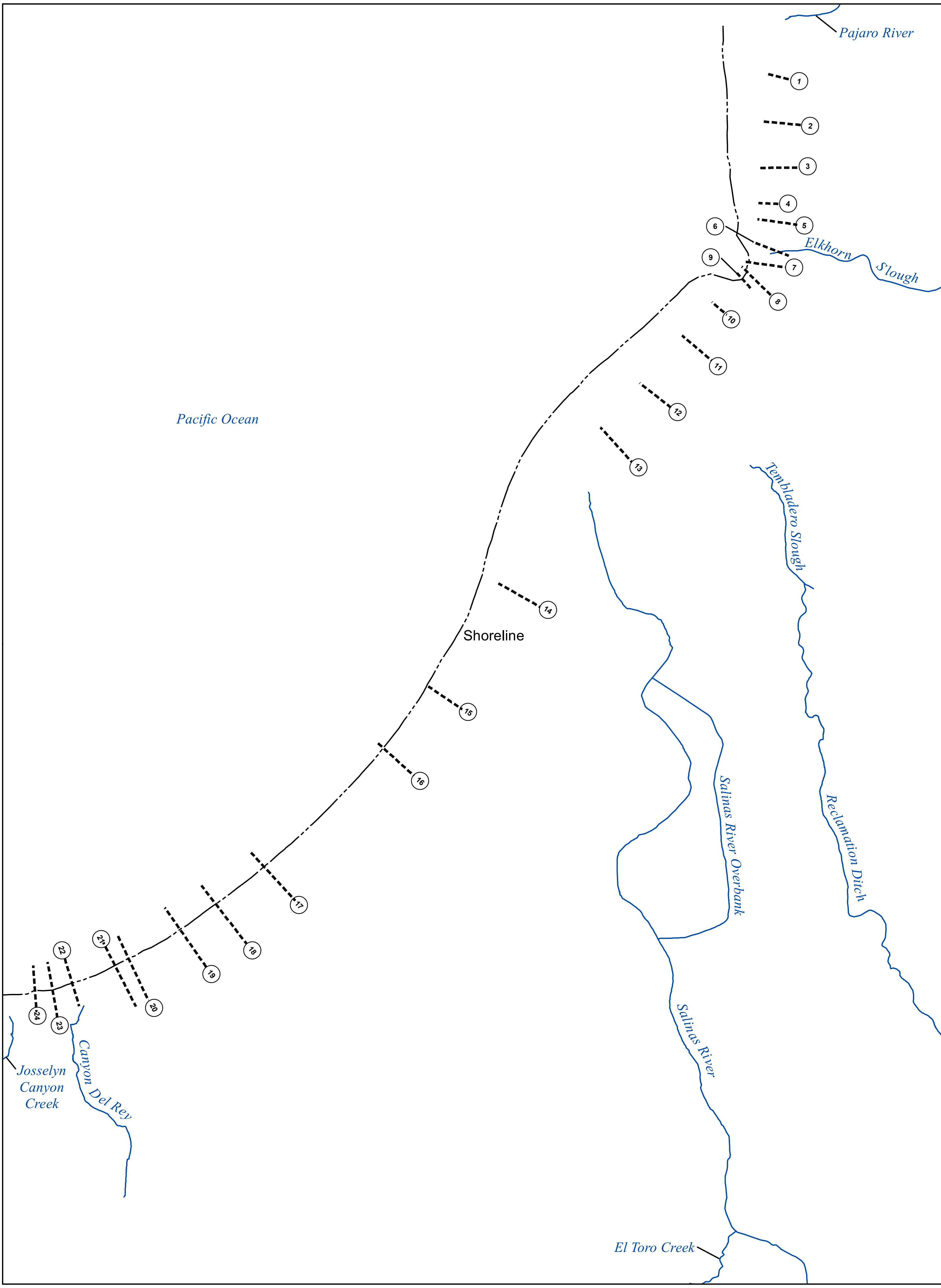
| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 80 | 620255.44 | 3999957.00 | 22.1 | 26.2 | 28.0 | 32.3 | VE | 28 |
| 81 | 622978.67 | 3996393.38 | 17.0 | 20.1 | 21.7 | 26.9 | VE | 22 |
| 82 | 625204.89 | 3992385.91 | 29.3 | 34.6 | 36.9 | 41.9 | VE | 37 |
| 83 | 627316.95 | 3987910.38 | 18.9 | 21.7 | 23.1 | 27.1 | VE | 23 |
| 84 | 630178.68 | 3985962.91 | 17.2 | 18.9 | 19.5 | 21.0 | VE | 20 |
| 85 | 633791.44 | 3984598.44 | 16.1 | 18.3 | 19.4 | 22.3 | VE | 19 |
| 86 | 635546.96 | 3981325.62 | 16.1 | 17.4 | 17.9 | 19.0 | VE | 18 |
| 87 | 636183.86 | 3978872.72 | 24.0 | 29.5 | 32.5 | 41.7 | VE | 32 |

**Table 17: Coastal Transect Parameters, continued**

| Transect | X,Y Coordinates (Meters, NAD83 UTM Zone 10) | | Total Water Elevation (feet NAVD88)[1] | | | | Zone | BFE (ft) |
|---|---|---|---|---|---|---|---|---|
| | X | Y | 10% Annual Chance | 2% Annual Chance | 1% Annual Chance | 0.2% Annual Chance | | |
| 88 | 636783.67 | 3976684.22 | 17.4 | 19.1 | 19.9 | 21.6 | VE | 20 |
| 89 | 637564.71 | 3974407.80 | 20.4 | 21.4 | 21.7 | 22.5 | VE | 22 |
| 90 | 639137.48 | 3971084.98 | 20.0 | 22.4 | 23.5 | 26.3 | VE | 24 |
| 91 | 641789.46 | 3968967.65 | 22.6 | 23.5 | 23.9 | 24.4 | VE | 24 |
| 92 | 643403.66 | 3967147.01 | 13.6 | 14.5 | 14.9 | 15.8 | VE | 15 |
| 93 | 647642.98 | 3963236.76 | 18.9 | 21.5 | 22.6 | 25.4 | VE | 23 |

[1]North American Vertical Datum of 1988
*Value has been rounded to the nearest tenth of a foot – precision of results to the hundredths of a foot resulted in rounding the BFE on the FIRM down to the nearest whole foot.

**Figure 9: Transect Location Map**



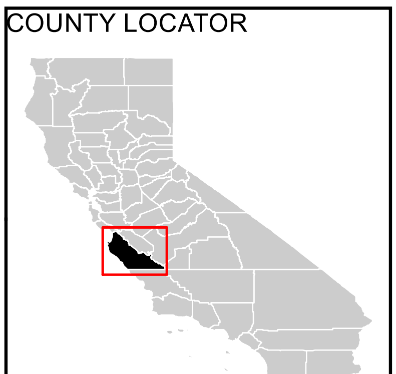

N

1 inch = 8,043 feet 1:96,518

0 2,350 4,700 9,400 14,100 18,800 Feet

Map Projection:
Universal Transeverse Mercator Zone 10 North;
North American Datum 1983

COUNTY LOCATOR



**NATIONAL FLOOD INSURANCE PROGRAM**

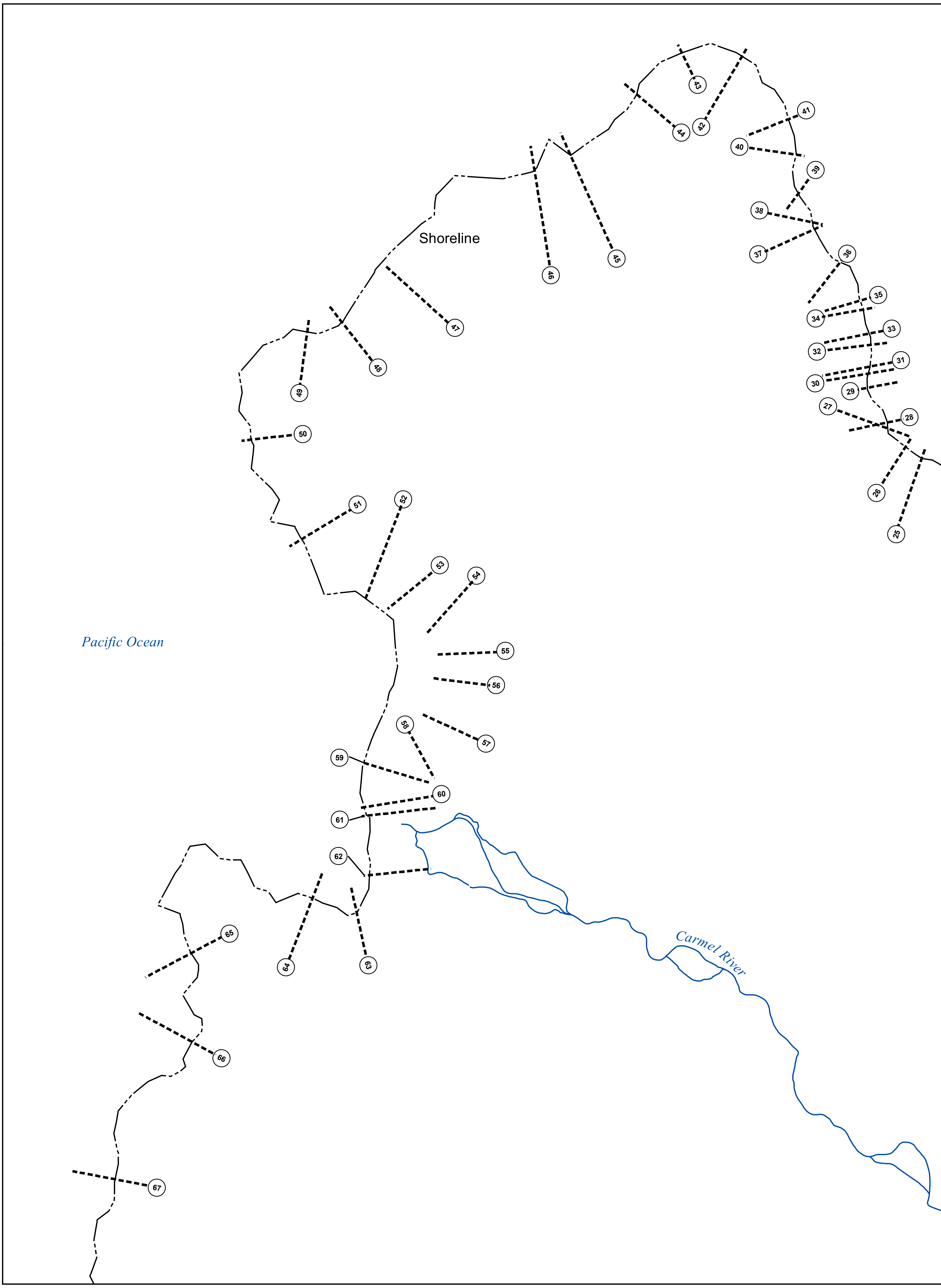
Transect Location Map

**PANELS WITH TRANSECTS:**

0058H, 0066H, 0068H, 0164H, 0168H, 0179H, 0181H, 0183H, 0187H, 0188H, 0189H, 0191H, 0302H, 0303H, 0304H, 0306H, 0307H, 0308H, 0312H, 0314H, 0316H, 0318H, 0326H, 0477H, 0483H, 0491H, 0681H, 0682H, 0684H, 0692H, 0711H, 0713H, 0952H, 0956H, 0957H, 0978H, 0979H, 0987H, 0993H, 0994H, 1207H, 1226H, 1228H, 1239H, 1243H, 1244H, 1482H, 1501H, 1503H, 1511H, 1512H, 1513H, 1514H, 1777H, 1781H, 1783H*, 1784H, 1811H

*Panel Not Printed

## Figure 9: Transect Location Map




N

1 inch = 4,972 feet 1:59,662

0 1,400 2,800 5,600 8,400 11,200 Feet

Map Projection:
Universal Transeverse Mercator Zone 10 North;
North American Datum 1983

COUNTY LOCATOR

**NATIONAL FLOOD INSURANCE PROGRAM**

Transect Location Map

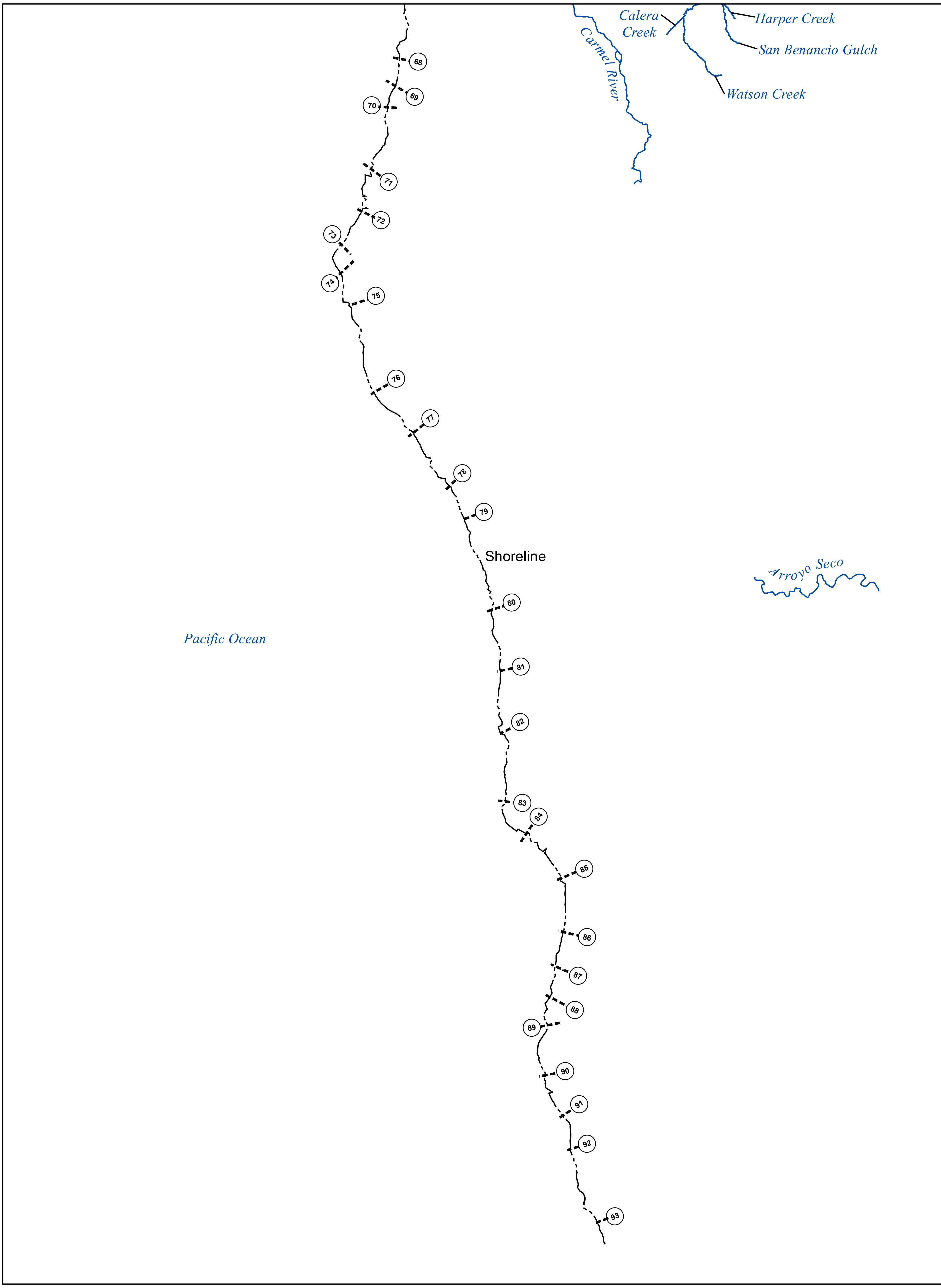
**PANELS WITH TRANSECTS:**

0058H, 0066H, 0068H, 0164H, 0168H, 0179H, 0181H, 0183H, 0187H, 0188H, 0189H, 0191H, 0302H, 0303H, 0304H, 0306H, 0307H, 0308H, 0312H, 0314H, 0316H, 0318H, 0326H, 0477H, 0483H, 0491H, 0681H, 0682H, 0684H, 0692H, 0711H, 0713H, 0952H, 0956H, 0957H, 0978H, 0979H, 0987H, 0993H, 0994H, 1207H, 1226H, 1228H, 1239H, 1243H, 1244H, 1482H, 1501H, 1503H, 1511H, 1512H, 1513H, 1514H, 1777H, 1781H, 1783H*, 1784H, 1811H

*Panel Not Printed

FEMA

**Figure 9: Transect Location Map**




1 inch = 26,756 feet    1:321,070

0  7,500  15,000  30,000  45,000  60,000 Feet

N

Map Projection:
Universal Transeverse Mercator Zone 10 North;
North American Datum 1983

COUNTY LOCATOR

## NATIONAL FLOOD INSURANCE PROGRAM

Transect Location Map

**PANELS WITH TRANSECTS:**

0058H, 0066H, 0068H, 0164H, 0168H, 0179H, 0181H, 0183H, 0187H, 0188H, 0189H, 0191H, 0302H, 0303H, 0304H, 0306H, 0307H, 0308H, 0312H, 0314H, 0316H, 0318H, 0326H, 0477H, 0483H, 0491H, 0681H, 0682H, 0684H, 0692H, 0711H, 0713H, 0952H, 0956H, 0957H, 0978H, 0979H, 0987H, 0993H, 0994H, 1207H, 1226H, 1228H, 1239H, 1243H, 1244H, 1482H, 1501H, 1503H, 1511H, 1512H, 1513H, 1514H, 1777H, 1781H, 1783H*, 1784H, 1811H

*Panel Not Printed

FEMA

### 5.4 Alluvial Fan Analyses

This section is not applicable to this Flood Risk Project.

**Table 18: Summary of Alluvial Fan Analyses**

**[Not Applicable to this Flood Risk Project]**

**Table 19: Results of Alluvial Fan Analyses**

**[Not Applicable to this Flood Risk Project]**

# SECTION 6.0 – MAPPING METHODS

## 6.1 Vertical and Horizontal Control

All FIS Reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS Reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS Reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS Report and on the FIRMs are referenced to NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between NGVD29 and NAVD88 or other datum conversion, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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 archived project documentation associated with the FIS Report and the FIRMs for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks in the area, please contact information services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

The datum conversion locations and values that were calculated for Monterey County are provided in Table 20.

**Table 20: Countywide Vertical Datum Conversion**

**[Not Applicable to this Flood Risk Project]**

A countywide conversion factor could not be generated for Monterey County because the maximum variance from average exceeds 0.25 feet. Calculations for the vertical offsets on a stream by stream basis are depicted in Table 21.

**Table 21: Stream-Based Vertical Datum Conversion**

| Flooding Source | Average Vertical Datum Conversion Factor (feet) |
|---|---|
| Arroyo Seco | 2.99 |
| Calera Creek | 2.91 |
| Canyon Del Rey (also know as Arroyo Del Rey) | 2.80 |
| Carmel River | 2.82 |
| Carmel River South Highway 1 Overbank | 2.75 |
| Carmel River North Highway 1 Overbank | 2.75 |
| Carmel River Hacienda | 2.77 |
| Carmel River Schutte Overbank | 2.82 |
| Carmel River Garland Ranch | 2.86 |
| Castroville Boulevard Wash | 2.74 |
| Corncob Canyon Creek (to include Overflow) | 2.72 |
| East Branch Gonzales Slough | 3.01 |
| El Toro Creek | 2.89 |
| Elkhorn Slough | 2.74 |
| Gabilan Creek | 2.75 |
| Gonzales Slough | 3.01 |
| Harper Creek | 2.93 |
| Josselvn Canyon Creek | 2.74 |
| Natividad Creek | 2.75 |
| Pajaro River | 2.71 |
| Pine Canyon Creek | 3.02 |
| Reclamation Ditch | 2.77 |
| Salinas River (including Salinas River Overbank) | 2.80 |
| Salinas River (near King City) | 2.99 |
| Salinas River (near San Ardo) | 3.14 |
| San Benancio Gulch | 2.95 |
| San Lorenzo Creek | 2.99 |
| San Miguel Canyon Creek | 2.73 |
| Santa Rita Creek | 2.72 |
| Tembladero Slough | 2.70 |
| Thomasello Creek | 2.72 |
| Watson Creek | 2.94 |

With the exception of the Corncob Canyon Creek Overflow as noted in the above table, a single conversion factor of 2.77 feet was used for all static elevations.

## 6.2 Base Map

The FIRMs and FIS Report for this project have been produced in a digital format. The flood hazard information was converted to a Geographic Information System (GIS) format that meets FEMA's FIRM database specifications and geographic information standards. This information is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community. The FIRM Database includes most of the tabular information contained in the FIS Report in such a way that the data can be associated with pertinent spatial features. For example, the information contained in the Floodway Data table and Flood Profiles can be linked to the cross sections that are shown on the FIRMs. Additional information about the FIRM Database and its contents can be found in FEMA's *Guidelines and Standards for Flood Risk Analysis and Mapping*, www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping.

Base map information shown on the FIRM was derived from the sources described in Table 22.

**Table 22: Base Map Sources**

| Data Type | Data Provider | Data Date | Data Scale | Data Description |
|---|---|---|---|---|
| Digital Orthophoto | Coastal Services Center | 2011 | * | Coastal California LiDAR and Digital Imagery |
| Digital Orthophoto | US Department of Agriculture | 2010 | * | NAIP Imagery |
| Political Boundaries | Association of Monterey Bay Area Government | 2004 | * | Municipal and county boundaries |
| Transportation Features | U.S. Census Bureau | 2009 | * | TIGER/Line shapefiles of transportation features |
| Public Land Survey System (PLSS) | U.S. Geological Survey | 1993 | * | Monterey County PLSS data |
| Public Land Survey System (PLSS) | California Resources Agency Legacy Project | 2004 | * | Public, conservation and Trust Lands |

## 6.3 Floodplain and Floodway Delineation

The FIRM shows tints, screens, and symbols to indicate floodplains and floodways as well as the locations of selected cross sections used in the hydraulic analyses and floodway computations.

For riverine flooding sources, the mapped floodplain boundaries shown on the FIRM have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using the topographic elevation data described in Table 23. For each coastal flooding source studied as part of this FIS Report, the mapped floodplain boundaries on the FIRM have been delineated using the flood and wave elevations determined at each transect; between transects, boundaries were delineated using land use and land cover data, the topographic elevation data described in Table 23, and knowledge of coastal flood processes. In ponding areas, flood elevations were determined at each junction of the model; between junctions, boundaries were interpolated using the topographic elevation data described in Table 23.

In cases where the 1% and 0.2% annual chance floodplain boundaries are close together, only the 1% 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.

The floodway widths 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. Table 2 indicates the flooding sources for which floodways have been determined. The results of the floodway computations for those flooding sources have been tabulated for selected cross sections and are shown in Table 24, "Floodway Data."

Certain flooding sources may have been studied that do not have published BFEs on the FIRMs, or for which there is a need to report the 1% annual chance flood elevations at selected cross sections because a published Flood Profile does not exist in this FIS Report. These streams may have also been studied using methods to determine non-encroachment zones rather than floodways. For these flooding sources, the 1% annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using the topographic elevation data described in Table 23. All topographic data used for modeling or mapping has been converted as necessary to NAVD 88. The 1% annual chance elevations for selected cross sections along these flooding sources, along with their non-encroachment widths, if calculated, are shown in Table 25, "Flood Hazard and Non-Encroachment Data for Selected Streams."

**Table 23: Summary of Topographic Elevation Data used in Mapping**

| | | Source for Topographic Elevation Data | | | | | |
|---|---|---|---|---|---|---|---|
| Community | Flooding Source | Description | Scale | Contour Interval | $RMSE_z$ | $Accuracy_z$ | Citation |
| Santa Cruz County | Pacific Ocean | LiDAR OPC/ USGS 2009-2011 & BATH NOAA | N/A | 2 ft | N/A | N/A | USGS, 2009-2011 |
| Marina, City of | All Sources | Topographic maps | 1:2,400 | 2 ft | N/A | N/A | Aero-Geodetic Corporation, 1979 |

**Table 23: Summary of Topographic Elevation Data used in Mapping, continued**

| Community | Flooding Source | Source for Topographic Elevation Data | | | | | |
|---|---|---|---|---|---|---|---|
| | | Description | Scale | Contour Interval | $RMSE_z$ | $Accuracy_z$ | Citation |
| Del Rey Oaks, City of | All Sources | Topographic maps | 1:4,800 | 10 ft | N/A | N/A | Monterey County Flood Control and Water Conservation District, 1977 |
| Monterey, City of | All Sources | Topographic maps and aerial photographs | 1:1,200 | 2 ft | N/A | N/A | City of Monterey, 1975 |
| Monterey, City of; Monterey County | Monterey Bay | Topographic maps and aerial photographs | 1:1,200<br>1:4,800 | 2 ft<br>4 ft | N/A | N/A | Ott Water Engineers, Inc. 1975; Ott Water Engineers, Inc., 1983 |
| Monterey County | All Sources | Aerial photographs | 1:6,000<br>1:12,000 | N/A | N/A | N/A | Harl Pugh and Associates, 1978 |
| Monterey County | All Sources | Topographic map | 1:24,000<br>1:6,000<br>1:12,000 | 10 ft | N/A | N/A | U.S. Department of the Interior, 1948 |
| Monterey County | Harper Creek and San Benancio Gulch | Topographic maps | 1;2,400 | 5 ft | N/A | N/A | James W. Sewall Company, 1977 |
| Monterey County | Pajaro River and Thomasello Creek | Topographic maps and aerial photography | 1:4,800 | 4 ft | N/A | N/A | Ott Water Engineers, Inc., 1983; Spink Corporation, 1978 |
| Monterey County; Salinas, City of | Reclamation Ditch | USGS 7.5-minute Quadrangle map | 1:24,000 | N/A | N/A | N/A | U.S. Department of the Interior, 1947 |

BFEs shown at cross sections on the FIRM represent the 1% annual chance water surface elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations.